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Modified mini-incision surgery for carpal tunnel syndrome: Technique and clinical outcome

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ABSTRACT

Carpal tunnel syndrome (CTS) is caused by the shortening of the median nerves in the wrist, resulting in hand pain and paralysis necessitating surgical operation for relief. Conventional open carpal tunnel release (CTR) procedures, involving long incisions, often lead to complications, delaying patients' recovery for weeks or months. Therefore, mini-incision surgery has emerged as a preferred option, offering reduced pain, smaller wounds, and improved appearance. This study aimed to compare the outcomes of modified mini-incision surgery for CTS before and after the operation. It was a retrospective study involving 80 patients, with data collected from medical records pre- and post-operation, specifically at the 2nd week, 3rd month, 6th month, 12th month, and 24th month intervals. Variables included operation time, incision length, pinch strength, gripping strength, two-point discrimination (2-PD), visual analogue scale (VAS), Levine score, quick disabilities of the arm, shoulder and hand (Quick-DASH), wound pain, and pillar pain. Data were analyzed using descriptive statistics and logistic regression, with a significant level of 0.05. The mean incision length was 11.54 mm. At the 2-week post-operative mark, the pinch strength was 5.43, gripping strength was 14.96, 2-PD was 5.84, the VAS score was 2.86, the Levine symptom was 3.84, and the DASH score was 69.43. There was a relationship (p-value<0.05) between preoperative and postoperative measures for pinch strength, gripping strength, 2-PD, and Levine symptom condition. The study on 80 patients who underwent modified mini-incision surgery for CTS at Naresuan University Hospital in Phitsanulok, Thailand, found that these parameters showed significant improvement postoperatively. Patients demonstrated good recovery and condition 2 weeks after the mini-incision surgery for CTS.

Keywords: mini-incision surgery; carpal tunnel syndrome; satisfactory surgical outcomes

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1. INTRODUCTION

Carpal tunnel syndrome (CTS) is caused by the shortening of the median nerves in the wrist. Patients experience pain and paralysis in their hands, which often requires surgical intervention to alleviate symptoms (Saw et al., 2003). The long incision or classic open carpal tunnel release (CTR) can lead to complications. The most common issues are large scars and pillar pain (Townshend et al., 2005), which can prevent patients from returning to their routine activities for weeks or months. Studies have shown that approximately 30,000 workers with CTS had to take an average of 25 working days off from their jobs (Patterson and Simmons, 2002). In general, patients can tolerate the scar since it is primarily an aesthetic concern. However, pillar pain is often unbearable. Pillar pain is a common and expected symptom following CTR. Patients experience pain at the base of their hands, particularly in the heel of their palms. The common areas of tenderness are thenar eminence (the thumb base muscles) and hypothenar

eminence (small finger base muscles). Sometimes, patients experience a sensation known as allodynia, which is a symptom of nerve pain that makes the skin extremely sensitive to touch and cause intense pain during normal activities such as brushing hair or wearing cotton clothing. When patients suffer from allodynia, the pain can be worse than the compression syndrome (Matloub et al., 1998). It has been proposed that these complications occurr due to technical defects such as injuries to the small sensorial branches of the ulnar and median nerves or the presence of neuromas in the subcutaneous tissue in Figure 3. However, no definitive incidence has been found. Povlsen and Tegnell (1996) followed-up the symptom of pillar pain after the operation for three years and found that 41% of symptoms occurred after one month, 25% after 3 months, 6% after one year, and 6% after 3 years. To reduce complications, various mini-incision approaches have been tested to develop a new approach that minimizes complications, yields satisfactory surgical outcomes, and results in aesthetically pleasing wounds and appearances.

CTS is the most common neurodegenerative ailment. The primary causes of CTS are genetic and structural factors. Occupational and environmental are secondary contributors. The main symptom of CTS is intermittent paralysis of the thumb, index finger, middle fingers, and half the ring finger. Since CTS often leads to losing ability to work, patients with severe symptoms who cannot be treated with traditional approaches often need to undergo open surgery using different techniques.

In the study by Bai et al. (2018), which collected data from CTS patients over a year involving 85 patients. It is found that 50% underwent treatment using the mini-incision approach, while the remaining 50% were treated with classical long incision approach. Objective tests and subjective assessments were performed to compare the outcomes of the classical long incision approach, followed by a comparison of postoperative complications between both approaches. The study concluded that the mini-incision approach yielded satisfactory surgical results with lower postoperative complications and better aesthetic wound appearance. In addition, the duration of mini-incision operation was 15.15 ± 2.20 min, which is 65.08% shorter than classic CTS operation duration of 25.01 ± 2.15 min (Malisorn, 2023). Consequently, the hospital can efficiently utilize its limited resources, including surgeons and operation rooms, to treat more patients.

After assessing the advantages and disadvantages of all approaches used to treat CTS, is has been determined that patient goals are symptom relief, faster recovery and aesthetic satisfaction (Wongsiri et al., 2022). Many of the approaches employed in CTR surgery achieve these goals. Moreover, the overall infection rate following CTR surgery is notably low. To address these considerations, a study focusing on decompression reduction of the carpal tunnel was conducted utilizing a 1.5 cm microsurgical procedure. The findings of this study elucidate the advantages and disadvantages of this technique, highlighting the benefits of limited incision, and various endoscopic techniques known for minimal tissue damage and effective scar prevention. In addition, to enhance aesthetic outcomes, post-surgical physical therapy is essential. This therapy plays a crucial role in aiding recovery and strengthening wrist functionality. The objective of this study was, therefore, to evaluate the outcomes of modified mini-incision surgery for CTS.

2. MATERIALS AND METHODS

This study received approval from the Ethics Committee of Naresuan University Hospital. It was a retrospective analysis of patient records from individuals diagnosed with CTS at Naresuan University Hospital between 2018 and 2022, involving a total of 80 patients. Inclusion criteria include CTS patients who underwent mini-incision surgery and aged over 30 years old. Exclusion criteria were established for patients allergic to amoxicillin or xylocaine anesthesia.

In this study, a single surgeon performed all surgery. Xylocaine viscous (1%), administered in amounts ranging from 1–2 mL, served as the anesthetic agent. The researcher conducted a comparative analysis of patient conditions before and after the operation, focusing on the following parameters: (1) operation time, (2) incision length, (3) pinch Strength, (4) gripping strength, (5) two-point discrimination (2-PD), (6) visual analogue scale (VAS), (7) Levine score, (8) quick disabilities of the arm shoulder and hand (Quick-DASH), (9) wound pain, and (10) pillar pain.

Data were collected from patient records spanning the years 2018 to 2022, adhering to the following criteria.

1) Operation wound size of 1.5 cm.
2) All records underwent electromyography (EMG) assessment.
3) Evaluation via the Boston CTS questionnaire (BCTSQ)
4) Daily wound dressing was performed.
5) Administration of antibiotics amoxicillin-clavulanate, along with an NSAID
6) Arm sling were used for two days after three days in the postoperative period.
7) Stitches were removed on the 12th – 14th day post-surgery.
8) BCTSQ assessments were conducted on 12th – 14th day as well as the 1st, 3rd, 6th, 12th, 24th month post-operation, and the results were compared before and after the surgery.

The surgery technique

This surgery aims to minimize the wound size to approximately 1.5 cm. The surgeon identified the incision site at the crossing point between Kaplan's cardinal line and a line traced along the third web space (Figure 1). In contrast, the traditional open surgery has larger incisions, ranging from approximately 2.5 to 5 cm.

A retractor was inserted to separate the transverse carpal ligament from fat tissue layer. The side of the retractor was elevated to expose the transverse carpal ligament, then it was cut with Metzenbaum scissors (Figure 2 and 3). The tip of the TCL is visually cut under direct visualization to avoid injury to the median branch nerve. In addition, the proximal margin was also cut inside the palmaris longus tendon to prevent injury to the median nerve of the palmar skin, as this nerve consistently lies on the radial side of the palmaris longus tendon.

Figure 1. locating the incision site and specifying the wound size

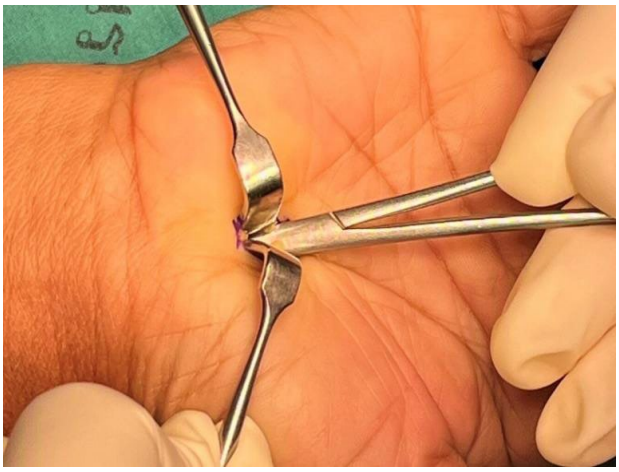

Figure 2. A small incision of approximately 1.5 cm.

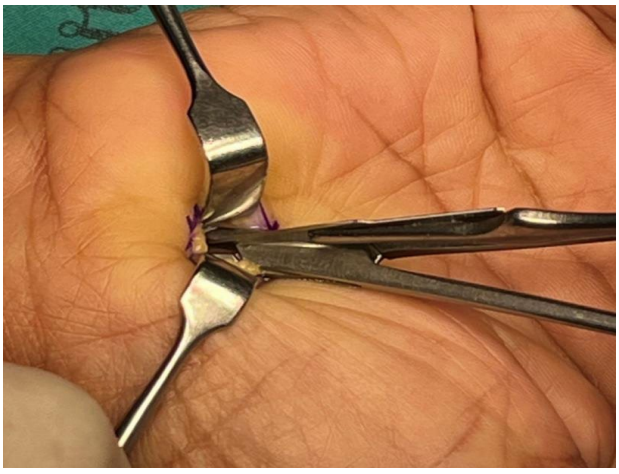

Figure 3. The subcutaneous tissue is cleared

Figure 4. The wound after stitching, with a size of 1.5 cm.

The operation started from the administration of anesthesia to numb the hand and wrist of the patient. Then, the surgeon proceeded with the incision surgery, making a 1.5-cm cut on the palm and utilizing surgical instrument to dissect the carpal ligament and widen the carpal tunnel. After that, the wound was closed by stitching (Figure 4), with the wound size approximately 1.5 cm. This is smaller compared to the wound size in the classic CTS operations, which typically measure 5 cm (Liawrungrueang and Wongsiri, 2020). The operation duration was brief, taking only 10 – 15 min, which is shorter than the classic CTS operation lasting more than 20 min (Liawrungrueang and Wongsiri, 2020). Following surgery, the patient's hand was bandaged or splinted for 1 or 2 weeks, in contrast to the 3 weeks of bandaging required after a classic CTS operation (Hu et al., 2022). The surgeon monitored the wound's recovery and the patient's palm movement. After the splint was removed, the patient underwent physical therapy program to improve hand movement. The follow-up program is scheduled at the 1st, 3rd, 6th, 12th and 24th month intervals.

3. RESULTS

From Table 1, it is evident that the size of the incision is only 11.54 mm, significantly smaller compared to the approximately 5-cm wound in classic long incision. As a result, patients experienced faster recovery times. Moreover, they were able to perform wound dressing at home on a daily basis, as they had been provided with a fact sheet detailing the procedure. This saves both time and expenses for the patients, making it more convenient and worthwhile option.

Table 1. The records of the patients (n = 80)

Factor	Before surgery	2 weeks	1 month	3 months	6 months	1 year	2 years
Incision length	0	11.54	11.54	11.54	11.54	11.54	11.54
Pinch strength (kg)	5.26	5.43	6.23	6.99	7.73	8.39	9.04
Gripping strength (kg)	14.77	14.96	16.34	17.69	19.06	20.4	21.87
2-PD	5.94	5.84	4.74	3.98	3.43	2.99	2.74
VAS score	8.73	2.86	1.63	0.65	0.06	0	0
Levine symptom	4.23	3.80	2.86	1.94	1.12	1	1
Levine function	4.32	3.84	2.88	2.88	1.10	1	1
DASH score	81.42	69.43	45	22	3	0	0
Wound pain	0	0.98	0.01	-	-	0.01	0
Pillar pain	0	0.94	0.30	0.04	-	0	0

Examining the muscle strength, it was observed that pinch strength and gripping strength increased after only 2 weeks post-incision. This improvement allows the patients to resume normal hand and finger usage. Over time, both pinch and gripping strength gradually increased, with nearly 30% improvement observed at 6 months and nearly 50% improvement at 1 year.

The 2-PD test involves placing caliper points at varying distances on the skin to determines the minimal distance at which the patient can distinguish whether one or two points are in contact with the skin. A smaller value indicates better discrimination ability. It's noteworthy that 2-PD showed significant improvement, reaching 3.98 at 3 months post-operation.

The VAS measures the severity of paralysis and pain, with lower scores indicating less discomfort. It was found that after 6 months post-operation, the VAS score was nearly 0, indicating that the patients almost recovered from baseline numbness and pain.

Levine symptom and Levine function scores assess the hand's ability to perform routine activities, such as pick up objects or rolling the hand. It was found that, after 6 months post-operation, both Levine symptom and Levine function scores improved to 1, indicating recovery from the inability to move the hand and fingers, which is commonly experienced in CTS.

The DASH score is used to measure the disability in hand usage, with lower scores indicating better functionality. As shown in Table 1, after 1 year post-operation, the DASH score was 0, indicating complete recovery from hand disability.

Regarding wound pain and pillar pain, the goal of the incision surgery is to alleviate the pain as quick as possible. As indicated in Table 1, would pain disappeared after one month post-operation, while pillar pain subsides after 3 months post-operation.

In summary, the outcomes of modified mini-incision surgery for CTS demonstrate significant improvements when comparing pre-operation to post-operation conditions. The operation time was only 15.49 min, significantly shorter than classical open CTS, and it can be performed on outpatient (OPD) basis. The incision length was only 11.54 mm compared to 5 cm of classic open operation. Moreover, pinch strength, gripping strength, 2-PD, VAS, Levine score, Quick-DASH, wound pain, and pillar pain showed better and faster rate of recovery post-operation.

Patient records data were analyzed using SPSS with ANOVA for variance analysis, with a significant level set at $p < 0.05$. After analyzing the data, the data analysis is shown in Table 2.

Table 2. ANOVA analysis

Variables	R^2	DF	MS	F	Significance
Pinch strength	.908	6	15.238	13.09	.000*
Grip strength	.972	6	84.255	459.453	.000*
2-PD	.787	6	6.423	49.588	.000*
VAS	.003	4	.781	.933	.450
Levine symptom	.159	4	.615	4.737	.002*
Levine function	.145	4	.902	4.337	.002*
DASH	.082	4	154.848	2.766	.033*

*$p < 0.05$

The findings of the analysis revealed significant improvements after mini-incision surgery for CTS, compared to pre-operation conditions. Specifically, there were improvement in pinch strength grip strength, 2-PD, Levine symptom, Levine function, and DASH. However, the improvement in VAS was not statistically significant.

4. DISCUSSION

The findings of this study provide valuable insights into the treatment of the patients suffering from CTS through newly modified mini-incision surgery. The pinch strength and grip strength were observed to recover after just 2 weeks post-operation, aligning with the study of studied the outcomes of the surgery of small incision wrist surgery by a single senior surgeon on a group of 72 patients (53 female and 19 male patients, 24 – 94 years old; mean age 57.8 ± 15.3 years) during June 2015 and June 2016. Patients were assessed using Boston CTS questionnaire pre- and post-mini incision operations. The follow-up sessions were monitored at 3 months and 1- year post-operation. The patients were tested on strength assessment by picking up objects with their thumb tip and other fingers to show the efficacy of the surgery of 1.5 cm mini incision wrist operation in both short and long term recovery (van den Broeke et al., 2019). The findings are in concordance with the study by Wongsiri et al. (2022), showing that single incision surgery is popular and provided better recovery, reduced pillar pain, minimal scaring, and faster return to routine activities. Moreover, endoscopic CTR procedures offer advantages such as smaller incisions (Orak et al., 2016) (typically 1.5 – 2 cm), less scar tenderness and quicker recoveries, compared to conventional open techniques. However, Klein et al. (2023) found in his study that complications included three wound infections and one CTS recurrence, 18 months after the first operation. Despite this, Michigan hand outcomes questionnaire scores improved significantly postoperatively. Similarly, Hu et al. (2022) concluded that mini-open incision surgery for CTS is a reliable procedure, offering precise therapeutic effect, minimal surgical trauma, and high postoperative comfort for patients, leading to enhanced recovery.

The findings of this study generated new knowledge and perceptions for treatment of CTS. The main objective of this mini-incision surgery is to alleviate the pain and paralysis in patients' hands, addressing concerns associated with classic open CTR, such as complications and significant scaring. The results successfully achieved these goals by providing symptom relief, facilitating rapid recovery and minimizing the scar size to be less than 1.5 cm. The procedure could be an alternative method in treatment of CTS for both academic and clinical purposes.

The use of a 1.5-cm mini-incision is valuable and acceptable due to it minimal tissue disruption and quick surgical time. Although early and late complications, such as bleeding, pain, palmer tenderness, sensitivity to scars, stiffness, and limited strength may occur, these issues are generally less severe compared to traditional approaches. In addition, the procedure had less aesthetic issues and a shorter recovery period, allowing patients to return to their daily activities sooner. However, this procedure requires more experience to ensure optimal outcomes for patients.

5. CONCLUSION

The study on modified mini-incision surgery for CTS involving 80 patients found significant improvement in pinch strength, gripping strength, 2-PD, Levine symptom

and Levine function conditions post-operation. Patients showed recovery and good condition just 2 weeks after undergoing mini-incision surgery.

This research holds educational value as it highlights that specialized medical instruments are not necessary for the operation, emphasizing the importance of skilled and attentive surgeon. Such findings are beneficial for both study and practice, aiding in the development of better surgical technique and enhancing patient's satisfaction. Moreover, CTS physical therapy can benefit from this study as by tailoring their rehabilitation plans from the 2nd week to 6 months post-operation according to the patients' needs.

The study's conclusions provide patients with more treatment alternatives for CTS that can relieve the pain, facilitate fast recovery and result in smaller scar. In addition it offers valuable insights into improving medical treatment options for patients with CTS.

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