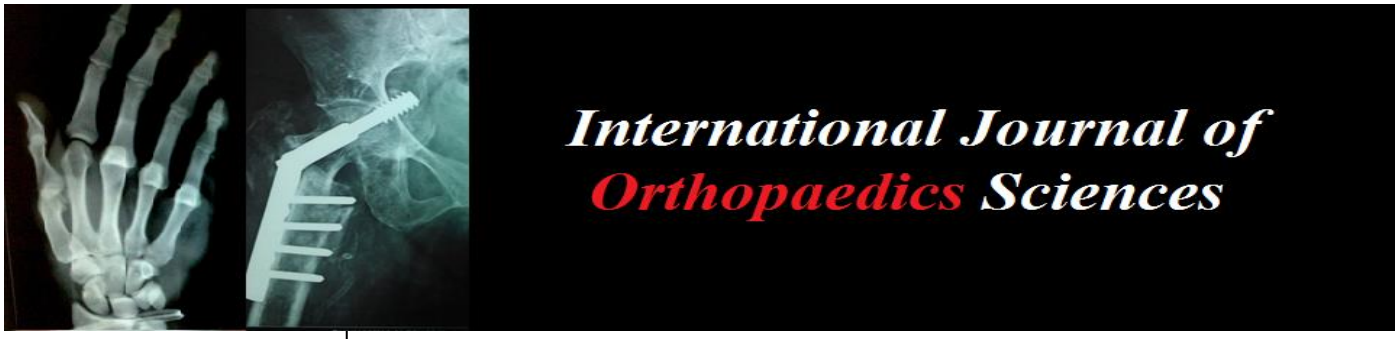

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A study on clinical efficacy and safety of percutaneous ultrasound guided carpal tunnel release in carpal tunnel syndrome

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Abstract
Objective: Surgical release provides immediate pain relief in patients with carpal tunnel syndrome not responding to the conservative management. The aim of this study is to evaluate the clinical efficacy and safety of ultrasound guided percutaneous carpal tunnel release (PCTR) and 3 months clinical results of sectioning of transverse carpal ligament and median nerve decompression after ultrasound guided PCTR surgery.
Methods: This was a prospective study of 30 patients with the carpal tunnel syndrome conducted between May 1, 2022, to May 31, 2023, with the follow-up period of 3 months. The Boston carpal tunnel questionnaire was administered at baseline, 1 and 3 months after release.
Results: Our study included 13 males and 17 females, with the right side being more commonly affected in 18 individuals. The mean age of the patients was 48.4 ranging from 33 to 70 years. The average time taken for the surgery was 6.3 minutes ranging from 4 to 9 minutes. The scar lengths varied from 3.0 mm to 6.0mm. The BCTQ symptom severity score was decreased from a mean score of 3.4 preoperatively to 1.3 at 3 months postoperatively. The functional status scores were decreased from a mean of 3.2 preoperatively to 1.2 at 3 months after release. The mean VAS score was 7.3 before release was improved to 1.2 at 1 month after release. MRI showed a complete section of TCL in all patients and nerve decompression in 100% of patients. No complications were noted.
Conclusion: Percutaneous ultrasound guided carpal tunnel release can be safely used to section the TCL, decompress the median nerve, and reduce self-reported symptoms.

Keywords: Carpal tunnel syndrome, carpal tunnel release, transverse carpal ligament, minimally invasive surgical procedures.

Introduction
Carpal tunnel syndrome is the most common nerve entrapment syndrome, and it is caused by compression of the median nerve in the carpal tunnel at the level of wrist. It affects 0.1 to 10% of the general population [1-3]. Females are more likely to suffer from carpal tunnel syndrome than males. Usually affects people between the ages of 40 and 50 years. Risk factors for developing carpal tunnel syndrome is multifactorial among that most common risk factors are hypothyroidism, rheumatoid arthritis, pregnancy, female sex, obesity, smoking and alcoholism. Diagnosis of carpal tunnel syndrome can be made clinically by signs and symptoms like burning pain, tingling, numbness, paraesthesia occurring in the distribution of the median nerve in the hand. Patients with atypical symptoms can be diagnosed by electrodiagnostic tests like nerve conduction study and electromyography. Sometimes radicular symptoms of cervical spondylosis may confuse the diagnosis and coincide with carpal tunnel syndrome. Treatment for carpal tunnel syndrome includes non-surgical and surgical techniques. The non-surgical treatment for carpal tunnel syndrome includes rest, splinting, physiotherapy and corticosteroid injections. However non-surgical methods don't provide sufficient pain relief in the patient suffering from carpal tunnel syndrome. Surgical technique provides immediate pain relief in most of the patients. Various surgical techniques include open carpal tunnel release (OCTR), endoscopic carpal tunnel release (ECTR), and ultrasound-guided percutaneous carpal tunnel release.

Regardless of the surgical technique, the main goal of the carpal tunnel release is to transect the transverse carpal ligament and avoiding injuries to the surrounding neurovascular structures. Open carpal tunnel release was performed with larger skin incision of 3 to 5 cm. Recently carpal tunnel release techniques have continuously evolved to reduce the incision size, reducing the postoperative pain and promoting faster recovery [4]. Currently available carpal tunnel release include open carpal tunnel release can be performed via 3 to 5-cm of palmar incision, mini-open carpal tunnel release via a 1 to 3-cm skin incision, endoscopic carpal tunnel release via 1 to 2 cm incision and ultrasound guided percutaneous carpal tunnel release can be performed via less than 1cm skin incision [5, 6]. Although endoscopic carpal tunnel release provides faster recovery and lesser postoperative pain when compared to open release, concerns have been raised regarding the increased chance of complications due to limited visualisation of surrounding structure while transecting the transverse carpal ligament [7]. While ultrasound-guided percutaneous release gives better visualisation of surrounding at-risk structures like median nerve, ulnar nerve and vessels while transecting the ligament and also provides immediate relief from symptoms due to compression, lesser postoperative pain and faster functional recovery when compared to the other surgical techniques [8-13]. It has been reported in the reviewed literature that US-guided carpal tunnel release has a success rate of greater than 98% and no reported neurovascular injuries. The aim of this study is to evaluate the efficacy and safety of the ultrasound guided percutaneous carpal tunnel release in patients suffering from carpal tunnel syndrome who do not respond to non-surgical management.

Methods and Materials

This was a prospective study of 30 patients with carpal tunnel syndrome studied between May 1, 2022 to May 31, 2023 conducted at the Department of Orthopaedics, Saveetha Medical College, Thandalam. This study was carried out after receiving approval from the institutional review board (IRB). Patients with symptoms of carpal tunnel syndrome for more than 6 months, had a confirmed diagnosis by electrodiagnostic tests such as nerve conduction studies and electromyography, patients who had failed non-surgical treatments were included in the study. Patients who had history of previous carpal tunnel release surgery and patients not willing for the procedure and follow-up were excluded from the study. All the patients arrived at the outpatient department in our hospital and were admitted. A proper history was elicited and clinical examination was performed and documented in the case sheet. Patient was taken up to the surgery after obtaining informed consent. All the percutaneous carpal tunnel release were performed in operating room under local anaesthesia by a single surgeon well-trained in the procedure as well as ultrasonographic evaluation. Before starting the procedure, surface marking of the median nerve, ulnar nerve and vessels, transverse carpal ligament, superficial palmar arch were performed under ultrasound guidance with the high-frequency transducer (18MHz) probe. Emphasis was placed on identifying anatomical variation as well as the recurrent motor and sensory branches of the median nerve. The primary objective of the preoperative ultrasonographic evaluation is to locate the transverse safe zone for skin incision. The retrograde division of transverse carpal ligament was performed with the 3-step ultrasound-guided surgery using distal antebrachial approach. At first, a 26-gauge needle was used to infiltrate local anaesthesia into the wrist crease. A 22-gauge needle was placed right below the transverse carpal ligament, above the capitate and lunate bone, under the guidance of an ultrasound. About 3 ml of local anaesthetic agent was injected and the space between the median nerve, flexor tendons, hook of hamate and the transverse carpal ligaments was expanded and longitudinal safe zone was created. Using 15 size scalpel blade, a vertical stab incision was made at the proximal wrist crease and was pierced through the deepest fibrous layer. After that, a hook knife was advanced into the longitudinal safe zone distal to the transverse carpal ligament which was created previously. Then the hook knife was rotated to point upward, after ensuring the blade was perpendicular to the transverse carpal ligament and hooked onto the TCL then pulled up to perform the retrograde dissection. Postoperatively clinical variables were assessed which includes the evaluation of scar and complications at day 7, 1 month and 3 months. All the patients were evaluated preoperatively and postoperatively at 1 month and 3 months using the Boston carpal tunnel syndrome questionnaires and VAS score, and their scores were recorded. The BCTQ is a self-administered patient questionnaire that consists of 19 questions, that assess functional status (8 questions) and the symptoms severity (11 questions) on a 5-point scale with 1 being the best and 5 being the worst score. T_1 and T_2 weighted fat saturation MRI were performed before surgery, as well as one month and three months postoperatively. The imaging variables to look at on T_2 axial sections of MRI post-operatively at 3 months and 6 months are the degree of transverse carpal ligament sectioning (absent, partial, or complete), and the size of the distinct gap in the transverse carpal ligament. T_2 axial sections were also used to assess the median nerve. The cross-sectional area of the median nerve was measured at the level of hook of hamate, where the nerve is most compressed. Based on the nerve's position in relation to the imaginary line connecting the hook of hamate and the ridge of the trapezium, decompression of the nerve was graded. The nerve might be superficial, intermediate or deep. The nerve is graded as superficial if it is located under the line, intermediate if it crosses the line, and deep if it is located above the line. After the percutaneous carpal tunnel release, the nerve was stated to have decompressed if the nerve position was changed from deep to superficial (under the imaginary line). Statistical analysis was performed using IBM SPSS Version 24.0. Armonk, NY: IBM Corp. Continuous data were expressed as means and standard deviations (SD), while categorical variables were expressed as percentages. Comparison of categorical variables was done using the Mc Nemar test. Continuous variables were compared using Student's tests and Student's t-tests for paired samples. A P value of less than 0.05 was considered as statistically significant.

Results

30 patients of carpal tunnel syndrome treated with ulultrasound-guidedercutaneous carpal tunnel release were studied between May 1, 2022, to May 31, 2023. Our study included 13 males and 17 females (Figure 1), with the right side being more commonly affected in 18 individuals. The mean age of the patients was 48.4 ranging from 33 to 70 years. The average time taken for the surgery was 6.3 minutes ranging from 4 to 9 minutes. The scar lengths varied from 3.0 mm to 6.0mm. The mean BCTQ symptom severity score before release was 3.4, with a range of 2.6 to 4.0; however,

after release at 1 month, the mean score improved to 2.0, with a range of 1.5 to 2.6 and at three months after release, the mean BCTQ symptom severity score was 1.3, with a range of 1.0 to 1.9. The mean BCTQ functional status score before release was 3.2 ranging from 2.2 to 3.9; however, at 1 month after release, the mean score improved to 1.7, with a range of 1.2 to 2.1. A mean BCTQ functional status score was 1.2 at three months after release, with a range of 0.8 to 1.6 (Figure 2). Difference in mean scores from pre-release to 3 months post-release in BCTQ-SS and BCTQ-FS was 2.1 and 2.0 respectively (Table 1). The mean VAS score before release was 7.3 ranging from 6 to 9, whereas mean VAS score at 1 month post-release was 2.1 ranging from 1 to 3. At 1 week and one month after release, no complications were seen. Three patients developed mild paraesthesia at 3 months. MRI results at 1 months and 3 months follow-ups revealed that all patients had a complete transection of the transverse carpal ligament. The average measurement of the distinct gap in the transverse carpal ligament was 4.7±1.4 mm. The mean cross-sectional area of the median nerve at the level of the hamate bone was 7.8±3.2 mm before US-guided carpal tunnel release and improved to 12.9±3.4 mm after release. None of our patients were lost to follow-up. (Table 2).

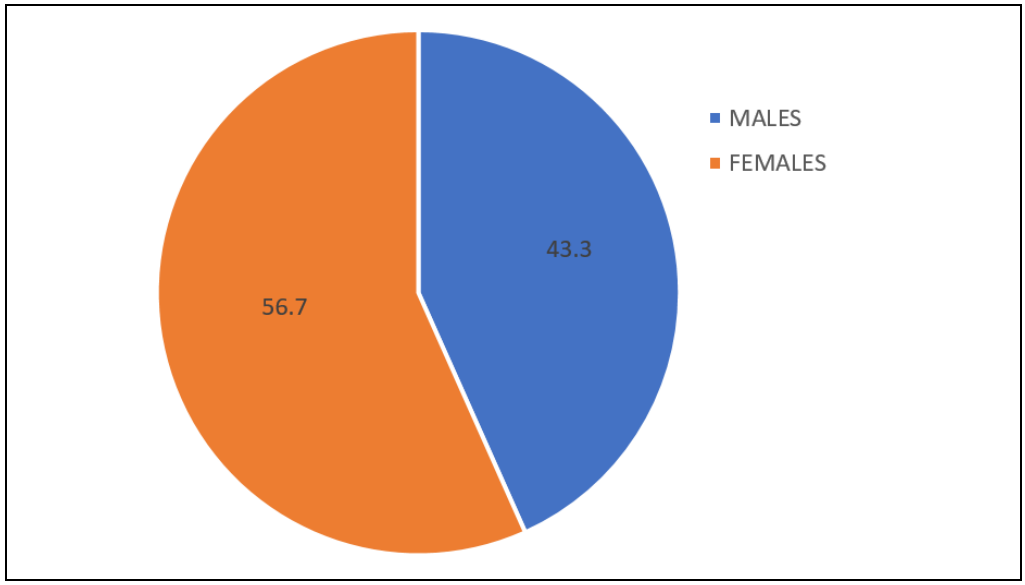

Fig 1: Distribution of gender of the study participants.

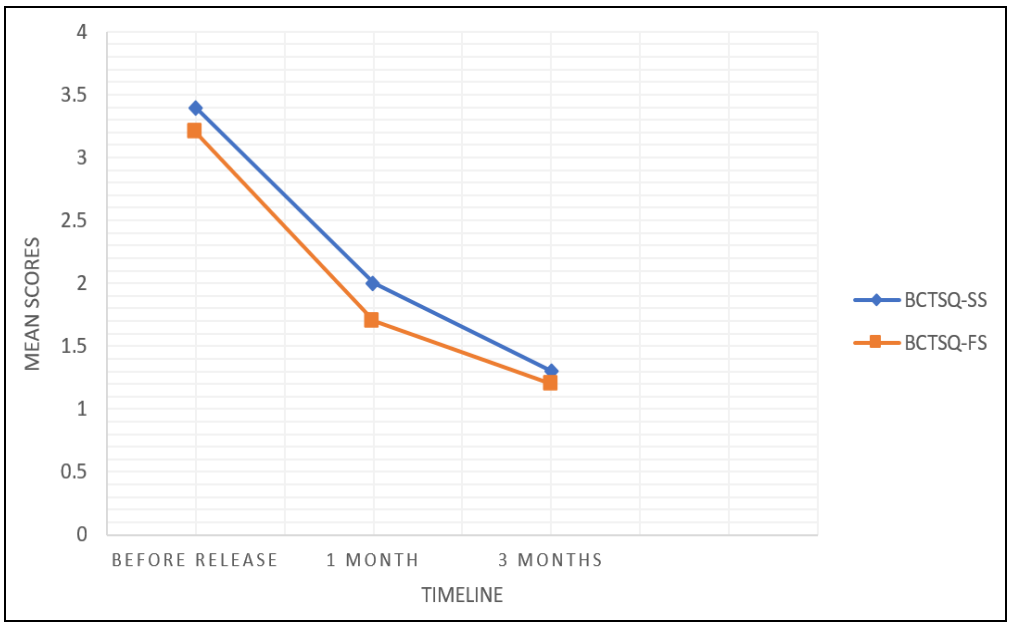

Fig 2: Mean scores at before release, 1 month and 3 months after release.

Table 1: Mean BCTQ scores (n=30)

Period	Symptoms severity (Range)	Functional status (Range)
Pre-release	3.4 (2.6-4.0)	3.2 (2.2-3.9)
1 month post-release	2.0 (1.5-2.6)	1.7 (1.2-3.9)
3 months post-release	1.3 (1.0-1.9)	1.2 (0.8-1.6)
3 months change in scores	2.1	2.0

Table 2: Patient Demographic details and data

S. No	Age	Sex	Side	Time taken for procedure in Mins	Vas Score		BCTSQ-SS			BCTSQ-FS		
					Pre-Release	Post-Release	Pre-Release	1 Month Post Release	3 Months Post Release	Pre Release	1 Month Post Release	3 Months Post Release
1.	33	M	R	4	8	3	4.0	2.2	1.7	3.7	2.0	1.6
2.	43	F	R	7	9	3	3.8	2.1	1.4	3.5	1.8	1.4
3.	51	F	L	5	7	2	3.0	1.8	1.2	2.8	1.5	1.0
4.	35	M	R	8	6	1	3.3	1.9	1.3	3.1	1.8	1.2
5.	42	M	L	9	8	3	2.9	1.7	1.0	2.6	1.3	1.0
6.	39	F	R	7	6	1	3.8	2.6	1.5	3.2	1.9	1.3
7.	66	M	L	5	7	2	3.5	2.2	1.3	3.7	2.0	1.6
8.	49	M	R	4	6	1	2.8	1.5	1.0	2.9	1.3	1.0
9.	35	F	L	7	8	3	4.0	2.1	1.5	3.9	1.8	1.4
10.	61	F	R	5	7	2	3.3	2.0	1.2	3.2	1.4	1.1
11.	43	F	L	8	6	1	3.9	2.1	1.4	3.1	1.5	1.2
12.	58	M	R	5	7	2	4.0	2.5	1.6	3.7	2.1	1.5
13.	47	F	L	5	8	3	2.6	1.5	1.0	2.7	1.3	0.9
14.	51	F	R	5	9	3	3.7	2.1	1.4	3.2	1.8	1.3
15.	38	M	R	7	6	1	4.0	2.4	1.8	3.7	1.9	1.5
16.	55	F	L	6	8	3	3.5	1.9	1.2	3.1	1.7	1.2
17.	45	F	L	8	7	2	3.1	1.7	1.1	3.5	1.9	1.4
18.	70	M	R	7	8	3	3.7	1.9	1.2	3.0	1.2	0.8
19	52	M	L	5	7	2	3.2	1.8	1.0	2.8	1.5	1.0
20.	37	F	R	6	8	2	3.1	1.7	1.3	2.9	1.6	1.1
21.	44	M	R	8	6	1	3.9	2.1	1.4	3.5	1.9	1.2
22.	50	F	L	8	7	2	3.3	1.8	1.2	3.3	1.8	1.4
23.	43	F	R	7	8	2	4.0	2.4	1.3	3.7	1.9	1.3
24.	62	F	R	5	9	3	3.2	2.0	1.0	3.2	1.5	1.1
25.	46	M	R	7	8	3	3.6	2.4	1.5	3.1	1.8	1.2
26.	52	F	L	8	7	2	4.0	2.3	1.9	3.9	2.0	1.5
27.	39	F	R	6	6	1	3.3	2.1	1.2	3.3	1.9	1.6
28.	66	M	R	5	7	2	3.5	2.2	1.3	2.2	1.3	0.9
29.	55	F	L	8	9	3	2.9	1.8	1.0	2.6	1.6	1.2
30.	47	M	R	4	8	2	4.0	2.1	1.6	3.8	2.0	1.4

Discussion

Carpal tunnel syndrome, a most common peripheral nerve entrapment syndrome, is caused by compression of the median nerve at the base of the palm by the transverse carpal ligament (TCL). When non-surgical treatments such as rest, splinting, physical therapy, and corticosteroid injections are ineffective, the median nerve is surgically released by sectioning the TCL. In this study, we performed the retrograde division of the transverse carpal ligament with a minimally invasive ultrasound-guided percutaneous procedure in patients with moderate to severe carpal tunnel syndrome, with baseline BCTQ symptom severity and functional status scores of 3.4 and 3.3, respectively. Currently, the mini-open method is used to conduct the majority of CTRs, with predictably good results and a low complication rate. However, because of the palmar incisions used in mini-open CTR, healing may take longer and necessitate significant changes to hand and upper limb function [4, 7]. Reduced procedural trauma and smaller incision sizes seem to hasten recovery. Studies demonstrated that individuals treated with endoscopic or US-guided CTR recover more quickly and may experience less postoperative pain than those treated with mini-open CTR [14].

Mini-open CTR uses smaller palmar incisions, which may make the treatment more technically difficult and still necessitate short-term avoidance of palmar pressure. Endoscopic CTR is more challenging to conduct outside of the operating theatre, despite it seems to promote a quicker recovery and may allow for rapid palmar weight bearing. In addition to being more expensive than mini-open CTR, endoscopic CTR has been linked to a higher risk of neuropraxia, most likely as a result of the relatively large cannula and lack of complete visualization of the surrounding structures [7]. With real-time visualisation of all relevant structures, ultrasound-guided CTR offers all the benefits of endoscopic CTR while enabling the surgeon to execute the surgery in an operating room or outpatient setting. The last twenty years have seen advancements in ultrasound-guided CTR. The most recent development in this field is ultrasound-guided CTR employing enhanced transverse safe zone control, which is unique in that it allows the user to reach the carpal tunnel through a small forearm incision and effectively cut the TCL in a variety of practice settings.

In our study, magnetic resonance imaging results 1 month after the procedure revealed that complete sectioning of the transverse carpal ligament along their entire length in all 30 patients. An indicator of decompression that can be measured by MRI is the change in nerve position relative to the line connecting the hook of hamate and the ridge of the trapezium. Better decompression is indicated by more superficial placement of nerve. In our study, after the procedure, the nerve location became more superficial in 82% of patients.

Campagna *et al*. studied 47 patients with carpal tunnel syndrome who had undergone open surgical release of the median nerve in 2009 and revealed that insufficient change in nerve position was associated with recurrence of carpal tunnel syndrome. Thirty-five patients out of 47 demonstrated electromyographic evidence of recurrent carpal tunnel syndrome. The remaining 12 patients lacked electrophysiologic evidences of recurrent carpal tunnel syndrome [15]. Therefore, we may assume that there won't be many recurrences within our patient population. There were no intra or post-operative complications among the patients. Neither the clinical evaluations nor the 1-month MRIs

revealed any nerve-related injury. Other trials that employed ultrasound to guide the surgery likewise reported positive clinical outcomes and no clinical signs of nerve injury.

In our study, CTR was performed by ultrasound-guided minimally invasive percutaneous technique, and the scar length ranged from 3.0 to 6.0 mm. Small incision points imply less infection and less potential for scar pain. Consistent with this observation, no pain or infections were reported in our study. In contrast, Atroshi *et al*. studied 128 patients with carpal tunnel syndrome in 2006, with 63 allocated to endoscopic surgery and 65 allocated to open surgery. Pain in the scar or proximal palm was less prevalent after endoscopic surgery than after open surgery, with more than 50% of patients reporting scar pain [16].

Nakamichi *et al*. studied 74 hands of 65 women with idiopathic carpal tunnel syndrome in 2010. Thirty-five hands of 29 women had the PCTR (incision, 4 mm), and 39 hands of 36 women had the mini-OCTR (incision, 1-1.5 cm). Patients reported less scar sensitivity with a 4 mm incision from PCTR than with a 10-15 mm incision from mini-OCTR [17].

We admit that the study has several limitations. First, neither the patients nor the assessors were blinded to the intervention, and there was no comparative or control group. Second, three months following the procedure, we are reporting our interim results. Although this time frame is brief, it is sufficient to document the safety of US-guided CTR with increased transverse safe zone control, as employed to treat our patients. TCL sectioning, nerve decompression, and patient-reported symptoms were used to assess the efficacy. Third, our sample size was small and only included patients treated by a single operator.

Conclusion

As a result, we conclude that ultrasound-guided PCTR can be used safely and efficiently to section the transverse carpal ligament and decompress the median nerve in patients with carpal tunnel syndrome by surgeons with expertise in advanced US-guided procedures.

Declarations

Funding
None

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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