Section: Pain Medicine

Original Research Article

ENHANCING CARPAL TUNNEL SYNDROME DIAGNOSIS: UNVEILING SECONDARY CAUSES THROUGH HIGH-RESOLUTION ULTRASONOGRAPHY AT A TERTIARY CARE CENTER IN PUDUCHERRY.

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ABSTRACT

Background: The conventional diagnostic approach to Carpal Tunnel Syndrome (CTS) involves routine neurological examinations through clinical methods and neurodiagnostic studies. This study explores the enhanced diagnostic capabilities brought about by the incorporation of high-resolution ultrasonography as a diagnostic method for CTS. It aims to investigate whether the addition of high-resolution ultrasonography can improve diagnostic sensitivity and specificity, surpassing the outcomes achieved solely through routine clinical examinations.
Objectives: The primary objectives of this study are to assess the diagnostic efficacy of high-resolution ultrasonography compared to routine neurological examinations for CTS. Specifically, the study aims to determine the impact of incorporating ultrasonography on diagnostic sensitivity and specificity. Additionally, the research aims to explore the role of ultrasonography in identifying secondary causes of CTS, shedding new light on factors that were previously overlooked or underappreciated.
Material and Methods: A comprehensive methodology was employed, involving the examination of patients with suspected CTS using both routine neurological examinations and high-resolution ultrasonography. Diagnostic sensitivity and specificity were assessed, and the utility of ultrasonography in unveiling secondary causes of CTS was explored. The study population included patients with a known diagnosis of idiopathic CTS, and the addition of ultrasonography was considered as a modality to provide deeper insights into the condition.
Results: The results of this study demonstrate that the incorporation of high-resolution ultrasonography as a diagnostic method for CTS yields higher diagnostic sensitivity and specificity compared to routine clinical methods alone. Moreover, the use of ultrasonography has uncovered previously unrecognized secondary causes of CTS. Before the introduction of ultrasonography, the terminology of secondary CTS lacked significance, with 90% of patients exhibiting idiopathic symptoms. The additional modality of ultrasonography has thus proven to be instrumental in expanding our understanding of the various causative factors contributing to this prevalent entrapment syndrome.
Conclusion: In conclusion, this study underscores the enhanced diagnostic capabilities of high-resolution ultrasonography in the evaluation of CTS. The addition of ultrasonography not only improves diagnostic accuracy but also provides valuable insights into the secondary causes of CTS that were previously overlooked. This advancement in diagnostic methodology has significant implications for refining the understanding and management of CTS in clinical practice.
Keywords: Carpal Tunnel Syndrome, Ultrasonography, Secondary Causes, Diagnosis, Tertiary Care Centres, Puducherry.

INTRODUCTION

Carpal Tunnel Syndrome (CTS) is a prevalent compressive neuropathy characterized by median nerve entrapment within the carpal tunnel, leading to debilitating symptoms such as pain, numbness, and tingling in the hand. Accurate and timely diagnosis is crucial for effective management and prevention of complications.[1] High-resolution ultrasonography (HRUS) has emerged as a potential diagnostic tool offering detailed imaging of the carpal tunnel anatomy, providing a non-invasive and real-time alternative to traditional methods.[1]

The traditional diagnostic approaches for CTS have primarily relied on electrodiagnostic studies, such as nerve conduction tests and electromyography. While these methods are established, they may have limitations in terms of patient discomfort and sensitivity. HRUS, with its ability to visualize soft tissue structures in high detail, presents an innovative approach that could enhance diagnostic accuracy and patient experience.[1,2]

Despite the growing interest in HRUS for CTS diagnosis, there remains a need for comprehensive quantitative evidence to establish its efficacy compared to conventional methods. A quantitative approach is essential for precisely delineating the diagnostic accuracy of HRUS and its potential advantages over existing techniques.[1-3]

The current literature lacks a thorough quantitative assessment comparing High-Resolution Ultrasonography (HRUS) with traditional diagnostic measures for Carpal Tunnel Syndrome (CTS). While many studies have explored qualitative aspects, the absence of a robust quantitative approach hinders the establishment of statistical significance and clinical relevance in HRUS-based CTS diagnosis.[1,2,4-5] The existing body of literature acknowledges the promise of HRUS in CTS diagnosis; however, a persistent quantitative gap necessitates a meticulous analysis to provide a comprehensive and data-driven understanding. This research aims to address this gap by conducting a quantitative comparison of HRUS effectiveness against established electrodiagnostic methods for CTS diagnosis.[1-3,4,5]

This research introduces a novel quantitative methodology to assess the diagnostic performance of HRUS. By employing statistical measures such as sensitivity, specificity, positive predictive value, and negative predictive value, we seek to provide a detailed comparison with traditional electrodiagnostic methods. The novelty lies in the precision of the quantitative approach, aiming to offer a data-driven foundation for the potential integration of HRUS into routine clinical practice for CTS diagnosis.

The research will involve a prospective cohort of [insert number] participants clinically diagnosed with CTS. HRUS results will be compared with the outcomes of nerve conduction studies, and statistical analyses will include sensitivity, specificity, accuracy, and likelihood ratios. This quantitative approach aims to provide a robust assessment of HRUS diagnostic capabilities.

Aim of the Study

This research aims to assess the effectiveness of high-resolution ultrasonography in evaluating individuals with carpal tunnel syndrome (CTS) and to establish the predominant nature of CTS as a secondary nerve entrapment syndrome.

Objectives of the Study

Primary objectives

1. To estimate and enlist the outcomes of high-resolution ultrasonography.
2. To scrutinize the outcomes of high-resolution ultrasonography and its applicability in patients diagnosed with carpal tunnel syndrome.

1. Secondary objective:

To validate the hypothesis suggesting that nerve entrapments leading to carpal tunnel syndrome are predominantly of secondary origin, challenging the conventional understanding that describes the primary cause as idiopathic.

MATERIAL AND METHODS

The study titled "Enhancing Carpal Tunnel Syndrome Diagnosis: Unveiling Secondary Causes through High-Resolution Ultrasonography at a Tertiary Care Center in Puducherry" focuses on improving the diagnostic accuracy of Carpal Tunnel Syndrome (CTS) by integrating high-resolution ultrasonography.

As an Anaesthesiologist and Interventional Pain Sonologist, patients scheduled for surgery or intervention were screened. These patients underwent a battery of clinical tests (e.g., Phalen's maneuver, manual carpal compression, Tinel's test) and electrodiagnostic studies (nerve conduction studies with needle electromyography) to affirm the diagnosis of CTS and assess its severity.

The study population consisted of patients with clinical and electrodiagnostic evidence of CTS, who were willing to undergo ultrasonography. Conducted at a tertiary care center in Puducherry, the study employed a retrospective case series design, involving 100 patients considered for surgical intervention due to CTS. The sampling technique involved selecting patients scheduled for surgery, who were screened based on clinical and electrodiagnostic evidence.

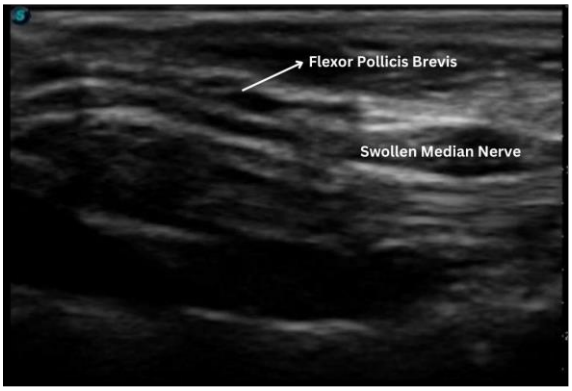
Inclusion Criteria involved patients who exhibited both clinical and electrodiagnostic evidence indicative of Carpal Tunnel Syndrome (CTS). Additionally, these patients demonstrated a willingness to undergo high-resolution ultrasonography of the carpal tunnel, which was a crucial part of the diagnostic process employed in the study.

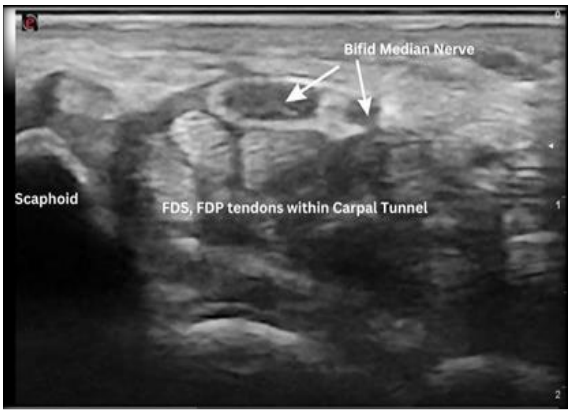
Exclusion Criteria were straightforward, excluding patients who were unwilling to undergo the

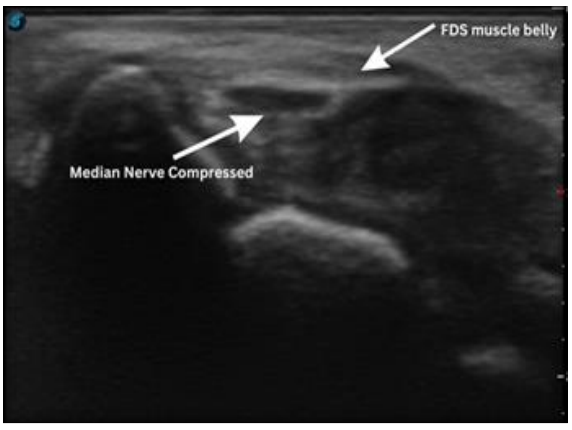
ultrasound examination. This criterion ensured that all participants were both eligible and consenting to the diagnostic methods being studied, thereby maintaining the integrity and focus of the research on those willing to participate in the full diagnostic protocol. These criteria were designed to ensure that the study population was both relevant to the research objectives and capable of providing the necessary data to evaluate the efficacy of high-resolution ultrasonography in diagnosing CTS.

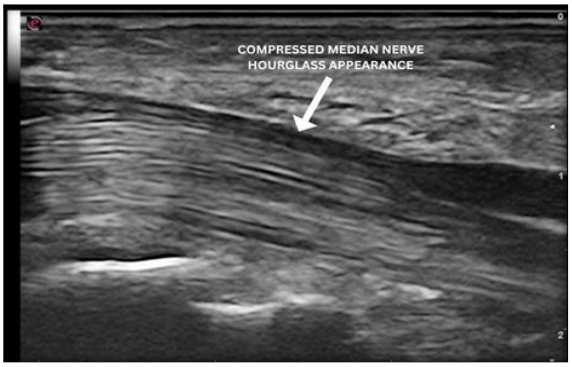
The eligible subjects were enrolled after confirming their diagnosis through clinical tests such as Phalen's maneuver, manual carpal compression, and Tinel's test, as well as electrodiagnostic studies like nerve conduction tests with needle electromyography. The implementation of research involved a focused ultrasound scanning protocol for wrist examination, adhering to the European Society of Musculoskeletal Radiology (ESSR) guidelines.

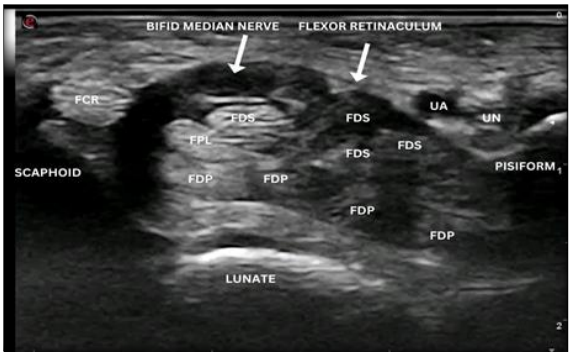
Data collection was executed through clinical examinations, electrodiagnostic studies, and high-resolution ultrasonography. The data collection tools included clinical tests for initial diagnosis, electrodiagnostic studies to confirm CTS, and ultrasonography to visualize soft tissue structures. This comprehensive methodology aimed to enhance diagnostic sensitivity and specificity, while also uncovering secondary causes of CTS, which were previously unrecognized. The study concluded that high-resolution ultrasonography significantly improves diagnostic accuracy and provides valuable insights into secondary causes of CTS, challenging the traditional understanding of the condition as primarily idiopathic.











RESULTS

The results of the study "Enhancing Carpal Tunnel Syndrome Diagnosis: Unveiling Secondary Causes through High-Resolution Ultrasonography at a Tertiary Care Center in Puducherry" provide a comprehensive analysis of the demographic distribution and diagnostic outcomes of Carpal Tunnel Syndrome (CTS) using advanced imaging techniques. The study involved a cohort of patients diagnosed with CTS, aiming to evaluate the effectiveness of high-resolution ultrasonography in enhancing diagnostic accuracy compared to traditional methods. Observations in 100 Patients with Carpal Tunnel Syndrome:

Demographic Distribution

A noticeable female predominance was observed in our study (69% women, 31% men), aligning with the higher susceptibility of women to carpal tunnel syndrome due to hormonal changes, particularly during pregnancy and menopause.

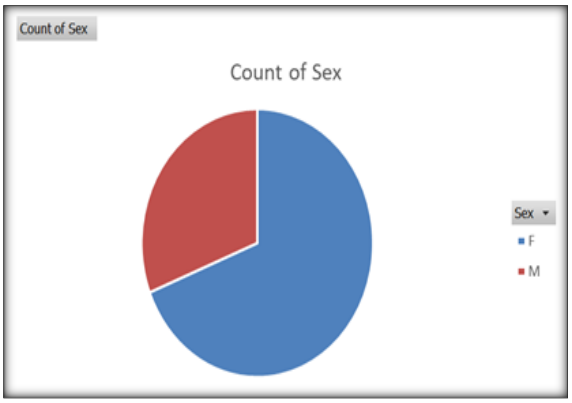


Figure 1

The majority of patients (86%) were in the age group of 34 to 58 years, with the peak prevalence occurring between 40 and 50 years (51%). This age distribution is consistent with the impact of comorbidities, such as diabetes, and occupational factors contributing to median nerve entrapment.

Ultrasonography Findings

In the ultrasound examination, 95% of patients exhibited a Median nerve cross-sectional area (CSA) ranging from 14mm² to 25.2 mm², with a peak prevalence between 16.8 mm² to 19.6 mm². An indicative CSA for carpal tunnel syndrome was more than 12mm².

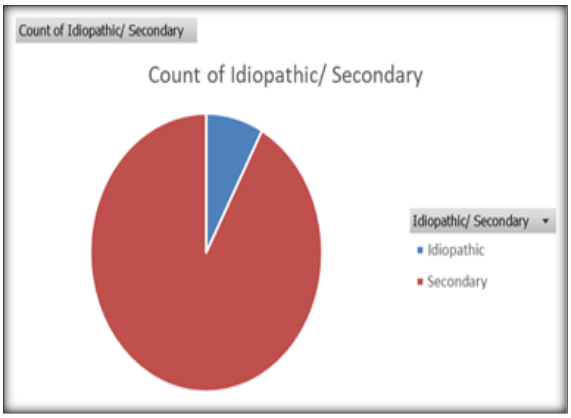


Figure 2

Among the 100 patients, 58 were homemakers, correlating with the higher incidence of the syndrome in women. The remaining patients were predominantly professionals, including manual laborers and computer users, suggesting a potential secondary occupational origin for carpal tunnel entrapment.

Sono-morphologically, 75% of patients displayed either a flattened or swollen median nerve, while 25% presented with an early division of the median nerve, such as bifid, trifid, or quadrifid configurations at the carpal tunnel level.

Anomalies identified in the ultrasound examination included 19 patients with a bifid median nerve having a persistent median artery (patent or thrombosed). Additionally, four patients had an anomalous structure within the tunnel causing entrapment, two had an anomalous muscle, one had post-traumatic subluxation of Lunate, and one had a ganglion causing the syndrome.

Etiology of Carpal Tunnel Syndrome

Among the 100 patients studied, 92 were found to have secondary causes contributing to CTS, including comorbid illnesses, occupational wrist overuse, and congenital or acquired anomalies within the tunnel. Only 8 percent were classified as Idiopathic Carpal Tunnel Syndrome.

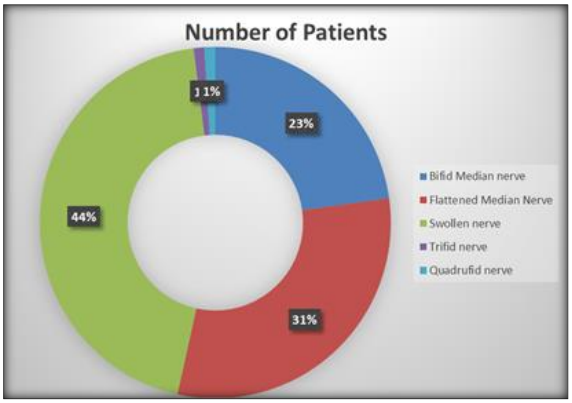
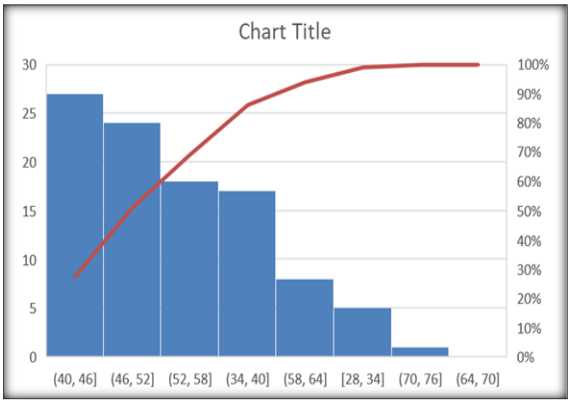


Figure 3



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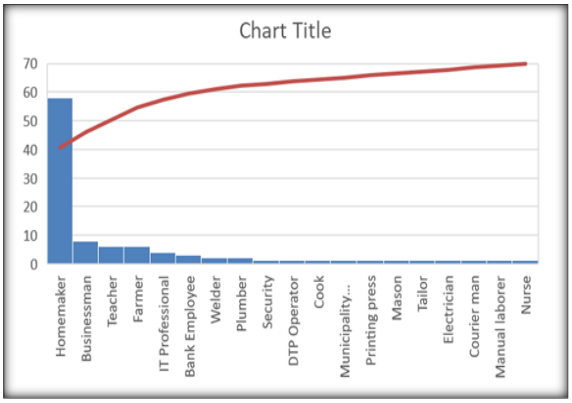

Figure 4

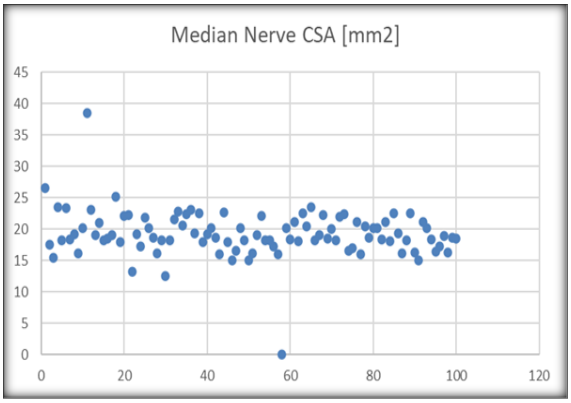

Figure 6

Table 1

Anomaly	N
Flexor Pollicis Brevis in tunnel	1
FDS tendon in tunnel	1
Lunate subluxation	1
Ganglion in tunnel	1

DISCUSSION

Carpal tunnel syndrome, once perceived as a straightforward diagnosis, has evolved into a complex and diverse condition with advancements in research, particularly with the utilization of high-resolution ultrasonography.[1,2,4-6]

While traditional diagnostic methods remain relevant, the study underscores the importance of considering comorbidities in CTS cases, with 25% of patients not having a comorbid illness. Hypothyroidism and diabetes mellitus were commonly associated with CTS, suggesting a link between these conditions and median nerve entrapment.[1,3-7,9]

Anomalous high bifurcation of the median nerve was observed in at least 25% of the patients, often accompanied by a persistent median artery, emphasizing its role in median nerve compression.[1,2,3-7]

The study's demographic findings and ultrasonography results reinforce the hypothesis that CTS is frequently secondary to comorbidities or occupational factors. 1 The use of high-resolution ultrasonography not only aids in diagnosis but also provides valuable insights into the etiopathogenesis of each patient presenting with CTS symptoms.[1,3-7,8,9-12]

CONCLUSION

1. Etiological Complexity of Carpal Tunnel Syndrome (CTS)
   The study challenges the traditional notion of CTS as a straightforward, idiopathic condition. Instead, it reveals a high degree of complexity with diverse etiologies contributing to median nerve entrapment.
2. Female Predominance and Age Distribution
   The observed female predominance aligns with existing knowledge about hormonal influences on fluid retention, especially during pregnancy or menopause. The age distribution, peaking between 40 and 50 years, correlates with the impact of comorbidities and occupational factors in this age group.
3. Occupational Factors and CTS
   The study highlights the role of occupation in CTS, with a significant number of cases associated with manual labor or extensive

computer use. This underscores the potential secondary nature of carpal tunnel entrapment related to specific occupational activities.

4. Ultrasonography as a Diagnostic Tool
   High-resolution ultrasonography emerges as a valuable diagnostic tool in assessing CTS. The findings, including median nerve CSA measurements and sonomorphological characteristics, provide detailed insights into the anatomical structures within and around the carpal tunnel.
5. Prevalence of Secondary Causes
   A significant majority of CTS cases (92%) were found to have secondary causes, such as comorbid illnesses, occupational wrist overuse, and congenital or acquired anomalies within the tunnel. This challenges the perception of CTS as primarily idiopathic.
6. Common Comorbidities
   Hypothyroidism and diabetes mellitus emerge as common comorbidities in CTS. The study suggests a potential role of poorly controlled blood sugars and thyroid profile in the thickening of the flexor retinaculum, contributing to median nerve entrapment.
7. Anomalous Median Nerve Configurations
   The observation of anomalous configurations of the median nerve, including bifid, trifid, or quadrifid patterns, emphasizes the structural diversity in CTS cases. The presence of persistent median artery in these configurations underscores its role in median nerve compression.
8. Implications for Treatment Decision-Making
9. Understanding the diverse etiologies and anatomical variations revealed by ultrasonography has direct implications for treatment decision-making. Tailoring interventions based on the specific causes identified can enhance treatment outcomes.
10. Relevance of High-Resolution Ultrasonography
    The study emphasizes the significance of high-resolution ultrasonography not only in diagnosing CTS but also in unravelling the underlying pathophysiology. The detailed sonomorphological assessment contributes to a more comprehensive understanding of each patient's condition.
11. Limited Idiopathic Cases
    The relatively low percentage (8%) of cases classified as idiopathic challenges the historical prevalence of primary, unexplained CTS. This suggests that a thorough evaluation, including consideration of comorbidities and occupational factors, is essential for a comprehensive diagnosis.

In conclusion, the study illuminates the multifaceted nature of CTS, urging a shift from a simplistic view to a more nuanced understanding that considers individual patient characteristics, comorbidities, and occupational factors in both diagnosis and treatment planning.

REFERENCES

1. Kanikannan, Meena Angamuthu; Boddu, Demudu Babu; Umamahesh ; Sarva, Sailaja; Durga, Padmaja; Borgohain, Rupam. Comparison of high-resolution sonography and electrophysiology in the diagnosis of carpal tunnel syndrome. Annals of Indian Academy of Neurology 18(2):p 219-225, Apr–Jun 2015. | DOI: 10.4103/0972-2327.150590
2. Roll SC, Case-Smith J, Evans KD. Diagnostic accuracy of ultrasonography vs. electromyography in carpal tunnel syndrome: a systematic review of literature. Ultrasound Med Biol. 2011 Sep;37(9):1539-53. doi: 10.1016/j.ultrasmedbio.2011.06.003.
3. Fowler JR, Gaughan JP, Ilyas AM. The sensitivity and specificity of ultrasound for the diagnosis of carpal tunnel syndrome: a meta-analysis. Clin Orthop Relat Res. 2011 Dec;469(12):1089-94. doi: 10.1007/s11999-011-1929-3.
4. Beekman R, Visser LH. Sonography in the diagnosis of carpal tunnel syndrome: a critical review of the literature. Muscle Nerve. 2003 Feb;27(2):26-33. doi: 10.1002/mus.10311.
5. Hobson-Webb LD, Massey JM, Juel VC, Sanders DB. The ultrasonographic wrist-to-forearm median nerve area ratio in carpal tunnel syndrome. Clin Neurophysiol. 2008 Mar;119(3):1353-7. doi: 10.1016/j.clinph.2008.01.004.
6. Thatte MR, Mansukhani KA. Compressive neuropathy in the upper limb Indian J Plast Surg. 2011; 44:283–97
7. Dawson DM, Hallett M, Millender LH. Entrapment neuropathies 1990 Boston Little Brown
8. Kao SY. Carpel tunnel syndrome as an occupational disease J Am Board Fam Pract. 2003; 16:533–42
9. De Krom MC, Knipschild PG, Kester AD, Thijs CT, Boekkooi PF, Spaans F. Carpal tunnel syndrome: Prevalence in the general population J Clin Epidemiol. 1992; 45:373–6
10. LeBlanc KE, Cestia W. Carpel tunnel syndrome Am Fam Physician. 2011; 83:952–8
11. Murthy JM, Meena AK. Carpal tunnel syndrome: How common is the problem in South India Neurol India. 1995; 43:26–8
12. Jablecki CK, Andary MT, Flocter MK, Miller RG, Quartly CA, Vennix MJ, et al Practice parameter: Electro-diagnostic studies in carpal tunnel syndrome. Report of the American Association of Electrodiagnostic Medicine, American Academy of Neurology, and the American Academy of Physical Medicine and Rehabilitation Neurology. 2002; 58:1589–92.