Received: 19.02.2014 / **Accepted:** 17.04.2014
DOI: 10.5137/1019-5149.JTN.10754-14.2

The Role of Wrist Magnetic Resonance Imaging in the Differential Diagnosis of the Carpal Tunnel Syndrome

Karpal Tünel Sendromunda Bilek Manyetik Rezonans İncelemesinin Ayırıcı Tanıdaki Yeri

Mehmet Resid ONEN[1], Ali Erhan KAYALAR[1], Elif Nurbegum ILBAS[2], Recai GOKCAN[2], Ilker GULEC[3], Sait NADERI[1]

[1]Umraniye Teaching and Research Hospital, Department of Neurosurgery, Istanbul, Turkey
[2]Umraniye Teaching and Research Hospital, Department of Radiology, Istanbul, Turkey
[3]Antalya Teaching and Research Hospital, Department of Neurosurgery, Antalya, Turkey

Corresponding Author: Mehmet Resid ONEN / E-mail: mresid@gmail.com

ABSTRACT

AIM: The carpal tunnel syndrome (CTS) is the commonest compressive neuropathy. Electromyography (EMG) is accepted as gold standard in diagnosis of CTS. However, pathologies and variations that are associated with a various findings may lead to failure.

MATERIAL and METHODS: Magnetic resonance Imaging (MRI) was applied to 69 wrists of 55 patients, who received a diagnosis of CTS by means of clinical and electrodiagnostic testing (EDT) during the years 2011 and 2013.

RESULTS: We detected a total of 71 additional pathologies in MRI analyses: 29 degenerative bone cysts, 28 ganglion cysts, 8 tenosynovitis, and 6 avascular necroses. While the MRI detected 44 (59.5%) additional radiological pathologies in 39 wrists diagnosed with mid-level CTS by means of EMG, the number of detected additional pathologies was 27 (36.5%) in 30 wrists diagnosed with advanced-level CTS.

CONCLUSION: Wrist MRI is an effective means to reveal associated pathologies in patients diagnosed with CTS by means of clinical testing and EDT. Additional pathologies may not only change the applicable type of surgery, but also decrease the number of postoperative failures. Wrist MRI is recommended, especially for young cases with unilateral CTS history accompanied by dubious clinical symptoms and lacking any pronounced predisposing factors.

KEYWORDS: Carpal tunnel syndrome, Magnetic resonance imaging, Compressive neuropathy, Electromyography

ÖZ

AMAÇ: Karpal tünel sendromu (KTS) nöroşirürji pratiğinde en sık opere edilen kompresif nöropatidir. Tanıda standart olarak elektromiyografi (EMG)'den yararlanılmaktadır. Bununla beraber olguların bir bölümünde eşlik eden patolojiler ve varyasyonlar nedeni ile başarısızlık ile karşılaşılabilir.

YÖNTEM ve GEREÇLER: 2011 ve 2013 yılları arasında klinik ve elektrodiyagnostik testlerle (EDT) KTS tanısı alan 55 hastanın 69 el bileğine manyetik rezonans incelemesi (MRİ) yapılmıştır.

BULGULAR: MRİ'de toplam 71 ek patoloji saptandı. Buna göre 29 dejeneratif kemik kisti, 28 ganglion kisti, 8 tenosinovit ve 6 avasküler nekroz saptandı. EMG'de orta şiddette KTS saptanan 39 el bileğinde radyolojik olarak 44 (% 61) adet ek patoloji saptanırken, şiddetli KTS saptanan 30 bilekte MRİ'de 27(% 38) adet ek patoloji saptandı. Tek taraflı olgularda 52 (% 61,7) ek patoloji görülürken, bilateral olgularda 19 (46,4%) ek patoloji görüldü.

SONUÇ: Klinik ve EDT ile KTS tanısı alan hastalarda bilek MRİ eşlik eden patolojileri ortaya koyabilmektedir. Ek patolojiler uygulanacak cerrahi şeklini değiştirebileceği gibi, postoperatif başarısızlığı da azaltılacaktır. Özellikle belirgin predispozan faktörü olmayan, tek taraflı KTS öyküsü bulunan, kliniğinde şüpheli semptomları olan olgularla ve endoskopik cerrahi planlanan hastalara el bileği MRİ önerilir.

ANAHTAR SÖZCÜKLER: Karpal tünel sendromu, Manyetik rezonans görüntüleme, Tuzak nöropati, Elektromyografi

INTRODUCTION

Carpal-tunnel-syndrome (CTS) is a common disease that is frequently seen in adult age groups. The incidence of this syndrome varies between 1-5% in the general population, but may increase up to 15% in certain age and gender groups (1, 20, 21, 26). In general, CTS is diagnosed by means of clinical findings and/or provocative and electrodiagnostic testing (EDT) results. The symptoms of CTS are caused by the entrapment of the median nerve in the carpal tunnel due to various factors. Provocative tests such as the Phalen test and Tinel sign are very valuable for clinical examination.

Electromyography (EMG), an EDT method, is a gold standard in diagnosis (10). Although EMG is the most frequently utilized means of diagnosis, it has a significant rate of false negativity and false positivity (12). Magnetic resonance (MR) has been used for CTS cases as well since its first introduction in the 1980's. However, it was neglected as a routine means of diagnosis (7, 13, 16, 17). In this study, we examined the contribution of wrist MR imaging to the diagnosis and treatment of cases that have been diagnosed with CTS by means of clinical and electrophysiological tests.

MATERIAL and METHODS

An MR Imaging was applied to 69 wrists of 55 patients, who received a diagnosis of CTS by means of clinical and electrodiagnostic testing (EDT) during the years 2011 and 2013. The purpose of MRI was to search for associated pathologies such as synovial cysts, avascular necrosis, degenerative bone cysts, or tenosynovitis, along with any abnormal signals of the median nerve of the tendon bundle located in the flexor retinaculum.

A 1.5T system was utilized for MR imaging. We imaged 3 standard sequences by means of a wrist coil: 1) coronal or sagittal localization T1-weighted spin echo study (4 mm section distance, 4 minutes, 256x192 matrix image), 2) axial T1-weighted spin echo study (256x256 matrix image, 4 mm section distance, 5.5 minutes), 3) axial fast STIR imaging (256x224 matrix image, 4 mm section distance, 5.25 minutes).

In the MR analysis, the signal density of the median nerve was observed to be identical to muscle density in T2-weighted images, while a thinning and a hyperintense appearance was observed in the nerve in parallel to the nerve compression. However, the signal might get lost in very advanced compressions (4).

For the purpose of EMG tests, we placed the probes onto the distal part of the middle phalanx and the first proximal phalanx. Since the median nerve is easily palpable only between the flexor carpi radialis tendon and the medial palmaris longus tendon, one of the probes was placed to this area. To achieve improved proximal stimulation, we placed the probes to the medial area of the antecubital fossa located on the brachial artery medial to the the forearm biceps tendon.

The statistical analyses of the study were calculated by means of SPSS ver. 16.0. We used the Mann-Whitney U-test (Spearman correlation coefficient) for the comparison and correlation assessments. The statistical significance value was selected as $p<0.05$.

RESULTS

The cases consisted 54 female (98.2%) patients and one male patient. 41 (74.5%) cases suffered from unilateral CTS, while bilateral CTS were observed in 14 (25.5%) cases. We carried out a total of 69 EMG analyses. As result, we detected mid-level CTS in 39 wrists (56.5%) and advanced-level CTS in 30 wrists (43.5%5) (Figures 1, 2).

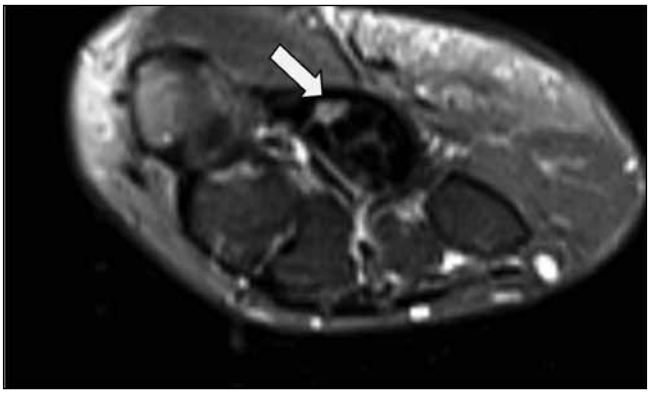

Figure 1: White arrow in T2-weighted MRI appearance of mid-level CTS.

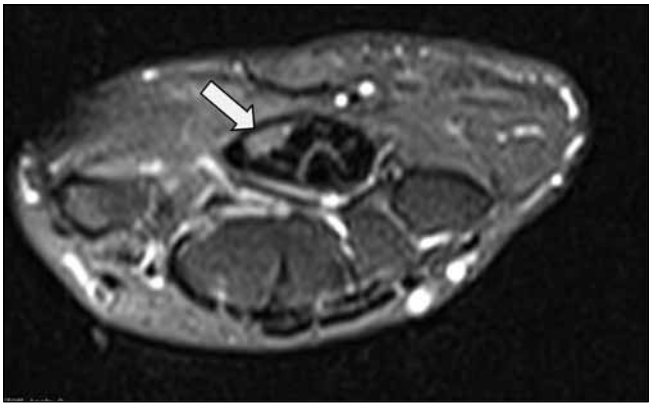

Figure 2: White arrow in T2-weighted MRI appearance of advanced-level CTS (white arrow: median nerve).

In 47 (68.1%) of 69 wrists that had been diagnosed with CTS in clinical and EMG tests, the CTS diagnosis was confirmed by MR imaging. While the MRI supported CTS in 26 wrists (66.6%) in mid-level CTS (as diagnosed by EMG), the results were positive in 21 wrists (70%) with an advanced-level CTS EMG finding.

In MRI analyses, we detected a total of 71 additional pathologies: 29 degenerative bone cysts, 28 ganglion cysts, 8 tenosynovitis, and 6 avascular necroses (Figures 3-6). While the MR detected 45 (63.3%) additional radiological pathologies in 39 wrists diagnosed with mid-level CTS by means of EMG, the number of detected additional pathologies was 26 (36.7%) in 30 wrists diagnosed with advanced-level CTS. In unilateral cases, we observed 52 (61.7%) additional pathologies. The number of observed additional pathologies was 19 (46.4%) in bilateral cases (Table I).

Based on MR findings, we carried out an assessment on associated additional pathologies in cases diagnosed with CTS by means of EMG. Accordingly, the number of additional pathologies seen in 47 cases diagnosed with CTS by means of MR was 25 (53%), while the number of additional pathologies in 22 CTS cases with negative MR (i.e., pseudo CTS) was 41 (186%). The latter number represents the number of at least

Table I: Distribution of MR Findings and Additional Pathologies in Cases Diagnosed with CTS by Means of EMG

EMG Finding	MR Compatible	Additional Pathologies			
		Ganglion cysts	Tenosynovitis	Avascular necrosis	Degenerative bone cysts
Mid-level CTS (n=39, 56.5%)	26 (66.6%)	20	7	3	15
Advanced CTS (n=30, 43.5%)	21 (70%)	8	1	3	14
		28	8	6	29

Table II: MR Compatibility and Observance of Associated Additional Pathologies in Cases Diagnosed with CTS by Means of EMG

EMG Finding			Additional pathology	Sign.
Mid-level CTS (n=39, 56.5%)	MR Compatible	n=26 (66.6%)	11 (25.6%)	P<0.05
	MRI Non-Compatible	n=13 (33.3%)	29 (64.4%)	
Advanced CTS (n=30, 43.5%)	MR Compatible	n=21 (70%)	14 (53.9%)	p>0.05
	MRI Non-Compatible	n=9 (30%)	12 (46.1%)	

one or more additional pathologies. In other words, the rate of additional pathologies in cases where the MR did not confirm CTS was much more common than in those with MR-confirmed CTS.

On the other hand, the number of additional pathologies in cases suffering from mid-level CTS was 11 (25.6%) in MRI positive cases, whereas the number in MRI negative cases was 29 (46.4%) (P<0.05). These results reveal that almost similar rates of additional pathologies are observed in mid-level and advanced cases where MR did not confirm CTS. In CTS patients with negative MR (Table II), the average symptom duration was 39.4 months (range: 2-204 months). The duration was 38.4 months (range: 2-120) in mid-level EMG cases, while a symptom duration of 36.7 months (range: 4- 204) was detected in advanced cases. No statistically significant relationship could be detected between the symptom duration and EMG findings (p>0.05). Similarly, no statistically significant relationship could be detected between the symptom duration and MRI findings (p>0.05).

DISCUSSION

As in many other diseases, MRI can be utilized to diagnose CTS. However, physicians prefer EMG as the primary means to diagnose CTS and MR was not developed into a standard method to diagnose CTS. Therefore, there is a lack of comprehensive, detailed studies that examine the role of MR in the diagnosis of CTS.

With this study, it is confirmed that MR contributes to the diagnosis of CTS, while revealing a large number of associated pathologies. The current study showed that the MRI confirmed the CTS diagnosis of 68% of patients who had been diagnosed with CTS by means of clinical and EMG tests. Besides, we detected additional pathologies in 72.4% of the wrists that we examined within the scope of the study. In other words, the MR revealed that the median nerve compression in some cases was not caused by a thickening of the transverse ligament, but by the presence of an associated pathology or the co-existence of both pathologies, in spite of a CTS diagnosis (i.e. compression of the nerve under the thickened transverse ligament) made by means of EMG and clinical tests.

The additional pathologies most frequently detected in the MR images of our study included degenerative bone cysts and ganglion cysts. Among these pathologies, we detected three ganglion cysts and two tenosynovites that applied pressure directly to the median nerve. Nowadays, EMG is routine procedure in the diagnosis of CTS. EMG is capable of eliminating cases of radiculopathy, polyneuropathy, and other trap neuropathy cases (10, 12, 22). However, EDT's with a reported sensitivity and specificity of 80.2%, and 78.7%, respectively, are rather subjective means of diagnosis due to factors depending on neurologist's interpretation, patient compatibility, and available devices (2,8,10). Moreover, EMG may deliver false positive results in 5% of all cases, although 93% abnormality is detected in cases with clinical symptoms (5, 12, 27).

Another means of diagnosis that can be utilized in CTS and other wrist pathologies for diagnostic purposes is ultrasound. Wrist ultrasound can be helpful to diagnose median nerve pathologies in the carpal tunnel along with other pathologies such as tenosynovitis (12, 15, 18). Nevertheless, the sensitivity and specificity of ultrasound have been reported as 77.6% and 86.8%, respectively (9).

As demonstrated by this study, MR is another means that can be employed to diagnose CTS. MRI is capable of providing a detailed image of the median nerve along with other neural, vascular, and bone structures.

MR findings supporting CTS include oedema in the median nerve, thinning, signal variations, and decreased volume of the carpal tunnel. The findings that came to the forefront in our study were as follows: median nerve alterations in the

MR, oedema and increased T2 signal density in mid-level CTS cases diagnosed by EMG, and median nerve thinning in advanced-level CTS cases diagnosed by EMG. In other words, while a signal increase due to oedema is observed in mid-level cases, no signal increase is found in advanced-level cases due to the thinning of the nerve. However, no compatibility could be detected between the severity of these changes and complaints. This is in harmony with other examples reported in the literature (3, 6, 19, 24, 25).

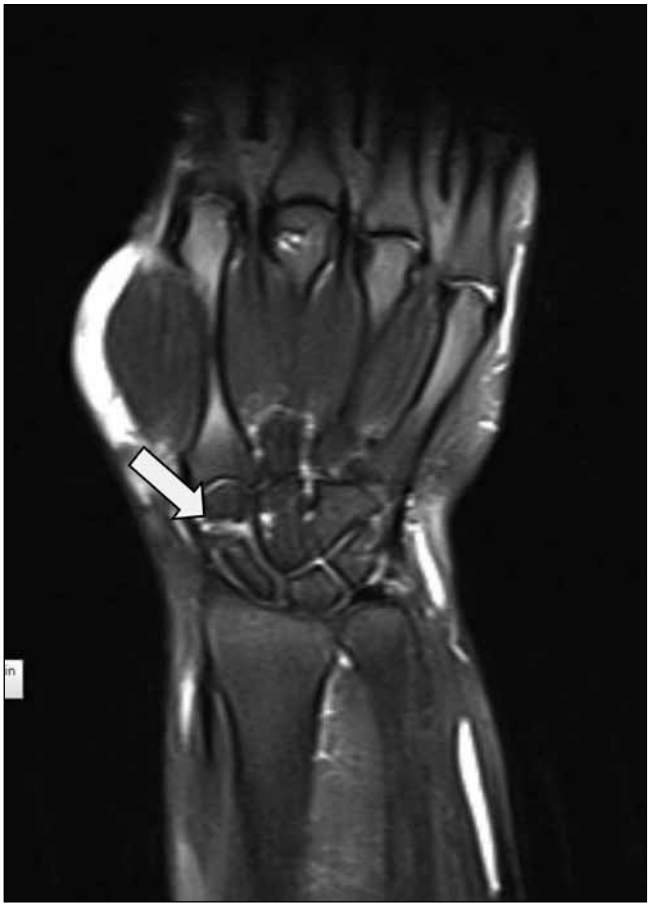

Figure 3: White arrow in T2-weighted MRI appearance of degenerative bone cyst in wrist.

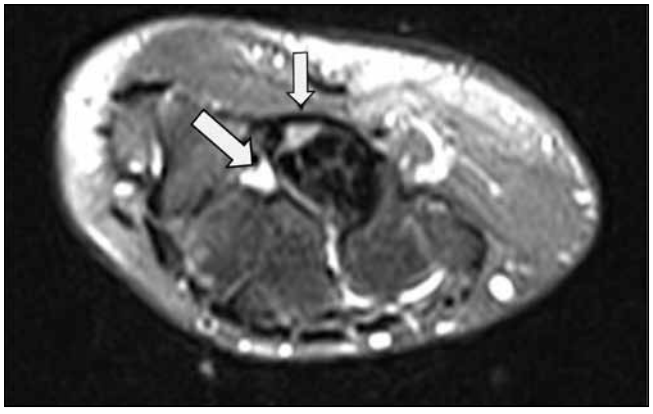

Figure 4: White arrows in T2-weighted MRI appearance of ganglion cyst in wrist.

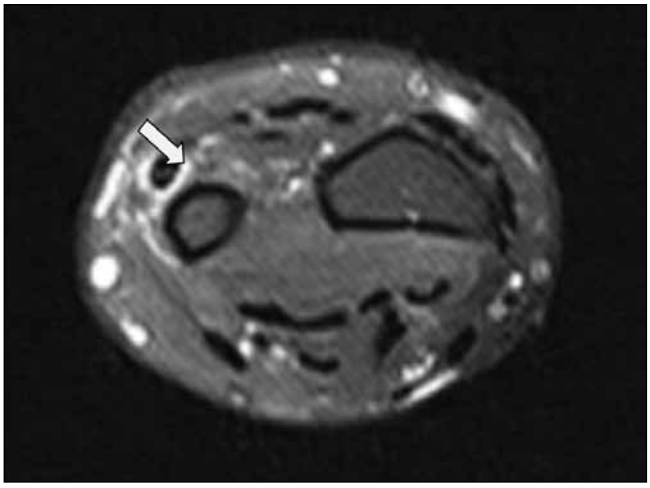

Figure 5: White arrow in T2-weighted MRI appearance of tenosynovitis in wrist.

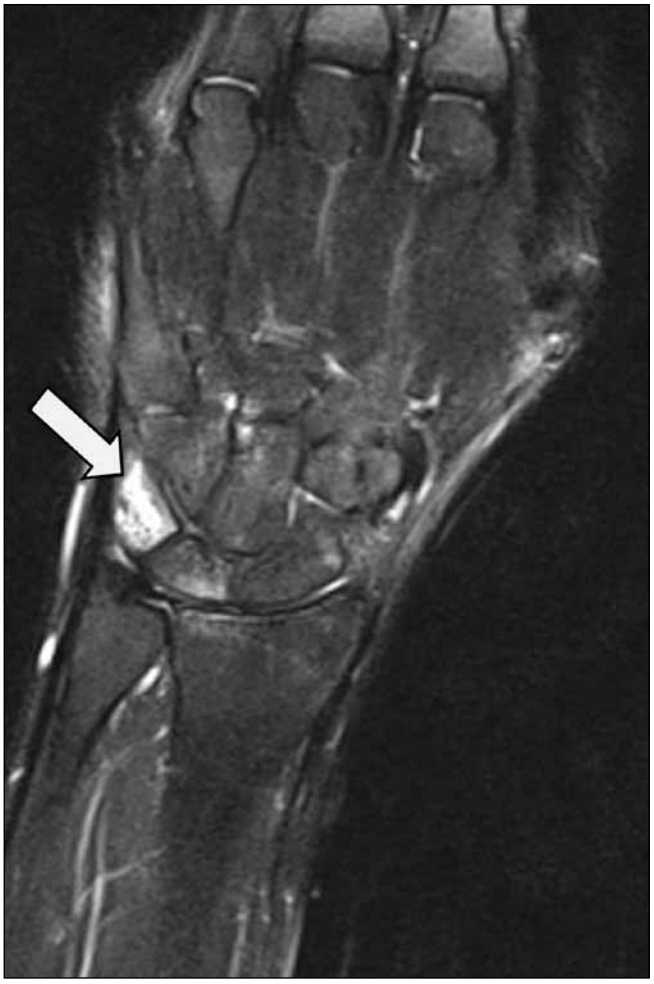

Figure 6: White arrow in T2-weight MRI appearance of avascular necrosis in wrist.

On the other hand, it has been reported that idiopathic CTS cases are of bilateral nature in general, and that other pathologies have to be taken into consideration in cases where the EMG delivers the diagnosis of unilateral CTS. Some previous studies have reported the presence of additional pathologies in unilateral CTS cases at a rate of 35–66% (3, 14, 23). In our study, the rate of observed pathologies in bilateral CTS cases was 46.4%, while this rate proved to be 61.7% in cases of unilateral CTS ($p<0.05$). Therefore, it is recommended to apply MR imaging to unilateral CTS cases.

The comparison of MR and USG reveals that MR gains the upper hand over ultrasound especially with respect to the imaging of bone deformities and ganglion cysts (15). Likewise, it has been reported that MRI is capable or delivering more detailed images of the wrist anatomy in cases with partial or no recovery despite surgical intervention (3, 11, 19, 25, 28). Besides, it is known that MR is an objective and non-invasive method compared to EMG. However, MR is a technique that is more expensive and more time-consuming than both USG and EMG.

CONCLUSION

Patients with suspected CTS can be diagnosed by means of clinical examinations and electrodiagnostic tests. However, a wrist MRI is recommended in cases with dubious clinical symptoms, along with those who belong to a young age group, are of male gender, suffer from unilateral complaints, have recurrent symptoms, or lack any pronounced predisposing factors. The concurrent use of EMG and MRI in the diagnosis of CTS will increase the rate of CTS patients benefiting from surgical treatment, accompanied by a decreased rate of postoperative failures.

REFERENCES

1. American Academy of Neurology. Practice parameter for carpal tunnel syndrome (summary statement). Report of the Quality Standards Subcommittee of the American Academy of Neurology. Neurology 13: 2106–2109, 1993
2. Atroshi I, Gummesson C, Johnsson R, Ornstein E: Diagnostic properties of nerve conduction tests in population based carpal tunnel syndrome. BMC Musculoskelet Disord 4: 9- 14, 2003
3. Bagutar AE, Zorer G, Oral B: The role of magnetic resonance imaging in carpal tunnel syndrome: Correlation of clinical electrodiagnostic and intraoperative finding and staging. Acta Orthop Traumatol Turc 36: 22-30,2002
4. Britz GW, Haynor DR, Kuntz C, Goodkin R, Gitter A, Kliot M: Carpal tunnel syndrome: Correlation of magnetic resonance imaging, clinical, electrodiagnostic, and intraoperative findings. Neurosurgery 37: 1097–1103, 1995
5. D'Aecy CA, McGee S: The rational clinical examination. Does this patient have carpal tunnel syndrome? JAMA 283:3110-3117, 2000
6. Deryani E, Aki S, Muslumanoglu L, Rozanes I: MR imaging and electrophysiological evaluation in carpal tunnel syndrome. Yonsei Med J 44: 27–32, 2003
7. Filler AG, Kliot M, Howe FA, Hayes CE, Saunders DE, Goodkin R: Application of magnetic resonance neurography in the evaluation of patients with peripheral nerve pathology. J Neurosurg 85: 299–309, 1996
8. Finsen V, Ruswurn H: Neurophysiology not required before surgery for typical carpal tunnel sydrome. J Hand Surg 26: 61-64, 2001
9. Fowler JR, Gaughan JP, Ilyas AM: The sensitivity and specificity of ultrasound for the diagnosis of carpal tunnel syndrome. Clin Orthop Relat Res 469: 1089-1094, 2011
10. Graham B, Regehr G, Naglie G, Wright JG: Development and validation of diagnostic criteria for carpal tunnel syndrome. J Hand Surg 31A:919-924, 2006
11. Horch RE, Allmann KH, Laubenberger J, Langer M, Stark GB: Median nerve compression can be detected by magnetic resonance imaging of the carpal tunnel. Neurosurgery 41: 76–83, 1997
12. Jablecki CK, Andary MT, Floeter MK, Miller RG, Quartly CA, Vennix MJ, Wilson JR: Practice parameter: Electrodiagnostic 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 58:1589–1592, 2002
13. Jarvik JG, Yuen E, Haynor DR, Bradley CM, Fulton-Kehoe D, Smith-Weller: MR nerve imaging in a prospective cohort of patients with suspected carpal tunnel syndrome. Neurology 58: 1597–1602, 2002
14. Kang HJ, Jung SH, Yoon HK, Hahn SB, Kim SJ: Carpal tunnel syndrome caused by space occuping lesions. Yonsei Med J 50(2):257-261, 2009
15. Keberle M, Jenett M, Kenn W, Reiners K, Peter M, Haerten R: Technical advances in ultrasound and MR imaging of carpal tunnel syndrome. Eur Radiol 10: 1043–1050, 2000
16. Kleindienst A, Hamm B, Hildebrandt G, Klug N: Diagnosis and staging of carpal tunnel syndrome: Comparison of magnetic resonance imaging and intraoperative findings. Acta Neurochir (Wien) 138:228–233, 1996
17. Kleindienst A, Hamm B, Lanksch WR: Carpal tunnel syndrome: Staging of median nerve compression by MR imaging. J Magn Reson Imaging 8: 1119–1125, 1998
18. Koyuncuoglu HR, Kutluhan S, Yesildag A, Oyar O, Guler K, Ozden A: The value of ultrasonographic measurement in carpal tunnel syndrome in patients with negative electrodiagnostic tests. European Journal of Radiology 56: 365–369, 2005
19. Mesgarzadeh M, Triolo J, Schneck CD: Carpal tunnel syndrome, MR imaging diagnosis. Magn Reson Imaging Clin N Am 3: 249-264, 1995
20. Middleton WD, Kneeland JB, Kellman GM, Cates JD, Sanger JR, Jesmanowicz A: MR imaging of the carpal tunnel: Normal anatomy and preliminary findings in the carpal tunnel syndrome. AJR Am J Roentgenol 148:307–316, 1987
21. Mondelli M, Giannini F, Giacchi M: Carpal tunnel syndrome incidence in a general population. Neurology 58(2):289-294,2002

22. Musluoglu L, Celik M, Tabak H, Forta H: Clinical, electrophysiological and magnetic resonance imaging findings in carpal tunnel syndrome. Electromyogr Clin Neurophysiol 44: 161–165, 2004
23. Nakamichi K, Tachibana S: Unilateral carpal tunnel sydrome and space occupying lesions. J Hand Surg 18: 48-49, 1993
24. Padua L, Pazzaglia C, Insola A, Aprile I, Caliandro P, Rampoldi M, Bertolini C, Tonali P: Schwannoma of median nerve may mimic carpal tunnel syndrome. Neurol Sci 26: 430-434, 2006
25. Pasternack I, Malmivaara A, Tervahartiala P, Forsberg H, Vehmas T: Magnetic resonance imaging finding in respect to carpal tunnel syndrome. Scand J Work Environ Health 29: 189-196, 2003
26. Phalen GS: The carpal-tunnel syndrome: Clinical evaluation of 598 hands. Clin Orthop 83:2–40, 1972
27. Pryse Philips WE: Validation of a diagnosis sign in carpal tunnel syndrome. J Neurol Neurosurg Psychiatry 47(8):870-872, 1984
28. Somay G, Somay H, Cevik D, Sungur F, Berkman Z: The pressure angle of the median nerve as a new magnetic resonance imaging parameter for the evaluation of carpal tunnel. Clin Neurol Neurosurg 111: 28-33, 2009