CASE REPORTS
PRIKAZI SLUČAJEVA

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ELECTROMYONEUROGRAPHY IN THE DIAGNOSTICS OF RARE CAUSES OF CARPAL TUNNEL SYNDROME

ELEKTROMIONEUROGRAFIJA U DIJAGNOSTICI RETKIH UZROKA SINDROMA KARPALNOG TUNELA

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Summary

Introduction. The paper points to the problem of electromyoneurography of the bifid median nerve as a rare cause of carpal tunnel syndrome. Carpal tunnel syndrome represents a set of symptoms caused by compression of the distal portion of the median nerve. It is important in clinical practice as it significantly effects the functionality and the quality of daily activities. One of the predisposing factors for the carpal tunnel syndrome is the bifid median nerve. Electromyoneurography is still the gold standard for the verification of the carpal tunnel syndrome. **Case Report.** A 48-year-old patient, after a clinical suspicion of carpal tunnel syndrome, has been confirm by ultrasonography to be suffering from moderate carpal tunnel syndrome, with a detection of 'incomplete' bifid median nerve in the carpal tunnel. Electromyoneurography also confirmed a mild level of carpal tunnel syndrome. However, as difficulties were exclusively present in the innervation area of the median nerve internal branch, and there was a possibility of incomplete correlation of electromyoneurography results, the lumbrical muscles and dorsal interossei muscles were examined, and confirmed a moderate degree of carpal tunnel syndrome. **Discussion**. The bifid median nerve can be the cause of the above insufficient sensitivity of this method, which is why it is necessary to apply optional electromyoneurographic techniques. **Conclusion**. The final practical significance lies in the fact that the presence of the diagnosed bifid median nerve could affect the choice and efficiency of certain therapeutical options.

Key words: Carpal Tunnel Syndrome; Electromyography; Diagnosis; Median Nerve; Anatomic Variation; Diagnostic Imaging

Sažetak

Uvod. Rad ukazuje na enigmatičnost elektromioneurografije bifidnog medijalnog nerva kao retkog uzroka sindroma karpalnog tunela. Sindrom karpalnog kanala predstavlja skup simptoma uzrokovanih kompresijom krajnjeg dela središnjeg živca u delu kanala ručja. Svojom učestalošću i fenomenologijom, koja značajno utiče na funkcionalnost i kvalitet dnevne aktivnosti, predstavlja jedan od značajnih entiteta kliničke prakse. Predisponirajući faktor u nastanku ovog sindroma je i bifidni medijalni nerv - anatomska varijacija grananja središnjeg živca već u karpalnom kanalu. Elektromioneurografija predstavlja „zlatni" standard u verifikaciji sindroma karpalnog kanala. Međutim, pored njegove algoritamske značajnosti, mogući su lažno negativni nalazi. **Prikaz slučaja.** Četrdesetosmogodišnjoj pacijenkinji, nakon klinički postavljene sumnje postojanja sindroma karpalnog kanala, ultrasonografski je potvrđeno njegovo postojanje srednjeg stepena, uz detekciju „inkopletnog" bifidnog medijalnog nerva u karpalnom kanalu i elektromioneurografskim pregledom takođe potvđen sindrom karpalnog kanala lakog stepena. Zbog isključive prisutnosti tegoba u inervacionom području unutrašnje grane središnjeg živca i mogućnosti nepotpune korelativnosti elektromioneurografskog nalaza, primenjena je glistasto-međukoštana studija i konstatovan je sindrom karpalnog kanala srednje teškog stepena. **Diskusija.** Bifidni medijalni nerv može biti uzrok navedene nedovoljne senzitivnosti ove metode, te u tim slučajevima pored konvencionalnog, rutinskog i obavezujućeg elektromioneurografskog pregleda potrebna je primena opcionih elektromioneurografskih tehnika. **Zaključak.** Krajnja praktična važnost je u činjenici da prisustvo dijagnostikovanog bifidnog medijalnog nerva može uticati na izbor i uspešnost određenih terapijskih opcija.

Ključne reči: sindrom karpalnog tunela; elektromiografija; dijagnoza; nervus medianus; anatomske varijacije; dijagnostički imidžing

Introduction

Carpal tunnel syndrome represents a set of symptoms and signs caused by compression of the distal portion of the median nerve in the carpal tunnel, defined in 1951 by Brian McArdle [1, 2].

Epidemiological data indicate that carpal tunnel syndrome is the most frequent mononeuropathy, prevalent in 2.7% of general population. Women are three times more likely to develop the carpal tunnel syndrome than men, and it mostly appears in the 5th and 6th decade of life [3]. Carpal tunnel syndrome

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Abbreviations
EMG – electroneurography

has a significant negative effect on the functionality and the quality of daily activities [4].

There is a large number of potential causes of carpal tunnel syndrome. The bifid median nerve, an anatomical variation of the branching of the median nerve happening already in the carpal tunnel, represents one of the rare causes of carpal tunnel syndrome, with frequency from 0.8% to 2.8%; recently, ultrasonographic findings have shown the prevalence of 18.5%. Arbitrarily, the nerve could be "complete" or "incomplete". The "complete" bifid median nerve is rarer, with the prevalence of 5% [1, 3, 5, 6], which affects the nerve and/or its environment by raising the intracanalicular pressure above 30 mm/Hg (normal values being 7 – 8 mm/Hg) and creates disproportion between the nerve volume and the tunnel space resulting in myelin remodeling, damage of axonal transport, the initiation of the cascade of ischemic nerve changes and the creation of intraneural connective tissue. After eliminating the causal factor, nerve remyelination is possible after several weeks [7, 8].

The main symptoms include paresthesia and pain in hands in the area of innervation of the median nerve (except the thenar area), with a possible propagation towards the shoulder, intensifying during the night and when performing certain activities (holding a telephone or a book…). Furthermore, thenar weakness is possible, accompanied by positive pathognomonic test results (Phalen's maneuver, Tinel's sign, carpal-compression test, and rarely used reverse Phalen's maneuver, hand elevation test, tourniquet test, Okutsu test) [1, 9–11]. Sensory symptoms are missing in the case of "pure motor carpal tunnel syndrome" [3].

Possible differential-diagnostic conditions include neuropathy of the median nerve in other locations (entrapment at the level of the Struthers' ligament, pronator syndrome, anterior interosseous nerve syndrome…), damage to the brachial plexus, radiculopathy (primarily of C6 and C7), initial forms of certain polyneuropathies (multifocal motor polyneuropathy, multifocal acquired demyelinating sensorimotor polyneuropathy), as well as migraines, focal epileptic seizures and transient ischemic attacks [1, 7].

Diagnosis of the carpal tunnel syndrome is primarily based on clinical symptoms, whereby electromyoneurography is a diagnostic method of choice. In addition to the confirmation of the diagnosis, information the degree of severity (mild, moderate and severe), the duration (frequently subacute or chronic), and other accompanying conditions. The conventional, routine and mandatory electromyoneurography includes, among others, placing electrodes on the pointer finger in order to register the sensory neurogram, as well as electrodes on the short adductor pollicis muscle in order to register the motor neurogram of the median nerve (external motor branch). Optionally, in case the previous results were in order, examination of lumbrical muscles and dorsal interossei muscles (internal motor branch), or examination of sensory latencies from the first finger of the median and radial nerve (external sensory branch) are also used in addition to other possibilities [3, 12, 13]. Presence of neurophysiological dissociation can be noted in these cases, which may only suggest the presence of the bifid median nerve, but cannot confirm it [5]. In these and other electromyoneurography possibilities, false negative results are found in 16 – 34% examinations [14].

After the examination, it is necessary to do an X–ray of the carpal area and routine lab tests [3, 12]. Ultrasonic examination of peripheral nerves has become a complementary method to electromyography, which not only helps to verify the diagnosis, but also to observe the structure of the median nerve and its environment, and to determine the degree of severity – a diagnostic technique which is used for detecting the bifid median nerve [15–17]. Nuclear magnetic resonance, primarily magnetic neurography, has proven to be a method of similar usefulness, but has not been routinely established yet [18].

Conventional treatment can be non-operative and operative. In the absence of direct external compression, conservative therapy consisting of immobilization and perineural application of corticosteroids are the first choice for the treatment of mild and moderate carpal tunnel syndrome. Immobilization is performed by wearing a special-purpose wrist orthosis during sleep for the period of three weeks. The application of corticosteroid therapy is contraindicated in the case of impaired skin integrity in the carpal tunnel area and in the presence of local infections as is relates to certain side effects –median nerve, ligament or blood vessel injuries. Surgical treatment is performed in cases of unsuccessful conservative treatment for the period of six months with a direct external cause of compression, and in the case of a severe carpal tunnel syndrome [3, 9, 19].

Treatment success rates vary from 40% with conservative therapy to 85% with surgical treatment [20]. The presence of the bifid median nerve poses a risk for the success of surgical approach [5].

Case Report

A 48-year-old patient, after a clinical suspicion of carpal tunnel syndrome (dominant night-time numbness of the second, third and outer half of the fourth finger on the palm side lasting for several months, accompanied by a positive Phalen's maneuver), has been confirmed by ultrasonography to be suffering from moderate carpal tunnel syndrome, with a detection of "incomplete" bifid median nerve in the carpal tunnel. The examination was performed with use of an ultrasound device Samsung Medison Co., LTD (Gangwon-do, Republic of Korea), with high-resolution linear probe 3-16 MHz **(Figure 1A)**. The existing ultrasonography results were afterwards verified on a magnetic resonance device using the 16-channel SENSE neuro-vascular coil, Philips Achieve, 1.5 – T **(Figure 1B).**

Electromyoneurography was performed conventionally and routinely on the median and ulnar nerve system with use of the Neuropack, Nihon Kohden

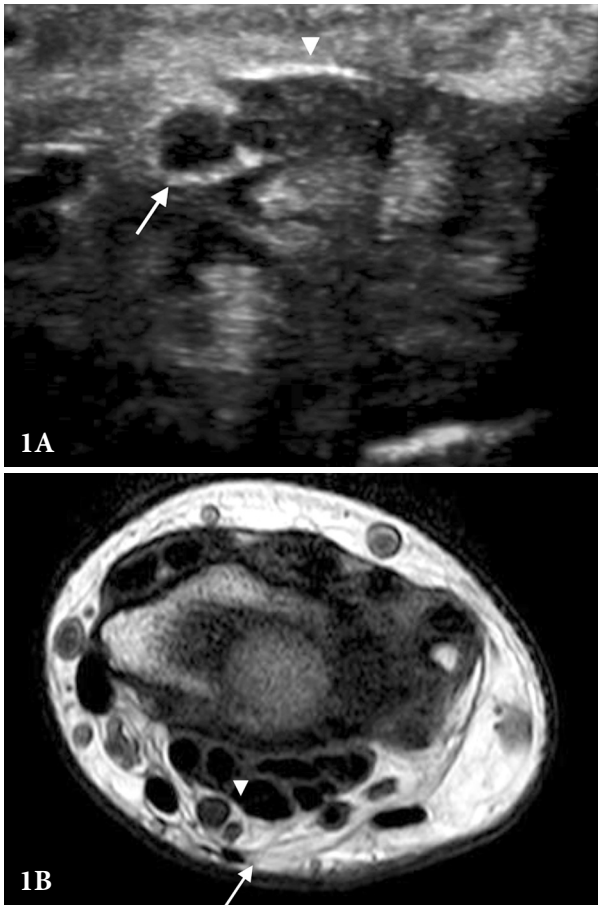

Figure 1A and B. Ultrasound and magnetic resonance of the "incomplete" bifid median nerve in the left-hand area. Asymptomatic external branch of the bifid median nerve, with the cross-sectional area of 6 mm^2 (represented by the arrow); symptomatic internal branch, with the cross-sectional area of 15 mm^2 (represented by the arrowhead).
Slika 1A i B. *Ultrazvuk i magnetna rezonancija "inkompletnog" bifidnog medijalnog nerva u nivou levog ručja. Asimptomatska spoljašnja grana bifidnog medijalnog nerva, površine poprečnog preseka 6 mm^2 (strelica); simptomatska unutrašnja grana, površine poprečnog preseka 15 mm^2 (glava strelice).*

device (Tokyo, Japan). Additionally, the electromyoneurography also confirmed a mild level of carpal tunnel syndrome **(Table 1)**. However, as difficulties were exclusively present in the innervation area of the median nerve internal branch, and due to the encouraging results of the imaging techniques and the possibility of incomplete correlation of electromyoneurography results, the lumbrical muscles and dorsal interossei muscles were examined. A significant difference in distal latencies of the median and ulnar nerve motor neurogram were registered using this technique (median nerve 4.3 ms, ulnar nerve 2.7 ms). The applied method confirmed a moderate degree of carpal tunnel syndrome.

Other potentially predisposing and causative factors were excluded by means of clinical and supplementary diagnostic methods.

The treatment was conducted with conventional approach, night-time immobilization for several months, and physical therapy, after which the patient showed a significant reduction of difficulties, followed by adequate objective findings.

Discussion

After a clinical suspicion of carpal tunnel syndrome, the ultrasonography and magnetic resonance imaging confirmed that the patient suffers from carpal tunnel syndrome and "incomplete" bifid median nerve was also diagnosed. In addition, a high degree of correlation between the clinical and imaging results was noticed – the internal branch of the bifid median nerve was symptomatic.

Conventional electroneurography (EMG) registered a status on the sensory fibers of the bifid median nerve internal branch, where affectedness was detected. Registration of a status on motor fibers of the bifid median nerve internal branch was also conducted at that point, but no damage was detected. It was concluded on the basis on these results that there is a mild degree of carpal tunnel syndrome. However, due to the fact that clinical and supplementary diagnostic findings showed a possibility of lesion on motor fibers of the internal branch (which was not found by the routine EMG), the lumbrical muscles and dorsal interossei muscles were examined, and damage to these fibers was detected. Therefore, the severity of the carpal tunnel syndrome was redefined as moderate.

The above shows that affectedness of exclusively one branch of the bifid median nerve and the application of conventional EMG may only cause a possibi-lity of false negative findings (in cases of damage on sensory fibers of the external branch, as neurography examinations are conducted only on sensory fibers of the internal branch) or insuffi-

Table 1. Electroneurography
Tabela 1. *Elektroneurografsko ispitivanje*

Nerve *Nerv*	Distal latency *Distalna latenca* (ms)	Conduction velocity *Brzina provođenja* (m/sec)	Amplitude *Amplituda*	
Median left side/*Medijanus levostrani*	3.7	57.9	9.3 mV	Motor study
Ulnar left side/*Ulnaris levostrani*	2.3	56.8	7.4 mV	*Motorna studija*
Median left side/*Medijanus levostrani*	3.4	38.5	11.7 μV	Sensor study
Ulnar left side/*Ulnaris levostrani*	2.7	52.2	48.2 μV	*Senzorna studija*

ciently valid findings (like in our case report, or in case of moderate damage to the external branch, when only damage on motor fibers is registered, when a wrong conclusion can be drawn about the pure carpal tunnel syndrome). In these cases, clinical findings can indicate application of an optional technique (examination of lumbrical muscles and dorsal interossei muscles (for motor fibers of the internal branch), i.e., examination of sensory latencies from the first finger of the median and radial nerve (for sensory fibers of the external branch))), which would provide a complete electromyoneurographic definition of these conditions.

Electromyoneurographic examinations that detect damage to exclusively one branch of the median nerve should raise suspicion about the existence of the bifid median nerve as a potential cause of carpal tunnel syndrome. A correct grading system of the severity levels of this syndrome, as well as verification of presence of this anatomical variation of the nerve, should result in a more successful selection of therapeutical options, and reduction of potential risks in case of surgical approach.

Conclusion

In certain cases, including the bifid median nerve, conventional, routine techniques are not completely reliable for establishing the appropriate electromyoneurographic verification and grading of the severity level of the carpal tunnel syndrome.

In case of carpal tunnel syndrome with electromyoneurographic disruption of only sensory or motor pathways of the median nerve, it would be mandatory to use one of the optional techniques, which would ensure getting more valid findings.

Furthermore, if the findings differ from the ones provided by the routine approach, and electromyoneurography was introduced as the initial supplementary diagnostic method, it would be mandatory to perform ultrasonography of peripheral nerves or magnetic resonance neurography as there is a possibility that the carpal tunnel syndrome is caused by the bifid median nerve.

This kind of approach would result in a more successful selection of certain therapeutical modalities and, furthermore, it would cause reduction of risks during the surgical treatment.

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