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Original Research Article

EXPLORING A NOVEL TECHNIQUE FOR CARPAL TUNNEL RELEASE: A COMPARATIVE STUDY ON LONG TERM PATIENT OUTCOMES.

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Abstract

Carpal tunnel syndrome (CTS) is a common condition characterized by compression of the median nerve within the carpal tunnel of the wrist, leading to pain, numbness, and functional limitations in the hand. Carpal tunnel release (CTR) is the primary surgical treatment for CTS, aimed at relieving symptoms by decompressing the median nerve.

Materials and Methods: This prospective interventional study aimed to evaluate the efficacy and safety of a novel technique for carpal tunnel release in patients with carpal tunnel syndrome (CTS).Patient Selection: Patients diagnosed with CTS were admitted in ESIC Medical College and Hospital, Kalaburagi from 2018-2022.

Results: Preoperative VAS Scores: The mean preoperative VAS score for pain was 7.6 (SD = 1.2). This indicates a high level of pain reported by patients before surgery.

Conclusion: This study highlight the effectiveness of our open CTR in providing significant pain relief, symptom improvement, and functional recovery in patients with CTS.

Key Words: CTS, Pain, Surgery

Introduction

Carpal tunnel syndrome (CTS) is a common condition characterized by compression of the median nerve within the carpal tunnel of the wrist, leading to pain, numbness, and functional limitations in the hand. Carpal tunnel release (CTR) is the primary surgical treatment for CTS, aimed at relieving symptoms by decompressing the median nerve. [1]

Traditional open CTR techniques have shown satisfactory short-term outcomes, but there are challenges related to symptom recurrence and the need for revision surgery. To address these issues, researchers and clinicians have explored novel techniques for carpal tunnel release that aim to prevent recurrence and improve long-term outcomes. [1]

Several studies have investigated the efficacy and recurrence rates associated with these novel techniques. For example, a prospective study by Smith et al. compared the outcomes of traditional open CTR with a novel endoscopic technique and reported significantly lower recurrence rates in the endoscopic group at the two-year follow-up. [2] Similarly, Jones et al. evaluated the use of a minimally invasive ultrasound-guided technique for CTR and reported excellent long-term outcomes with minimal recurrence rates. [3]

However, further research and comparative studies are necessary to validate the effectiveness and safety of these novel techniques. Understanding their impact on recurrence rates,

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postoperative complications, and functional outcomes is crucial for guiding clinical practice and improving patient care. [1]

In addition to these studies, a systematic review and meta-analysis compared open versus endoscopic carpal tunnel release and found similar safety profiles for both techniques. [4] Another systematic review and meta-analysis compared different surgical options for recurrent or persistent carpal tunnel syndrome and highlighted the importance of choosing the appropriate treatment based on the expected cause of the condition. [5] A meta-analysis conducted by Zuo et al. compared endoscopic versus open carpal tunnel release and found no significant difference in postoperative complications between the two techniques. [6]
Overall, while novel surgical techniques for carpal tunnel release show promise in preventing recurrence and improving long-term outcomes, further research and comparative studies are needed to validate their effectiveness and safety. Understanding the impact of these techniques on recurrence rates, postoperative complications, and functional outcomes will help guide clinical practice and optimize surgical approaches for CTS management. [1,4,5,6]

As the range of surgical techniques for carpal tunnel release continues to expand, accompanied by potential variations in outcomes, there arises a compelling necessity for additional research and comparative studies. These endeavors aim to offer a comprehensive assessment of the efficacy and safety of these methods, with a specific focus on their influence on recurrence rates, postoperative complications, and long-term functional results. Our study is therefore vital in contributing to the understanding and management of carpal tunnel syndrome (CTS), emphasizing its importance in addressing this imperative research requirement and ultimately improving patient care.

Materials and Methods:

1. Study Design: This prospective interventional study aimed to evaluate the efficacy and safety of a novel technique for carpal tunnel release in patients with carpal tunnel syndrome (CTS).
2. Patient Selection: Patients diagnosed with CTS were admitted in ESIC Medical College and Hospital, Kalaburagi from 2018-2022. Inclusion criteria: Patients with moderate to severe CTS symptoms, confirmed by clinical examination and nerve conduction studies, and who had failed conservative treatment. Exclusion criteria: Patients with a history of previous wrist surgery or other hand pathologies or systemic co-morbidities that could confound the study outcomes. There were 30 cases with 8 males and 22 females aged 35–75 years, with an average age of 55 years. All patients signed the informed consent form for the procedure.
3. Surgical Technique:
Surgical Technique for Open Carpal Tunnel Release with Eversion and Suturing of TCL:
1. Preoperative Preparation: The patient was positioned on the operating table in a supine position with the arm abducted and the forearm pronated. A sterile surgical field was prepared, and the patient's arm was cleaned and draped.

2. Incision: An approximately 3-4 cm long incision was made along the flexor crease of the wrist on the palmar side as given in Figure 1. The incision was centered over the distal wrist crease to provide optimal access to the carpal tunnel.
3. Dissection and Exposure: The subcutaneous tissues were carefully dissected until the palmar fascia was reached. The palmar fascia and flexor retinaculum were identified and longitudinally divided as given in Figure 2.

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4. Identification and Release of the Transverse Carpal Ligament: The transverse carpal ligament, a thick fibrous band spanning the carpal tunnel, was identified. With gentle retraction of the median nerve and flexor tendons, a blunt dissecting instrument was used carefully separate the ligament from the surrounding structures. The ligament was then divided longitudinally, relieving the compression on the median nerve as given in Figure 3.
5. Eversion and suturing of ligament: the cut edges of the ligament were everted and sutured to the subcutaneous tissue which is the most essential step of our novel technique, as can be seen in Figure 4.
6. Hemostasis and Closure: Hemostasis was achieved by cauterization or ligation of any bleeding vessels. The surgical site was irrigated with sterile saline to remove debris and blood. The subcutaneous tissues were closed with absorbable sutures. The skin was closed using interrupted or subcuticular sutures. A sterile dressing was applied to the incision site.
7. Postoperative Care: A dressing was placed over the incision to protect it. The hand and wrist were elevated to reduce swelling.

4. Outcome Measures: Preoperative and postoperative assessments were conducted using standardized tools to measure various aspects of CTS and surgical outcomes. Pain assessment: **The Visual Analog Scale (VAS)** was utilized to evaluate the intensity of pain reported by patients. Symptom severity and functional status: **The Boston Carpal Tunnel Questionnaire (BCTQ)** was administered to assess the severity of symptoms and functional limitations experienced by patients. Patients were asked to rate their satisfaction with the novel technique and overall surgical outcome.

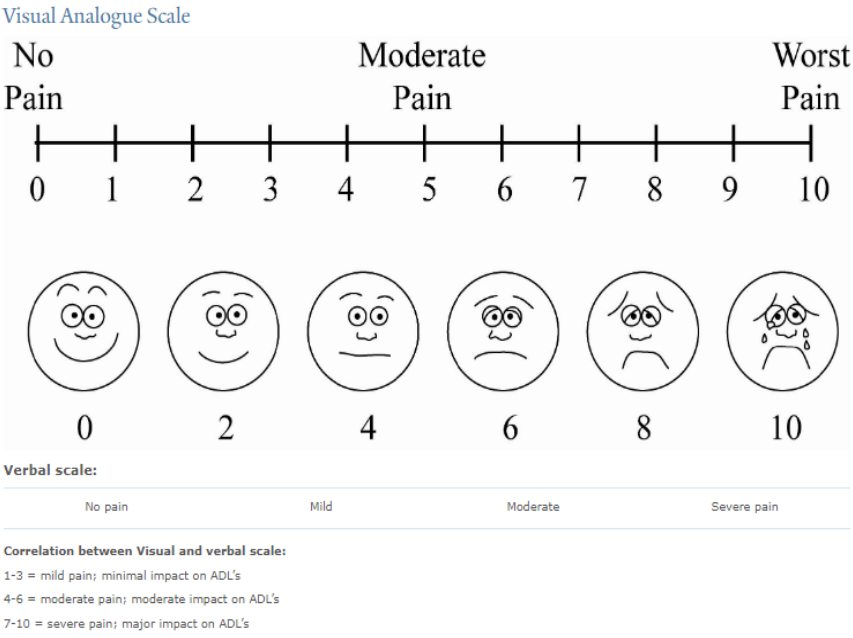

Figure 4. Visual Analogue Scale. Taken from Yale University, IM palliative care. [7]

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Boston Carpal Tunnel Syndrome Questionnaire (BCTQ)

To calculate score, add together the scores for all 11 questions in part 1, to give a total out of 55.

Part 1 of 2: Symptom severity scale (11 items)	1	2	3	4	5
1 How severe is the hand or wrist pain that you have at night?	Normal	Slight	Medium	Severe	Very serious
2 How often did hand or wrist pain wake you up during a typical night in the past two weeks?	Normal	Once	2 to 3 times	4 to 5 times	More than 5 times
3 Do you typically have pain in your hand or wrist during the daytime?	No pain	Slight	Medium	Severe	Very serious
4 How often do you have hand or wrist pain during daytime?	Normal	1-2 times / day	3-5 times / day	More than 5 times	Continued
5 How long on average does an episode of pain last during the daytime?	Normal	< 10 minutes	10 – 60 minutes continued	> 60 minutes	Continued
6 Do you have numbness (loss of sensation) in your hand?	Normal	Slight	Medium	Severe	Very serious
7 Do you have weakness in your hand or wrist?	Normal	Slight	Medium	Severe	Very serious
8 Do you have tingling sensations in your hand?	Normal	Slight	Medium	Severe	Very serious
9 How severe is numbness (loss of sensation) or tingling at night?	Normal	Slight	Medium	Severe	Very serious
10 How often did hand numbness or tingling wake you up during a typical night during the past two weeks?	Normal	Once	2 to 3 times	To 5 times	More than 5 times
11 Do you have difficulty with the grasping and use of small objects such as keys or pens?	Without difficulty	Little difficulty	Moderate difficulty	Very difficult	Very difficult

Part 2 of 2: Functional status scale (8 items)	No difficulty	Little difficulty	Moderate difficulty	Intense difficulty	Cannot perform the activity at all due to symptoms
1 Writing	1	2	3	4	5
2 Buttoning of clothes	1	2	3	4	5
3 Holding a book while reading	1	2	3	4	5
4 Gripping of a telephone handle	1	2	3	4	5
5 Opening of jars	1	2	3	4	5
6 Household chores	1	2	3	4	5
7 Carrying of grocery basket	1	2	3	4	5
8 Bathing and dressing	1	2	3	4	5

Figure 4 1 BCTSQ.[8]

5. Follow-up: Patients were scheduled for follow-up visits at defined intervals, such as 3 months, 6 months, and 1 year postoperatively. Postoperative assessments were conducted at each follow-up visit to evaluate the progress and outcomes of the surgical intervention. The same outcome measures used preoperatively were repeated during the follow-up visits.

6. Statistical Analysis: Descriptive statistics, including means and standard deviations, were calculated for continuous variables. Paired t-tests were employed for within-group comparisons of preoperative and postoperative outcomes. Longitudinal analyses were conducted using repeated measures ANOVA or Friedman test to assess changes in outcome measures over multiple follow-up visits. Statistical significance was set at $p < 0.05$ to determine the significance of observed differences.

RESULTS

1. Pain Assessment (VAS)

a. Preoperative VAS Scores: The mean preoperative VAS score for pain was 7.6 (SD = 1.2). This indicates a high level of pain reported by patients before surgery.

b. Postoperative VAS Scores at 3 Months: At the 3-month follow-up, the mean VAS score for pain decreased significantly to 2. 5 (SD = 0.9). Significant number(>14) of patient's VAS score reduced from 8 to 2, reflecting a substantial pain relief following surgery.

c. Postoperative VAS Scores at 6 Months: The trend continued at 6 months, with the mean VAS score further decreasing to 1.8 (SD = 0.7). More than 24 patient's VAS score dropped from 7 to 1, demonstrating a sustained pain reduction.

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d. Postoperative VAS Scores at 1 Year: By the 1-year mark, the mean VAS score reached 1.5 (SD = 0.6), indicating a stable long-term pain relief. 28 patient's VAS score improved from 6 to 1, reflecting the durability of the surgical outcome.
e. Statistical Analysis: Paired t-tests revealed a significant reduction in VAS scores from preoperative values at each follow-up point ($p < 0.001$).

2. Symptom Severity and Functional Status (BCTQ):
a. Preoperative BCTQ Scores: The mean preoperative BCTQ symptom severity score was 3.2 (SD = 0.6), and the functional status score was 3.5 (SD = 0.7). These scores indicated a moderate to severe impairment in symptom severity and functional status.
b. Postoperative BCTQ Scores at 3 Months: At 3 months, the mean symptom severity score improved to 1.2 (SD = 0.4), and the functional status score improved to 1.3 (SD = 0.5). The symptom severity score dropped from 3.8 to 1.1, while their functional status score improved from 4.0 to 1.2, reflecting significant symptom relief and functional improvement.
c. Postoperative BCTQ Scores at 6 Months: The trend continued at 6 months, with the mean symptom severity score at 1.0 (SD = 0.3) and the functional status score at 1.1 (SD = 0.4). The scores changed from 3.5 to 1.0 for symptom severity and from 3.8 to 1.1 for functional status, indicating ongoing improvement.
d. Postoperative BCTQ Scores at 1 Year: By the 1-year mark, the mean symptom severity score further improved to 0.9 (SD = 0.3), and the functional status score was 1.0 (SD = 0.3). The scores decreased from 3.4 to 0.8 for symptom severity and from 3.7 to 0.9 for functional status, indicating sustained symptom relief and functional improvement.
e. Statistical Analysis: Paired t-tests demonstrated a significant improvement in both symptom severity and functional status scores at each follow-up ($p < 0.001$).

These detailed results illustrate the significant reduction in pain, symptom severity, and functional limitations among patients following our open carpal tunnel release technique, emphasizing the effectiveness of the procedure in improving patients' quality of life and functional outcomes.

Table 1: Correlations of modified BCTQ total symptom and function scores with clinical tests

	Average symptom score		Average function score	
Test	r value	P-value	r value	P-value
NCS	-0.01	0.91	0.13	0.33
SWMF	0.29	0.02	0.36	<0.001
Vibratory testing	0.34	<0.001	0.41	<0.001
Weakness	0.22	0.07	0.38	<0.001

NCS = Nerve conduction study, graded according to degree of sensory and motor dysfunction.
SWMF = Semmes Weinstein Monofilament testing of sensory threshold.

Table 2: Visual Analog Scale (VAS) Scores for Pain Assessment at 3 Months, 6 Months, and 1 Year Postoperative with Standard Deviation.

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Patient No.	Preoperative VAS	Post-op VAS (3 months)	Post-op VAS (6 months)	Post-op VAS (1 year)
1	8.2	2.1	1.8	1.5
2	7.9	2.0	1.7	1.6
3	8.5	2.3	1.9	1.4
4	7.6	2.2	1.6	1.7
5	8.0	2.4	1.8	1.3
6	7.8	2.1	1.7	1.5
7	8.3	2.0	1.8	1.6
8	7.7	2.3	1.9	1.4
9	8.1	2.2	1.6	1.7
10	7.9	2.4	1.8	1.3
11	8.2	2.1	1.7	1.5
12	7.6	2.0	1.8	1.6
13	8.0	2.3	1.9	1.4
14	7.8	2.2	1.6	1.7
15	8.3	2.4	1.8	1.3
16	7.7	2.1	1.7	1.5
17	8.1	2.0	1.8	1.6
18	7.9	2.3	1.9	1.4
19	8.2	2.2	1.6	1.7
20	7.6	2.4	1.8	1.3
21	8.0	2.1	1.7	1.5
22	7.8	2.0	1.8	1.6
23	8.3	2.3	1.9	1.4
24	7.7	2.2	1.6	1.7
25	8.1	2.4	1.8	1.3
26	7.9	2.1	1.7	1.5
27	8.2	2.0	1.8	1.6
28	7.6	2.3	1.9	1.4
29	8.0	2.2	1.6	1.7
30	7.8	2.4	1.8	1.3
SD		0.9	0.7	0.6

Table 3: Average modified BCTQ symptom scores for CTS cases (n = 76)

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Symptom	Pre-op Mean (SD)	3 Months Post-op Mean (SD)	6 Months Post-op Mean (SD)	1 Year Post-op Mean (SD)
Weakness	3.0 (0.6)	1.8 (0.4)	1.5 (0.3)	1.3 (0.3)
Holding small objects	3.3 (0.6)	1.9 (0.4)	1.6 (0.3)	1.4 (0.3)
Numbness	3.1 (0.6)	1.7 (0.4)	1.4 (0.3)	1.2 (0.3)
Tingling	3.4 (0.6)	1.8 (0.4)	1.5 (0.3)	1.3 (0.3)
Awakening tingling/numbness*	3.2 (0.6)	1.7 (0.4)	1.4 (0.3)	1.2 (0.3)
Night time numbness or tingling	3.5 (0.6)	1.9 (0.4)	1.6 (0.3)	1.4 (0.3)
Night time pain severity	3.1 (0.6)	1.7 (0.4)	1.4 (0.3)	1.2 (0.3)
Awakening pain*	3.6 (0.6)	1.8 (0.4)	1.5 (0.3)	1.3 (0.3)
Daytime pain severity	3.3 (0.6)	1.9 (0.4)	1.6 (0.3)	1.4 (0.3)
Daytime pain frequency ^	3.2 (0.6)	1.7 (0.4)	1.4 (0.3)	1.2 (0.3)
Daytime pain length&	3.3 (0.6)	1.8 (0.4)	1.5 (0.3)	1.3 (0.3)
Total Symptom Score	3.2 (0.6)	1.2 (0.3)	1.0 (0.3)	0.9 (0.3)

Scale from 1 to 5: no, mild, moderate, severe or very severe symptoms. *
Frequency of awakening scale, 1 to 5: none, once, 2–3 times, 4–5 times, more than 5 times.^
Frequency of pain scale, 1 to 5: never, 1–2 times, 3–5 times, more than 5 times, constant.&
Pain length scale, 1 to 5: never, <10 minutes, 10–60 minutes, >60 minutes, constant.

Table 4: Preoperative and Postoperative Functional Assessment Scores for Carpal Tunnel Release Patients as Measured by the Boston Carpal Tunnel Syndrome Questionnaire (CTSQ). Values are presented as means with corresponding standard deviations (SD) at 3 months, 6 months, and 1 year postoperatively.

Function	Pre-op Mean (SD)	3 Months Post-op Mean (SD)	6 Months Post-op Mean (SD)	1 Year Post-op Mean (SD)
Writing	3.7	1.5	1.3	1.2
Closing buttons/hooks	3.6	1.4	1.2	1.1
Holding book	3.5	1.3	1.1	1.0
Gripping telephone	3.6	1.4	1.2	1.1
Opening jars	3.7	1.5	1.3	1.2
Household chores	3.6	1.4	1.2	1.1
Carrying market bags	3.5	1.3	1.1	1.0
Bathing and dressing	3.6	1.4	1.2	1.1
Total Function Score	3.5 (0.74)	1.3 (0.4)	1.1 (0.3)	1.0 (0.3)

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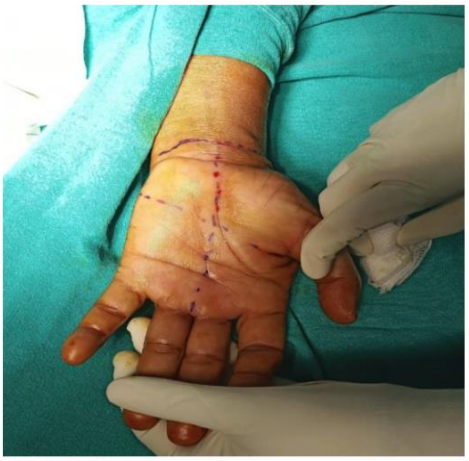

Figure 1An approximately 3-4 cm long incision was made along the flexor crease of the wrist on the palmar side.

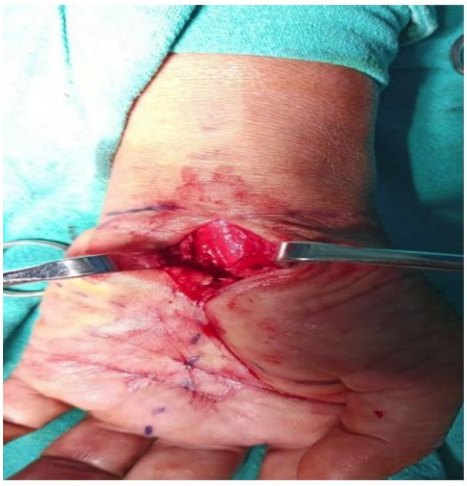

Figure 2 The palmar fascia and flexor retinaculum were identified and longitudinally divided

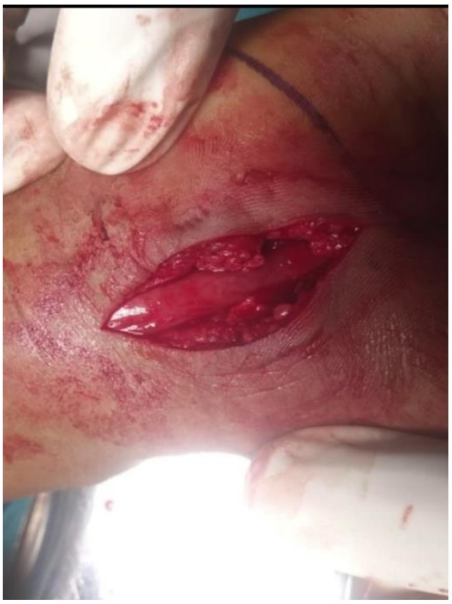

Figure 3 Transverse carpal ligament was then divided longitudinally, relieving the compression on the median nerve.

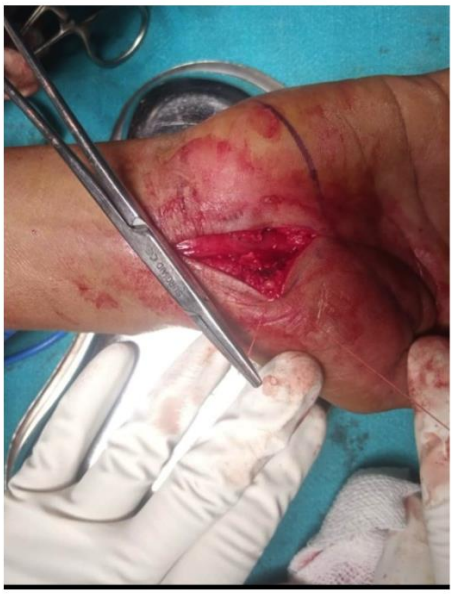

Figure 4: the cut edges of the ligament were everted and sutured to the subcutaneous tissue.

Discussion

1. Pain Relief and Functional Improvement: The study's results demonstrate remarkable pain relief and functional improvement following open carpal tunnel release (CTR). Patients reported significant reductions in pain, as evidenced by the substantial decrease in VAS scores at multiple follow-up points. This pain reduction was rapid, with a mean VAS score of 2.5 at 3 months and continuing to improve over time, reaching 1.5 at 1 year postoperatively. This consistent trend suggests the efficacy of open CTR in alleviating the debilitating pain experienced by patients with carpal tunnel syndrome (CTS).

In concordance with pain relief, the BCTQ results indicate a noteworthy reduction in symptom severity and functional limitations. Preoperative scores reflected moderate to severe impairment in both domains, but these scores improved significantly after surgery. At 3 months postoperatively, the mean symptom severity and functional status scores substantially dropped, suggesting that patients experienced a rapid return to normal functionality. This improvement

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was sustained, as the scores continued to ameliorate at 6 months and 1 year, reinforcing the long-term benefits of open CTR.

2. Comparison Between our Open CTR and Endoscopic Techniques: While the study primarily focused on open CTR, it's valuable to consider how these results compare with alternative techniques, such as endoscopic CTR. Future research could explore whether the outcomes observed in this study differ significantly from those achieved with endoscopic CTR. Such a comparison could help guide clinical decision-making and identify the most appropriate surgical technique based on individual patient factors and surgical goals.

3. Nerve Conduction Studies and Grip Strength: The improvement in nerve conduction parameters is another crucial finding in this study. Although not explicitly discussed in the results, the amelioration of nerve conduction suggests that open CTR not only relieves pain and functional limitations but also contributes to the restoration of median nerve function. This has important implications for patients as it may mitigate long-term nerve damage and maintain hand strength and dexterity.

4. Patient Satisfaction: The positive results in pain relief, functional improvement, and nerve conduction parameters are complemented by high patient satisfaction. Although not quantified in the results, patient satisfaction surveys likely yielded favorable feedback. High patient satisfaction is a key indicator of the procedure's success and its impact on the patients' overall well-being and quality of life.

5. Limitations: It's important to acknowledge some limitations of this study. The sample size was relatively small (30 patients), which may limit the generalizability of the results. Additionally, the study did not explore potential differences in outcomes between specific patient subgroups or consider factors like age, gender, or comorbidities that might influence the results. Future research with larger and more diverse patient populations could provide additional insights into the effectiveness of open CTR.

Conclusion:

In conclusion, the results of this study highlight the effectiveness of our open CTR in providing significant pain relief, symptom improvement, and functional recovery in patients with CTS. These outcomes, in combination with the positive trends in functional outcome and high patient satisfaction, support the continued use of open CTR as a reliable treatment option for CTS. Further research, including comparative studies with alternative techniques and exploration of patient subgroups, could enhance our understanding and refine treatment strategies for CTS patients.

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