ULTRASONOGRAPHY IN THE EVALUATION OF MEDIAN NERVE IN CARPAL TUNNEL SYNDROME PRE AND POST OPERATIVELY AND ITS CORRELATION WITH CLINICAL SYMPTOMS

[1]Dr. Sheima M, [2]Dr.Josey Verghese, [3]Dr.Beenamol, [4]Dr. Chinchu, Dr.Vaishak

Dept of Radidiagnosis.
Government TD Medical College, Alappuzha, Kerala.

STRUCTURED ABSTRACT

Introduction: Carpal tunnel syndrome (CTS) is the most common upper extremity compression neuropathy and results from median nerve compression beneath the transverse carpal ligament. The current reference standard for CTS diagnosis consists of evaluating clinical symptoms and their location in combination with abnormal median nerve function based on nerve conduction studies. Recent advances in high- frequency and duplex ultrasound have improved its ability to visualize and grade abnormalities, thus increasing the scope for less expensive, non-invasive, real-time assessment of median nerve in carpal tunnel syndrome.

Objectives: To determine the correlation between clinical and ultrasonographic findings in median nerve cross sectional area in patients with carpal tunnel syndrome before and 12 weeks after surgery.

Materials and Methods: A longitudinal study of thirty-seven patients of Govt. T. D. Medical College Alappuzha, diagnosed as carpal tunnel syndrome and planning for surgery, were subjected to ultrasonographical evaluation of median nerve cross sectional area at the carpal tunnel inlet, before and 12 weeks after surgery and the results were correlated with clinical symptoms using BCTQ scores.

The study was conducted over a period of 18 months.

Results: In our study, the mean CSA of median nerve in carpal tunnel in CTS patients reduced from 13.0 to 9.16 mm^2, the mean BCTQ-S score from 2.5 to 1.35 and mean BCTQ-F from 2.43 to 1.38, 12 weeks after surgery.

Conclusion: The median nerve CSA measurement in CTS by ultrasonography predict preoperative symptom severity and functional disabilities. But, postoperative reduction in median nerve swelling was not found to be associated with postoperative reduction in clinical symptoms or functional disabilities. Hence, our study concludes that high-frequency ultrasound examination of the median nerve can be considered as an alternative diagnostic modality for the evaluation of CTS.

Keywords: Carpal tunnel syndrome, median nerve cross sectional area, ultrasonography, BCTQ score

INTRODUCTION

Carpal tunnel syndrome (CTS) is the most common upper extremity compression neuropathy and results from median nerve compression beneath the transverse carpal ligament. This syndrome most often affects middle aged females. The carpal tunnel is bounded by the hook of hamate and pisiform bone medially, the scaphoid tubercle and trapezial ridge laterally and the carpal bones arching dorsally. The roof of the carpal tunnel is formed by the flexor retinaculum, consisting of the deep forearm fascia proximally, the transverse carpal ligament over the wrist, and the aponeurosis between the thenar and hypothenar muscles distally. In the carpal tunnel, median nerve is the most palmar structure. Lying deep to the median nerve in the carpal tunnel are the nine long finger and thumb flexor tendons.

Main symptoms are numbness, tingling, paresthesia and pain in the distribution of median nerve in hand. Symptoms are exacerbated by strenuous gripping, repetitive flexion and extension of the wrist, or exposure to vibration and are worse at night.

Several diagnostic methods routinely applied in CTS include nerve conduction studies (NCS) and imaging techniques in addition to clinical signs and symptoms, such as the Tinel sign (percussion over the median nerve elicits dysesthesia) and Phalen sign (dysesthesia after wrist flexion). The current reference standard for CTS diagnosis consists of evaluating clinical symptoms and their location in combination with abnormal median nerve function based on NCS.

Even though non-invasive, NCS may be painful and discomfortable to the patient. Ultrasound is widely available, inexpensive, non-invasive and can exclude anatomical variants such as bifid median nerve and space-occupying lesions, such as ganglia and neural tumors.

The most commonly used ultrasonographic diagnostic parameter is median nerve cross-sectional area (CSA) at the carpal tunnel inlet. Its use is based on the fact that median nerve is enlarged due to edema and fibrous tissue proliferation, proximal to the site of compression in the carpal tunnel.

The correlations between Boston carpal tunnel questionnaire (BCTQ) scores and median nerve CSA enlargement in CTS was demonstrated by several authors and suggested CSA can predict symptom severity, and others have also reported that CSA has significantly reduced after carpal tunnel release. The modifications in the cross-sectional area of median nerve after surgical release in CTS patients can predict the clinical and electrophysiological outcomes.

Recent advances in high-frequency and duplex ultrasound like transducer technology, better image resolution, post-processing capability, signal strength and spectral analysis capabilities have improved its ability to visualize and grade

abnormalities, thus increasing the scope for less expensive, non-invasive, real-time assessment of median nerve in carpal tunnel syndrome.

Sonography is comparable to electrodiagnostic study in the diagnosis of CTS and can be considered as initial test of choice for patients suspected of having CTS.

AIM AND OBJECTIVES

To determine the correlation between clinical and ultrasonographic findings in median nerve cross sectional area in patients with carpal tunnel syndrome before and 12 weeks after surgery.

MATERIALS AND METHODS

STUDY DESIGN

Longitudinal study

STUDY SETTING

Department of Radiodiagnosis and Department of Orthopaedics, Govt. TD Medical College, Alappuzha.

STUDY POPULATION

Patients with symptoms of CTS (planning for surgery) referred from Orthopaedics department to department of Radiodiagnosis, Govt. TD Medical College, Alappuzha. **STUDY PERIOD**

January 2019 to June 2020

SAMPLE SIZE AND SAMPLING TECHNIQUE

$$n = \frac{(Z_{1-\beta} + Z_{1-\alpha/2})^2}{\frac{1}{2}\ln\left(\frac{1+r}{1-r}\right)^2}$$

r = correlation coefficient [0.38 - taken from a previous study conducted by Jae Kwang Kim et al][135]

$Z_{1-\alpha/2}$ = Desired confidence level 1-β = Power = 80

α error = 5

According to the formula, sample size = 37

All patients who are clinically detected to have CTS and who come under inclusion criteria during the study period will be studied.

INCLUSION CRITERIA

- Age >18 with clinical suspicion of carpal tunnel syndrome and planning for surgery
- Unilateral or bilateral

EXCLUSION CRITERIA

- Patients with tumors in wrist
- Patients with trauma to wrist
- Patients with wrist surgery
- Patients who are not willing to participate in the study

DATA COLLECTION TOOLS

Pretested semi-structured proforma will be used for data collection and ultrasound will be done with high resolution transducer ML6-15 of VOLUSON E8 from GE health care.

STUDY PROCEDURE

Median nerve CSA will be measured at the proximal inlet of the carpal tunnel using pisiform bone as a reference; before and 3 months after surgery when they come for orthopaedic follow up.

TECHNIQUE

Patients were seated in front of the examiner with hands kept on the lap of the patient over the pillow in the supine and neutral wrist position.

Systematic scanning with very little pressure and by applying thick layer of gel along the course of the median nerve in and proximal to the carpal tunnel was carefully scanned with the transducer in both the transverse and longitudinal planes to investigate the presence of median nerve compression criteria.

Sonographic examinations included measurement of cross-sectional area of the median nerve at the tunnel inlet by using digital calipers at the time of the examination. Sonograms were digitally saved.

IMAGE ANALYSIS

The normal median nerve is a bundle of hypoechoic nerve fascicles surrounded by hyperechoic epineural connective tissue, all of which is encased in the hyperechoic perineural sheath. Nerve swelling was defined as an enlargement of the cross-sectional area of the nerve to 0.11 cm^2 or more within or proximal to the carpal tunnel. The cross- sectional area of the nerve was defined as the area of the nerve bundles in the perineural fibrous tissue. All measurements were rounded to the nearest 0.01 cm^2.

BOSTON CARPAL TUNNEL QUESTIONNAIRE (BCTQ)

Patients will be asked to complete the BCTQ preoperatively and at 12 weeks postoperatively. The BCTQ consists of 2 scales that evaluate symptoms (BCTQ-S) and function (BCTQ-F). BCTQ-S consists of 11 questions that address the severity and frequency of pain, numbness, weakness and loss of dexterity. Five possible responses are offered for each question and are scored from 1 (no symptom) to 5 (severe). Results are expressed as the average scores of the 11 responses. BCTQ-F is composed of 8

questions that address difficulties in performing daily tasks. Responses are also scored using a 5-point scale (1 to 5, where 5 indicates greatest difficulty) and again results are averaged.

DATA ENTRY

Data would be entered in Microsoft excel and analyzed using SPSS.

DATA ANALYSIS

The Student t-test will be used to compare median nerve CSAs and BCTQ scores at the 2 time points (pre-operatively and at 12 weeks post-operatively). Pearson's correlation analysis will be used to investigate the relationship between BCTQ scores and median nerve CSAs and the relationship between changes in BCTQ scores and median nerve CSAs at the 2 time points. Results are presented as mean ± SD, and statistical significance was accepted for P-values of < 0.05.

RESULTS

After the completion of the study, the following observations were made from the analysis of the study variables. Besides the comparison of the median nerve cross sectional area with the BCTQ scores, several other variables were also analysed which provided additional valuable information.

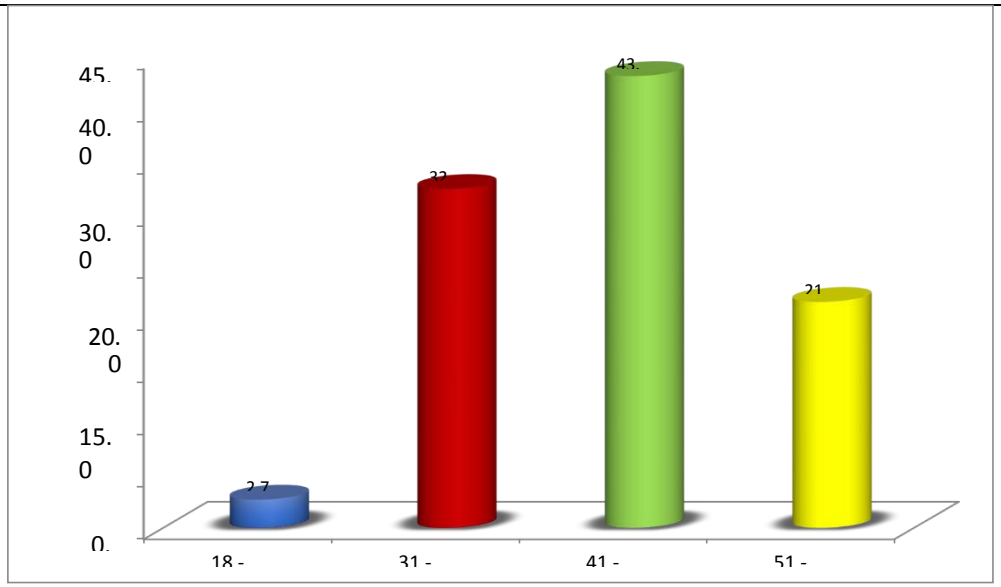
Age distribution of patients

In our study, the youngest patient was aged 29 years and oldest was 60 years. The age distribution in the patient population studied was between 18-60 years with the most number (43.2%) of patients falling in the group 41-50 years and least (2.7%) in the age group of 18-30 years.

This suggests the prevalence of CTS in middle to elderly age group.

Percentage distribution of the sample according to age

Age	Count	Percent
18 - 30	1	2.7
31 - 40	12	32.4
41 - 50	16	43.2
51 - 60	8	21.6



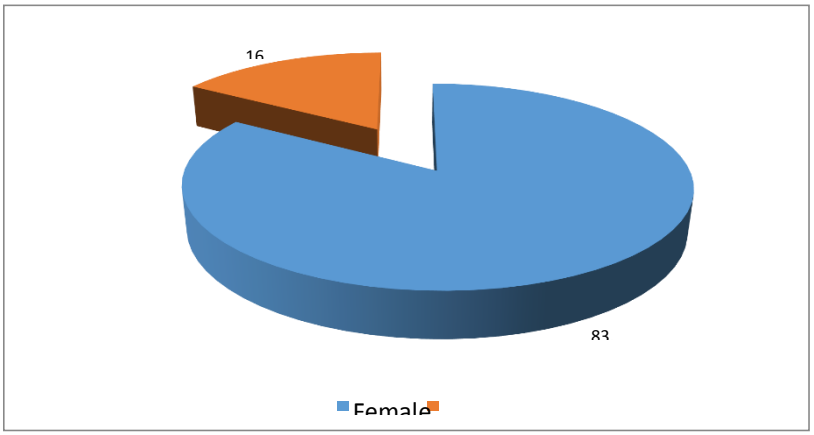
Bar chart showing percentage distribution of the sample according to age

Sex distribution of patients

Among the 37 patients who were enrolled in the study, 83.8 % were female, which is in comparison to previous literature which describes CTS as having a female preponderance.

Percentage distribution of the sample according to sex

Sex	Count	Percent
Female	31	83.8
Male	6	16.2



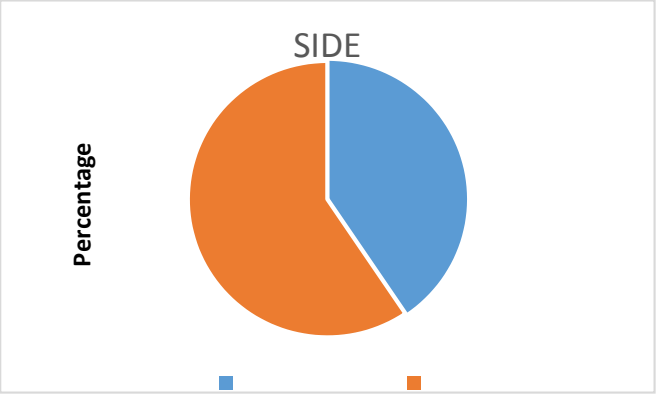
Pie chart showing percentage distribution of the sample according to sex

Hand dominance

Out of the total 37 subjects involved in the study, 15 wrists studied were on the non-dominant hand and 22 were on the dominant side.

Table 5: Percentage distribution of the sample according to hand dominance

SIDE	NUMBER OF CASES
Non-dominant	15
Dominant	22



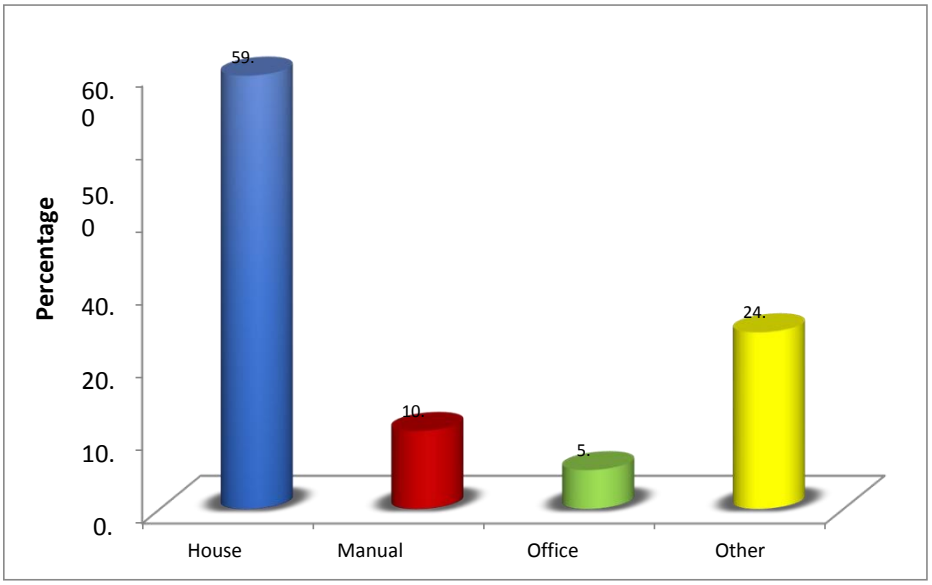
Pie chart showing percentage distribution of the hand dominance

Occupation

Majority of the patients (59.5%) were doing only household work, while a mere 5.4% were involved in office work.

Table 6: Percentage distribution of the sample according to occupation

Occupation	Count	Percent
House wife	22	59.5
Manual labourer	4	10.8
Office work	2	5.4
Others	9	24.3



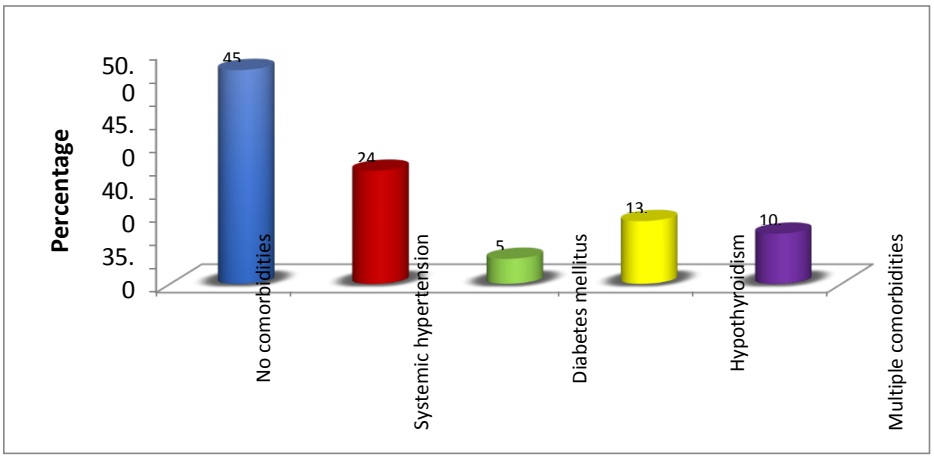
Bar chart showing percentage distribution of the sample according to occupation

Comorbidities

Out of the 37 enrolled in the study, 17 were having no comorbidities, 5 having only hypothyroidism as an underlying condition and 4 were having multiple comorbidities.

Percentage distribution of the sample according to comorbidities

Comorbidities	Count	Percent
No comorbidities	17	45.9
Systemic hypertension	9	24.3
Diabetes mellitus	2	5.4
Hypothyroidism	5	13.5
Multiple comorbidities	4	10.8



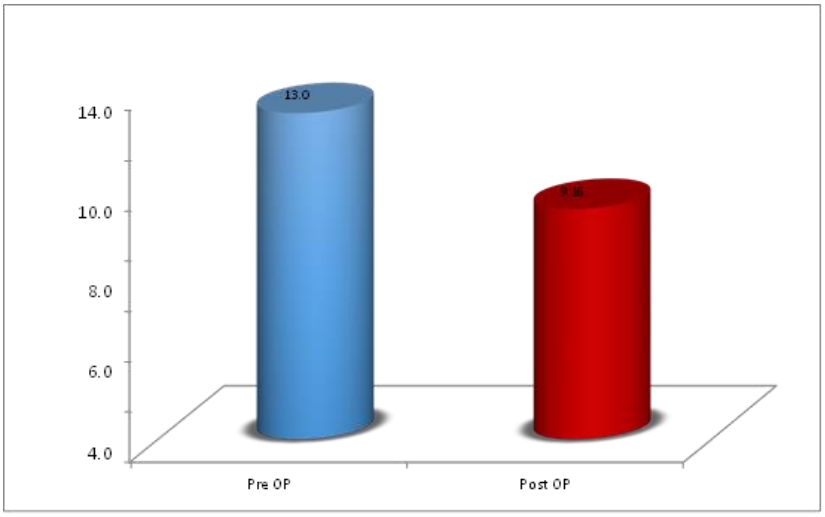
Bar chart showing percentage distribution of the sample according to comorbidities

Cross sectional area

In our study, the mean cross sectional area of the median nerve before the surgery was 13 mm^2 and at 12 weeks post-operatively, it decreased to 9.16 mm^2.

Mean median nerve CSA before and after surgery.

	Mean
PRE OPERATIVE	13.0
POST OPERATIVE	9.16



Bar chart showing mean median nerve CSA before and after surgery

Table 9: Effectiveness of change in CSA as a result of surgery

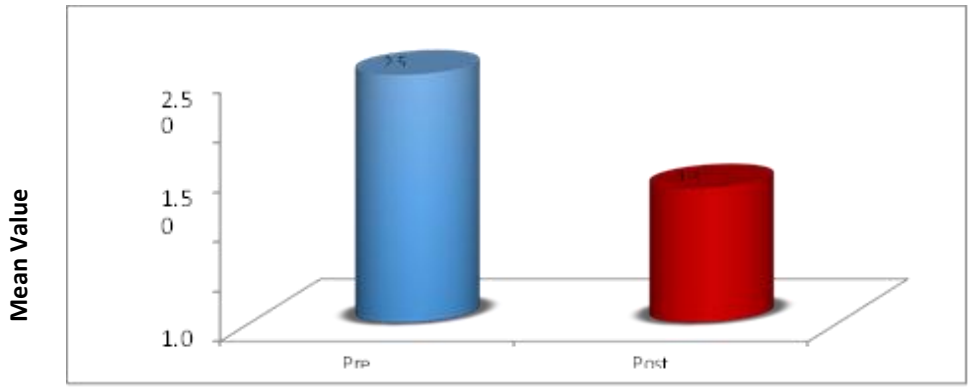
CSA	Mean	SD	N	Mean Difference	Paired t	p
Pre-op Post-op	13.0	1.6	37	3.81	15.39	p<0.01
	9.16	1.34	37			

BCTQ-S score

In our study, the mean BCTQ-S score before the surgery was 2.50 and at 12 weeks post- operatively, it decreased to 1.35.

Mean BCTQ-S score before and after surgery

	MEAN
PRE-OPERATIVE	2.50
POST OPERATIVE	1.35



Bar chart showing mean BCTQ-S score before and after surgery

Table 11: Effectiveness of change in BCTQ-S as a result of surgery

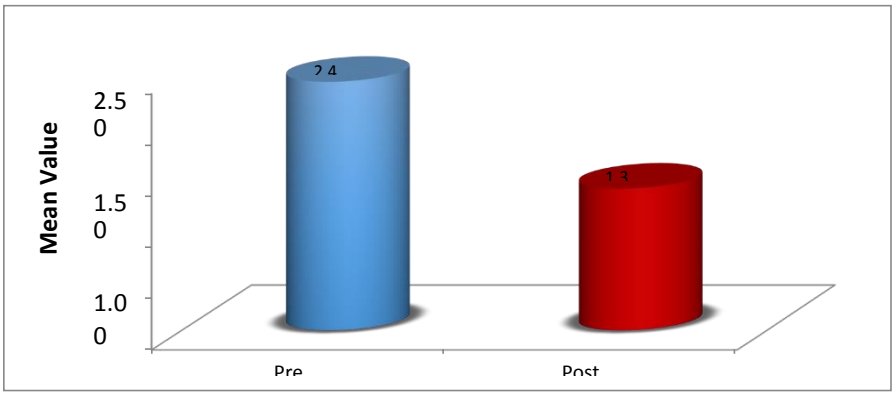
BCTQ-S	Mean	SD	N	Mean Difference	Paired t	p
Pre-op	2.50	0.50	37	1.15	14.09	p<0.01
Post-op	1.35	0.29	37			

BCTQ-F score

In the current study, the mean BCTQ-F score before the surgery was 2.43 and the 12 weeks postoperative score reduced to 1.38.

Mean BCTQ-F score before and after surgery

	MEAN
PRE OPERATIVE	2.43
POST OPERATIVE	1.38



Bar chart showing mean BCTQ-F score before and after surgery

Table 13: Effectiveness of change in BCTQ-F as a result of surgery

BCTQ-F	Mean	SD	N	Mean Difference	Paired t	p
Pre-op	2.43	0.43	37	1.05	13.81	p<0.01
Post-op	1.38	0.29	37			

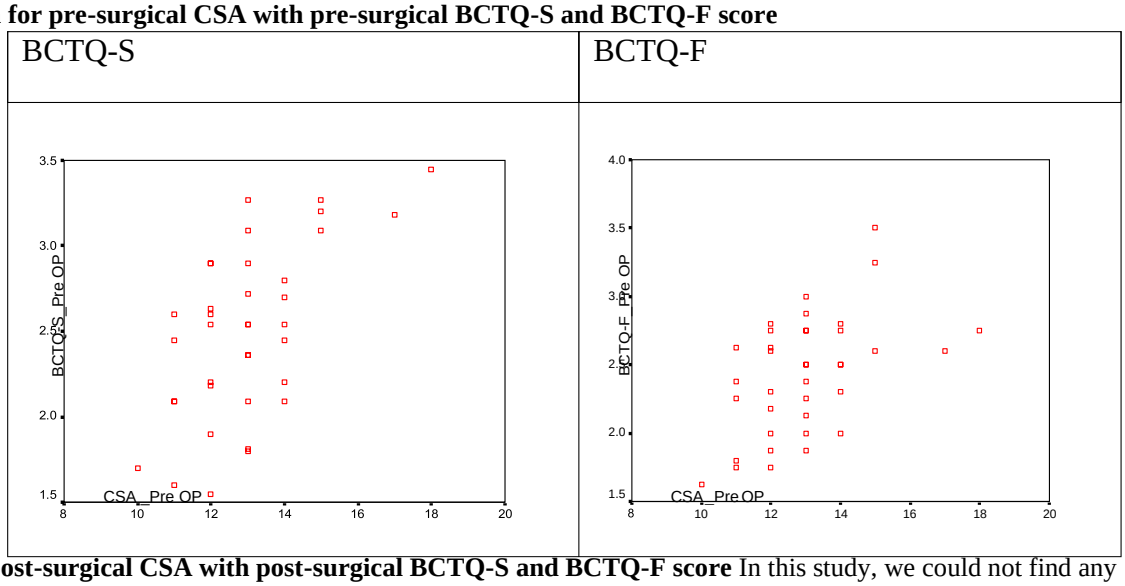
Correlation of pre-surgical CSA with pre-surgical BCTQ-S and BCTQ-F score In our study, it is found that there is moderate positive correlation between pre-surgical CSA and pre-surgical BCTQ scores.

Correlation of pre-surgical CSA with pre-surgical BCTQ-S and BCTQ- F score

	r	p
BCTQ-S	0.612**	< .01
BCTQ-F	0.501**	0.002

**: Significant at 0.01 level

Scatter diagram for pre-surgical CSA with pre-surgical BCTQ-S and BCTQ-F score

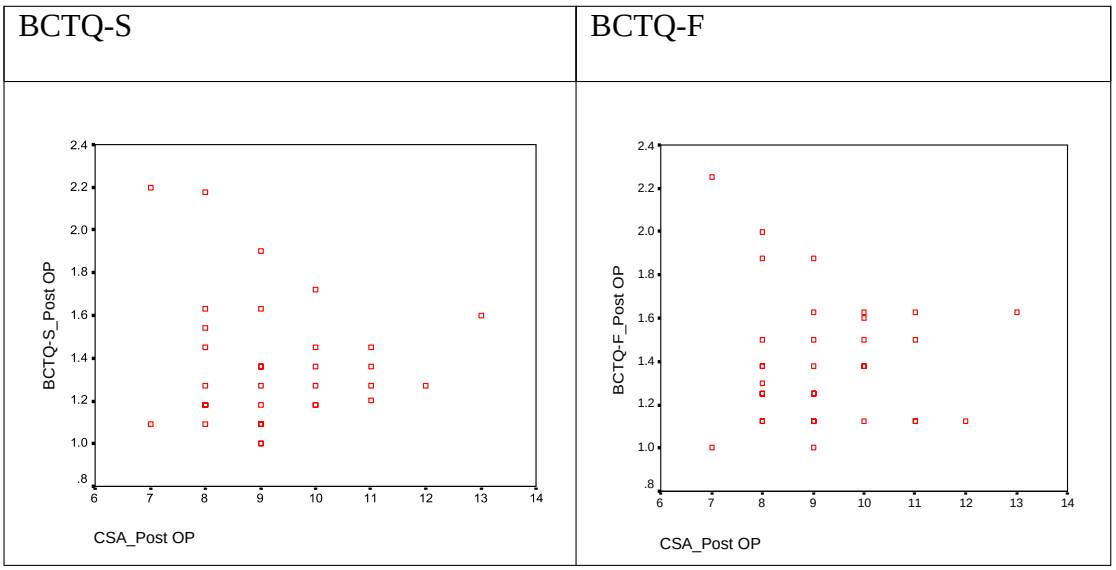


Correlation of post-surgical CSA with post-surgical BCTQ-S and BCTQ-F score In this study, we could not find any correlation between post-surgical CSA and post- surgical BCTQ scores.

Correlation of post-surgical CSA with post-surgical BCTQ-S and BCTQ-F score

	r	p
BCTQ-S	-0.059	0.731
BCTQ-F	-0.071	0.674

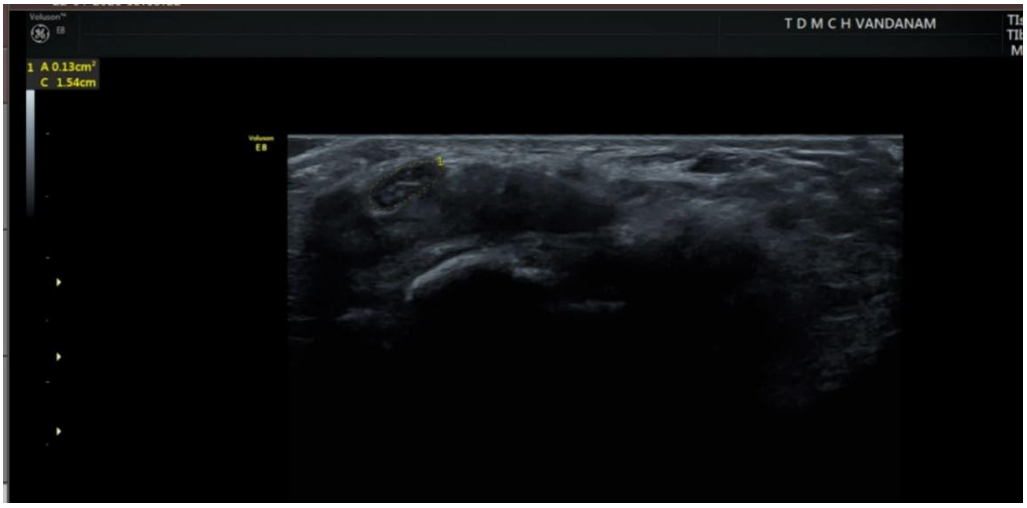
Figure 16: Scatter diagram for post-surgical CSA with post-surgical BCTQ-S and BCTQ-F score



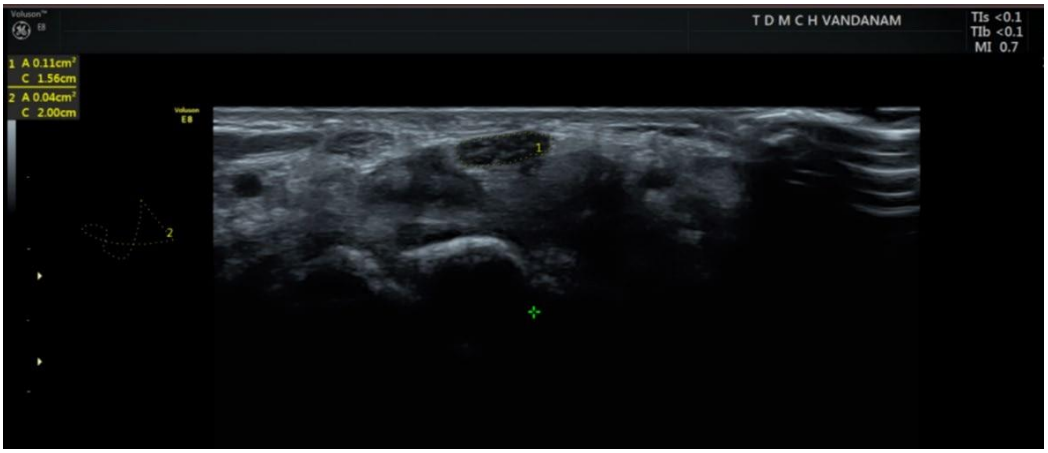
Statistical Tests Used

Categorical and quantitative variables were expressed as frequency (percentage) and mean ± SD respectively. Paired t test was used to find the changes in selected parameters after surgery. Karl Pearson correlation was used to find out the relationship of CSA and BCTQ with selected variables. For all statistical interpretations, $p<0.05$ was considered the threshold for statistical significance. Statistical analyses was performed by using a statistical software package SPSS, version 20.0

IMAGE GALLERY



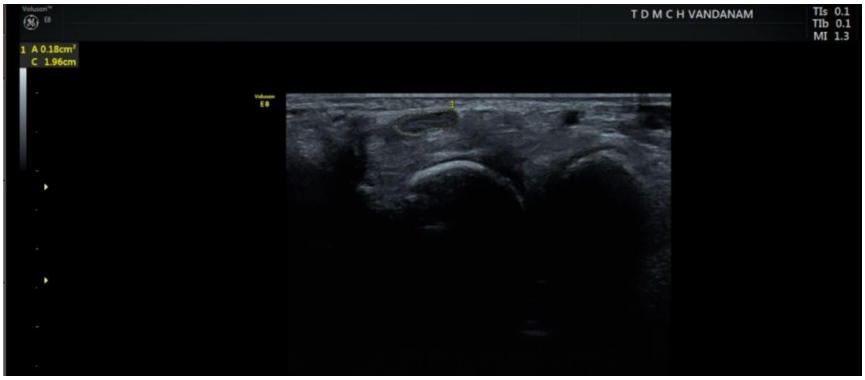
Pre-op median nerve CSA



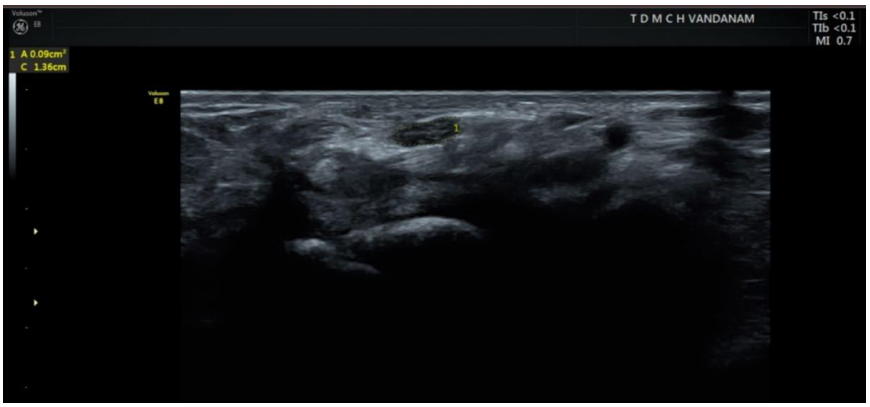
Post-op median nerve CSA

Figure 17: Transverse sonogram showing (a) pre-op median nerve CSA and

(b) post-op median nerve CSA

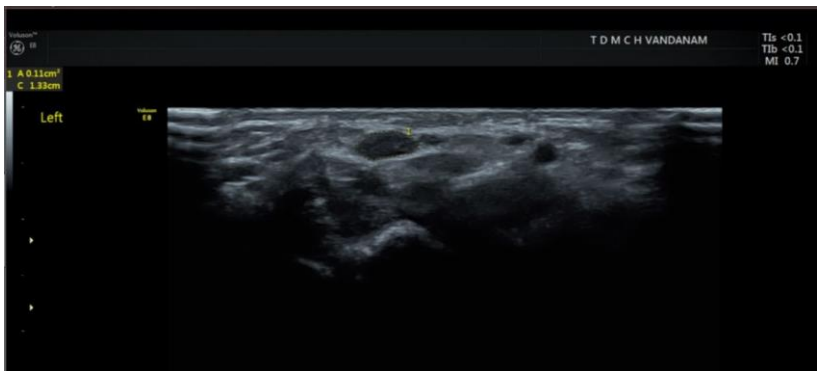


Pre-op median nerve CSA



Post-op median nerve CSA

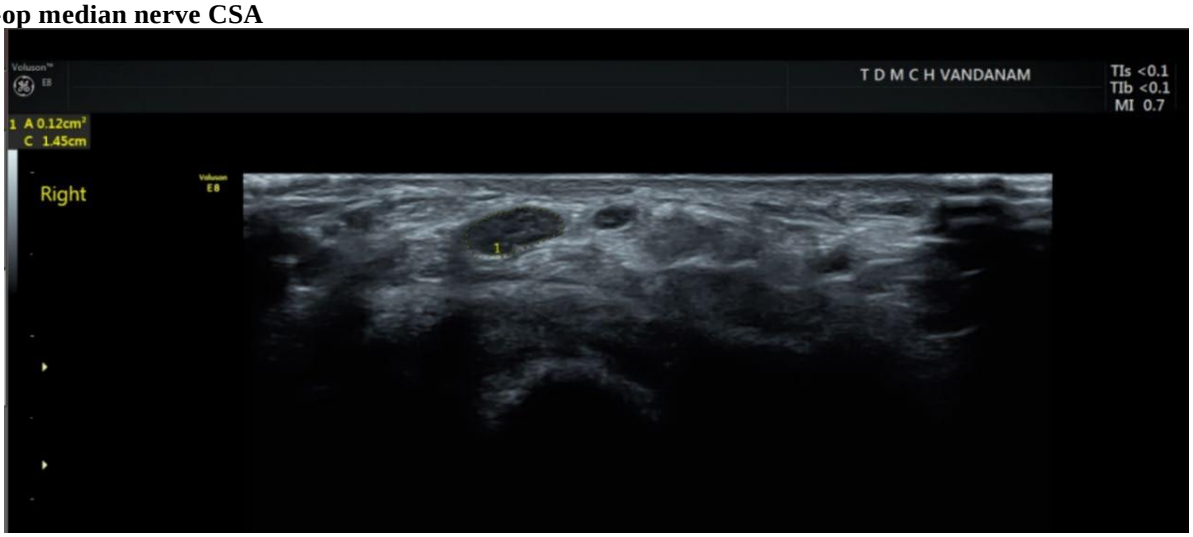
Figure 18: Transverse sonogram showing (a) pre-op median nerve CSA and (b) post-op median nerve CSA



Pre-op median nerve CSA

Post-op median nerve CSA

Figure 19: Transverse sonogram showing (a) pre-op median nerve CSA and (b) post-op median nerve CSA



Pre-op median nerve CSA

Post-op median nerve CSA

Figure 20: Transverse sonogram showing (a) pre-op median nerve CSA and (b) post-op median nerve CSA

DISCUSSION

In the current study, the role of ultrasonography in the evaluation of median nerve in CTS was evaluated by measuring the median nerve CSA pre-operatively and 12 weeks post-operatively and is correlated with clinical symptoms.

Maximum number of patients in our study were in the age group between 41 and 50 years (43.2%), followed by the age group between 31 and 40 years (32.4%). According to the study by Tay L B et al, more than two-thirds of the patients in their study were between 40 and 70 years of age[136].

The present study showed a female preponderance in carpal tunnel syndrome patients. Of 37 patients, 83.8 % were females and 16.2% were males. According to the study by Mondelli et al, carpal tunnel syndrome is the most commonly encountered entrapment neuropathy with an incidence more in women than men[137]. In the studies done by Phalen et al[138], and Radecki P et al[139] 3-4 times higher incidence of carpal tunnel syndrome in females have been quoted. The present study showed almost similar findings as the above studies.

Majority of cases having symptoms were housewives engaged in household works (59.5%) and 10.8 % cases were manual labourers. Experimental studies have shown a higher incidence of CTS in workers who are involved in high force and repetitive work compared to workers who are not. Silverstein BA et al[23] noted a prevalence of 5.6% among workers in high force and high repetitive jobs compared to 0.6% among workers in low force and low repetitive jobs.

Majority of patients (45.9%) had no obvious cause, were considered to be idiopathic. Most of the idiopathic CTS patients had CTS in their dominant hands. Reinstein L et al have stressed that 'idiopathic CTS' occurs slightly more frequently in the dominant hand[140].

Diabetes alone and along with other comorbidities comprise 16.2 % of patients. In the study by Urkude R et al diabetes mellitus was present in 13.4% patients with CTS[141]. Diabetes mellitus is a very commonly occurring systemic disease that is also associated with the presence of CTS. Carpal tunnel syndrome develops in 6% of all Type 2 diabetes sufferers. Median nerve

compression is only one of its many complications. According to Dellon et al**,** in diabetic patients, the median nerve, as in other peripheral nerves, is already involved by a polyneuropathy, and is more easily subject to compression[142].

In our study, hypothyroidism was seen in 13.5% patients with CTS. Thyroid diseases such as hypothyroidism and hyperthyroidism can cause CTS. In hypothyroidism, the swelling of the tissue inside the carpal canal causes the syndrome. CTS can be the first sign of hypothyroidism (Golding DN) [143]. In the study by Stevens JC et al[9] 5.2% of patients with CTS had hypothyroidism at the time of presentation.

Nakamichi and Tachibana directly compared the measurements of the median nerve obtained sonographically with the measurements found in anatomical cross-sections in cadaver limbs[144]. Ultrasound is a precise method for determining these measurements. This was later confirmed by Kamolz et al[145].

The sensitivity of the cross sectional areas ranged from 48% to 89% [17-19, 21, 30, 116, 119, 121-124, 171, 172] and the CSA cut off at which the value was considered abnormal varied from 9 mm^2 [17, 19] to 15 mm^2 [28]. In our study, the cut off for an abnormal nerve was taken as 0.11 cm^2 at the inlet.

Many studies have been reported on postoperative CSA changes in the median nerve after carpal tunnel release surgery, and most showed median nerve CSAs notably decreased at 12 weeks post operatively, which concurs with our findings. In our study, significant reduction in median nerve swelling was noted 12 weeks after surgery.

The correlation between preoperative BCTQ scores and preoperative median nerve CSAs has been previously reported in many studies. However, it is seen that only few have studied the relationship between postoperative BCTQ scores and postoperative CSAs. Furthermore, contradictory results have been reported for the associations between postoperative clinical outcomes and postoperative CSA. Smidt and Visser measured CTR outcomes using a 6-point ordinal transition scale[146]. In their series, the mean median nerve CSA decreased from 14 mm^2 to 11 mm^2 in patients with good outcomes, but remained almost the same (13 mm^2 to 12.5 mm^2) in those with poor outcomes. Vogelin et al[8] measured postoperative clinical outcomes using a 4-point Likert type scale and concluded that a postoperative CSA of $\leq$ 10 mm^2 tended to be associated with better clinical outcomes than a postoperative CSA of
$>$ 10 mm^2. On the other hand, Naranjo et al[147] measured the main outcome variables of CTR using a 5-point Likert scale and concluded ultrasonography was of limited value for assessing patients with poor outcomes after CTR because patients with cure or great improvement and those with slight or no improvement exhibited similar CSA reductions at 3 months after surgery. In the present study, significant correlation was found between preoperative CSAs and preoperative BCTQ scores; but no correlation was obtained between postoperative changes in CSA and postoperative changes in BCTQ-scores.

CONCLUSION

1. This study shows that clinical symptoms recover after CTR at 12 weeks post- operatively.
2. This study suggests that median nerve swelling predict pre-operative symptom severity and functional disabilities.
3. Furthermore, a post-operative reduction in median nerve swelling was not found to be associated with post-operative reduction in clinical symptoms or functional disabilities.

LIMITATIONS OF THE STUDY

1. Relatively small sample size.
2. The study sample might not be true representative of the real world due to sampling error.