

Surgical versus conservative treatment in patients with cervical radiculopathy

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Abstract

Cervical radiculopathy (CR) is most commonly caused by spinal nerve root compression in the neural foramen. Main symptoms and signs are sharp or burning pain in the scapular region, neck, shoulder, arm and chest, sensory disorders and muscle weakness. Symptoms differentiate greatly between patients, while the results of clinical tests are often unreliable. Imaging and electrodiagnostic studies are therefore used to establish the diagnosis. The goals of conservative or operative treatment are mainly pain reduction, function improvement and prevention of reoccurring symptoms. Differences between conservative and operative treatment are still not clear. To analyse patients with CR and comparison of long-term effectiveness between conservative and surgical treatment. Retrospective analysis of demographic and clinical characteristics of patients with electro-physiologically confirmed CR and comparison of long-term effects between conservative and surgical treatment. The 7th cervical nerve root is most commonly affected, independently of patients' hand dominance. The majority of patients are male >50 years old. The most common symptoms are neck and arm pain with upper limb numbness. Surgical and conservative treatment are comparatively successful. Both methods significantly decrease pain in the neck and upper limb, reduce and improve reoccurring symptoms and fulfil patients' expectations. Untreated patients had lower pain intensity at the beginning, which did not improve and is present in their everyday life. This approach does not meet patients' expectations. Results are consistent with the conclusions of other studies considering surgical and conservative treatment of patients with CR. Furthermore, the results show the effectiveness and importance of physiotherapeutic treatment. Keywords: cervical radiculopathy, electrodiagnosis, conservative and operative treatment

Primerjava operativnega in konservativnega zdravljenja pacientov s cervikalno radikulopatijo

Povzetek

Najpogostejši vzrok cervikalne radikulopatije (CR) je okvara vratne živčne korenine pri izstopu iz hrbtenjače, ki se kaže z ostro ali pekočo bolečino med lopaticami, v vratu, ramenu, roki ali v predelu prsnega koša, motnjami senzibilitete in mišično šibkostjo. Simptomi in znaki se med posamezniki zelo razlikujejo, zato je za potrditev diagnoze potrebna natančna anamneza, klinični pregled ter elektrofiziološke in slikovne preiskave. Zdravljenje je operativno in konservativno s ciljem zmanjšanja bolečine, izboljšanja funkcije in preprečevanja ponovnega nastanka težav. Razlika med konservativno in operativno zdravljenimi pacienti kljub številnim raziskavam še vedno ni pojasnjena. Analiza pacientov s CR in primerjava dolgoročne uspešnosti operativnega in konservativnega zdravljenja. Retrospektivna raziskava s pregledom medicinske dokumentacije in opisom demografskih, anamnestičnih in kliničnih značilnosti pacientov z elektrofiziološko potrjeno okvaro vratnih živčnih korenin ter primerjava dolgoročne uspešnosti operativnega in konservativnega zdravljenja. Najpogosteje gre za okvaro korenine C7 neodvisno od dominantnosti zgornje okončine, pogosteje pa so prizadeti moški po 50. letu starosti. Najpogostejši simptom je bolečina v vratu in roki z mravljinčenjem v zgornjem udu. Učinkovitost operativnega zdravljenja in fizioterapevtske obravnave je primerljiva. Obe metodi značilno zmanjšata bolečino v vratu in roki ter pogostost pojavljanja težav, izboljšata stanje in izpolnita pričakovanja pacientov. Za paciente brez zdravljenja pa je značilnejša manjša začetna bolečina, ki se pri večini ne spreminja in je stalna. Takšen pristop praviloma ne izpolni pričakovanj pacientov. Ugotovitve se skladajo z rezultati že objavljenih raziskav in kažejo na pomembnost in učinkovitost fizioterapevtske obravnave. Ključne besede: cervikalna radikulopatija, elektrofiziološke meritve, konservativno in operativno zdravljenje

1. INTRODUCTION

Neck pain has become a common problem within the adult population. It is estimated that 30-50% of United States of America adult residents will experience it at least once in a given year (Roth et al., 2009), but only 20% of all neck and shoulder pain are of neurological origin (Gangavelli et al., 2019). Pain can be radicular, myopathic, or musculoskeletal in which the etiological mechanism is not yet completely clear, as opposed to myopathic and radicular pain (Kuhta, 2012). Cervical radiculopathy (CR) is a neurological disorder, caused by spinal nerve root compression, most commonly in the neural foramen region (Woods and Hilibrand, 2015). The population-based study performed in Rochester, Minnesota, estimated the annual incidence of CR to be 103.3 per 100.000 for men and 63.5 per 100.000 for women (Radhakrishnan et al., 1994). The aetiology of CR is associated with mechanical compression of the nerve roots, which is commonly a result of a herniated intervertebral disk, formation of osteophytes or spondylosis, but in some cases the cause may remain unknown (i.e., idiopathic CR) (Iyer and Kim, 2016; Abbed and Coumans, 2007). It typically presents with sharp or burning pain in the scapular region, neck, shoulder, arm, or chest pain (Abbed and Coumans, 2007), sensory changes, muscle weakness, and diminished myotatic reflexes of the affected upper limb (Woods and Hilibrand, 2015). Location and symptom distribution depend on the affected nerve root (Abbed and Coumans, 2007). Sensory changes are more common than motor deficits (85% and 68%, respectively) (Henderson et al., 1983). Based on the duration of symptoms we can distinguish between acute (50%), subacute (24%), and chronic (26%) CR (Abbed in Coumans, 2007; Radhakrishnan et al., 1994). Acute CR mostly occurs in younger patients, while subacute radiculopathy is more common in patients with pre-existing cervical spondylosis. Chronic radiculopathy develops from untreated acute or subacute CR or in patients who have failed to respond to treatment (Abbed in Coumans, 2007). Symptoms and clinical signs differ greatly among patients. A thorough history, neurological clinical examination, and further electrodiagnostic or imaging studies are therefore of most importance (Iyer and Kim, 2016; Young, 2009). Treatment of CR consists of conservative or operative management aimed at reducing pain, improving arm and neck function, and preventing symptoms from reoccurring. Surgical treatment is usually considered in patients with significant progressive neurological deficits or has failed to respond to at least 6 to 12 weeks of conservative treatment (Liang et al., 2019). Physiotherapy of CR patients consists of mobilization and stabilization exercises, short-term use of neck collar, mechanical or manual traction, stretching and strengthening exercises of neck musculature and mobilization or manipulation of the cervical and thoracic spine. Education of patients encourages them to cooperate and work independently (Blanpied et al., 2017). Despite a lot of research, the difference between conservative and surgical treatments of patients with CR has not yet been clarified.

2. METHODS

Our retrospective study included patients with electrophysiologically confirmed cervical nerve root compression at the Institute of Clinical Neurophysiology, Ljubljana University Medical Centre, between February 2011 and 2021. The inclusion criteria were CR symptoms and clinical signs and electrophysiologically confirmed cervical spinal nerve root compression. Typical symptoms and clinical signs include neck and/or arm pain, numbness, sensory changes, muscle weakness and diminished myotatic reflexes. Patients with unclear clinical signs, cervical myelopathy, fibromyalgia, unruled differential diagnosis (e.g. neuralgic amyotrophy, polyneuropathy, brachial neuritis, etc.) or with a surgical procedure done on the cervical spine before electrophysiological studies were completed, were excluded from this study. The data was transferred to Excel (Microsoft Office Professional Plus, Redmond, USA). Descriptive statistics were made using SPSS (IBM Software, Stanford, USA) and GraphPad program (GraphPad Software, San Diego, USA). We used the Kruskal-Wallis one-way analysis of variance test and a Z-test for population comparison. Significance level was set at $p < 0.05$.

3. RESULTS

Between February and May 2021, we revised the medical charts of patients with an electrophysiological confirmed cervical spine nerve root compression (n=325), who have been diagnosed at the Institute of Clinical Neurophysiology in the last ten years. 243 patients were enrolled in our research, based on the inclusion and exclusion criteria. We gathered demographic, clinical and electrophysiological data from the given medical charts. Patients were asked to participate in our study and fulfil the informed consent. Additional data regarding some general information (handedness, occupation, other chronic health conditions, use of cigarettes), the course of treatment, and their current status was also gathered. No standardized questionnaire for patients with CR exists. Therefore, a questionnaire used by Wibaolt (2018) was translated, adjusted and sent to patients. In case of an uncompleted or incompletely filled out questionnaire, patients were called via phone (n=87) if it was possible.

The first part of the research was based on demographic and clinical data of 243 patients with electrophysiologically confirmed CR. Results show a significantly larger percentage of patients with compression of only one cervical nerve root (n=185; 76%) (Table 1). Therefore, we focused on this group of patients. Bilateral spinal nerve root compression is rarer (n= 15; 6 %). CR is significantly more common in males (p <0.00001) above the age of 50 at the time of their first appointment in EMG laboratory. Results show no differences between the affected left or right side (p = 0.44).

Table 1: Demographic characteristics of patients with one cervical spinal nerve root impingement

Demographic characteristics	Percentage
Number; n	185
Male; n (%), p-value	116 (63), p <0.00001
Age at first EMG exam; mean (SD), min – max (years)	52 (11), 28-80
Affected side; n (%), p-value	96 (52), p = 0.44
Duration of symptoms; mean (SD), min – max (months)	7 (12), 1-84

SD – standard deviation

The 7th cervical spinal nerve root is most commonly affected (64 %) (Table 2). We found no differences among affected spinal nerve root levels regarding sex or hand dominance.

Table 2: Population comparison among affected spinal nerve root levels

	C5, C6	C7	C8, Th1	SUM
Number; n (%)	31 (17)	119 (64)	35 (19)	185 (100)
Male; n (%)	18 (58)	80 (67)	18 (51)	116 (62)
Affected right side; n (%)	14 (45)	64 (53)	19 (54)	96 (52)

Patients with electrophysiologically confirmed one cervical spinal nerve root compression experienced pain in the neck (67%) and/or arm pain (77%) with numbness (77%). Information about pain in the scapular region and chest pain was missing in revised medical charts in 81 and 94 % of cases, respectively. A clinical neurologic examination results were similarly missing in most cases. Information about muscle trophicity was present in 35%, muscle strength in 46%, sensibility in 51%, and myotatic reflexes in less than 50% of cases. Carpal Tunnel Syndrome was coincidental in 26% of patients with C7 spinal nerve root compression.

In the second part of the research, we compared demographic, clinical, electrophysiological characteristics and the long-term effects between surgical, conservative and untreated patients with CR (n=107). Effectiveness was measured based on the level of neck and arm pain before and after treatment (Visual Analog Scale), current problems assessment, and expectation fulfilment. Demographic and anamnestic characteristics of 107 patients are shown in Table 3. There was no significant difference in sex and occupation. A third of patients was cigarette smokers and 60% had another chronic condition, most commonly circulatory system diseases (38 %). Most patients have had

electrophysiologically confirmed compression of one cervical spinal nerve root (84%), and only 26% had a control EMG exam later on. Patients were most commonly treated with a conservative approach (61%), in which physiotherapy was used in 77%. Surgical procedure underwent 19% of patients and 20% were left untreated. The use of alternative methods is relatively low (1%), but 9% of patients combined physiotherapy with alternative techniques such as chiropractic, acupuncture, EFT tapping, MTVSS, Barsi technique and home use of a bioprone machine.

Table 3: Demographic and anamnestic characteristics of 107 patients with a fully completed questionnaire.

Demographic and anamnestic characteristics	Proportion
Male; n (%)	48 (45)
Age at first EMG exam; mean (SD), min – max (years)	55 (10), 32-78
Right-handed; n (%)	94 (88)
Smokers; n (%)	34 (32)
Blue colour workers; n (%)	57 (53)
Other chronic conditions; n (%)	
No chronic diseases	43 (40)
Diseases of circulatory system	42 (38)
Endocrine, nutritional, and metabolic diseases	21 (20)
Diseases of the musculoskeletal system and connective tissue	11 (10)
Diseases of the nervous system	5 (5)
Respiratory disease	5 (5)
Neoplasms	3 (3)
Mental and behavioural disorders	2 (1.9)
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	1 (1)
Diseases of genitourinary system	1 (1)
Compression at one level; n (%)	90 (84)
Control EMG exam after treatment	28 (26)
Types of treatment	
Surgical; n (%)	20 (19)
Conservative; n (%)	66 (61)
Physiotherapy; n (%)	51 (77)
Medication; n (%)	8 (12)
Alternative methods; n(%)	1 (1)
Physiotherapy combined with alternative methods; n (%)	6 (9)
No treatment; n (%)	21 (20)

SD – standard deviation

Table 4 shows the demographic and clinical characteristics of 92 patients underwent a surgical procedure (22%), had physiotherapy (55%), or were not treated (23%) and participated in this part of the research with a completely fulfilled questionnaire. We found that men rarely decide for operative treatment (25 %) and are more likely to not receive any (66 %). There are no statistically significant differences in age between groups. Results show that patients have waited longer for physiotherapy than a surgical procedure. Control EMG exam was more often performed in operated patients. Those who have bilateral and multilevel compression of cervical spinal nerve root are more often treated with surgery. There are no electrophysiological differences between different groups of patients. 20% of patients were treated with physiotherapy before a surgical procedure, meanwhile, 95% of them

received physiotherapy afterward. There was a high need for additional therapies (67%) in conservatively treated patients.

Table 4: Comparison of demographic characteristics and efficiency of surgical (SUR), physiotherapeutic (PHY) treatment, and untreated (UNT) patients.

	SUR	PHY	UNT	DIFF
Demographic characteristics				
Number; n (%)	20 (22)	51 (55)	21 (23)	SUR/PHY PHY/UNT
Male; n (%)	5 (25)	23 (45)	14 (66)	SUR/UNT
Age at first EMG exam; mean (SD), min–max (years)	52 (10), 32-71	57 (10), 38-78	53 (10), 33-76	NSS
Time EMG – treatment; median (5-95 perc)	1 (0-11)	0 (0-8)	/	/
Control EMG; n (%)	11 (55)	10 (20)	3 (14)	SUR/PHY SUR/UNT
One-sided one level impingement; n (%)	14 (70)	44 (86)	18 (86)	NSS
One-sided multi-level impingements; n (%)	1 (5)	6 (12)	1 (5)	NSS
Bilateral multi-level impingements; n(%)	5 (25)	1 (2)	2 (9)	SUR/PHY
Treatment efficiency				
Neck pain (VAS)				
Before treatment; mean (SD) min – max	8 (3), 0-10	7 (2), 0-10	5 (4), 0-10	SUR/UNT PHY/UNT
After treatment; mean (SD), min – max	2 (3), 0-9	4 (2),0-10	4 (3), 0-9	NSS
Score difference; mean (SD), min – max	5 (3), 1-10	4 (2), 1-10	1 (4), 5-10	SUR/UNT PHY/UNT
Decreased neck pain; n (%); Δ mean (SD), min – max	18 (90); 5 (3), 1-10	43 (84); 5 (2), 1-10	8 (38); 5 (3), 2-10	SUR/UNT PHY/UNT
Increased neck pain; n (%); Δ mean (SD), min – max	1 (5); 1 (1), 1-2	1 (2); 1 (1), 0-1	4 (19); 3 (1), 5-1	PHY/UNT
Unchanged neck pain; n (%)	1 (5)	7 (14)	9 (43)	SUR/UNT PHY/UNT
Arm pain (VAS)				
Before treatment; mean (SD) min – max	8 (3), 0-10	7 (2), 0-10	5 (4), 0-10	SUR/UNT PHY/UNT
After treatment; mean (SD) min – max	2 (3), 0-9	3 (2), 0-9	3 (4), 0-10	NSS
Score difference; mean (SD) min – max	5 (3), 2-10	4 (2), 1-10	2 (4), 6-9	SUR/UNT PHY/UNT
Decreased arm pain; n (%); Δ mean (SD), min – max	17 (85); 6 (3), 0-10	47 (92); 4 (2), 1-10	9 (43); 5 (2), 2-9	SUR/UNT PHY/UNT
Increased arm pain n (%); Δ mean (SD), min – max	1 (5); 1 (1), 8-9	1 (2); 1 (1), 7-8	3 (14); 4 (2), 6-1	PHY/UNT
Unchanged arm pain; n (%)	2 (10)	3 (6)	9 (43)	SUR/UNT PHY/UNT
Reoccurrence of problems after treatment; n (%)				
Never; n (%)	2 (10)	1 (2)	4 (19)	PHY/UNT
Sometimes; n (%)	9 (45)	23 (45)	5 (24)	NSS
Multiple times per week; n (%)	3 (15)	8 (16)	1 (5)	NSS
Every day; n (%)	2 (10)	7 (14)	3 (14)	NSS
Constantly; n (%)	4 (20)	12 (23)	8 (38)	NSS

Current problems; n (%)				
Completely gone; n (%)	3 (15)	3 (6)	4 (19)	NSS
Distinctly improved; n (%)	5 (25)	14 (27)	3 (14)	NSS
Slightly improved; n (%)	7 (35)	24 (47)	4 (19)	PHY/UNT
Unchanged	2 (10)	3 (6)	4 (19)	NSS
Slightly worse; n(%)	2 (10)	4 (8)	4 (19)	NSS
Distinctly worse; n(%)	1 (5)	3 (6)	2 (10)	NSS
Patient's expectations; n (%)				
Fully met	11 (55)	18 (35)	6 (29)	NSS
Not met	3 (15)	10 (20)	12 (57)	SUR/UNT PHY/UNT
Partially met	6 (30)	23 (45)	3 (14)	PHY/UNT

The level of statistical significance was set at $p < 0.0$; NSS – no statistical significance

Results show THAT untreated patients have significantly lower neck and arm pain at the beginning compared to two other groups of patients. Both surgical as well as physiotherapeutic treatment improve neck and arm pain (>85% and >84%, respectively). The percentage of patients with unchanged neck (43%) or arm (14%) pain was significantly higher in untreated patients. Figure 1 represents the level of neck and arm pain intensity patients experienced before and after treatment.

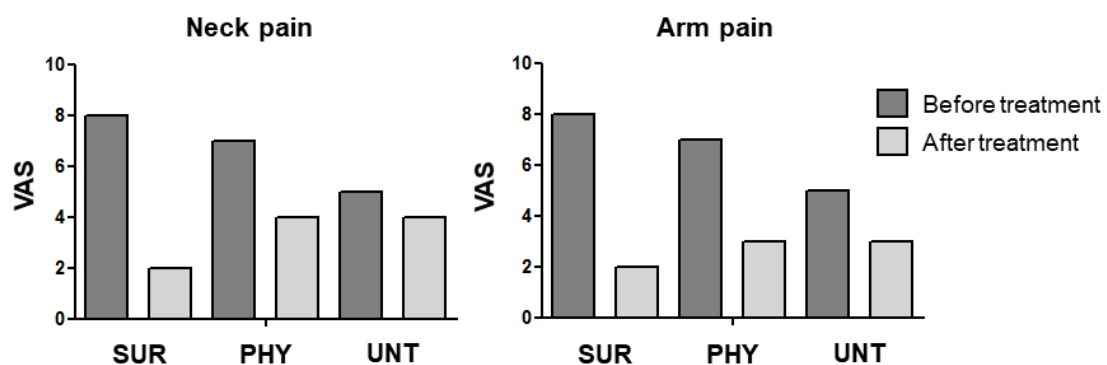


Figure 1: Differences in neck and arm pain intensity (VAS) before and after surgical treatment (SUR), physiotherapy (PHY) and in untreated patients (UNT).

Percentage of patients with none or occasional problems is comparable within surgically (55%) and physiotherapeutically treated (47%), and higher than in the group with no treatment (43%). Untreated patients experience symptoms every day or are present all the time (52%). Number of surgically or conservatively managed patients with fully to partly improved symptoms was similar (75% and 80%, respectively). Meanwhile, the percentage of untreated patients with improved symptoms is 42%. Patients' expectations were met in 55% of operated patients, 23% of physiotherapy group and 29% of untreated patients. The no-treatment approach did not meet the expectations of 57% of those patients.

4. DISCUSSION

Based on the results of our retrospective study, we found that among 243 patients with electrophysiologically confirmed CR most patients have one cervical spinal nerve root compression ($n=185$, 76%). The 7th cervical spinal nerve root (C7) is most frequently affected (64%). Bilateral compression of cervical spinal nerve roots is rare (6%) and more common among slightly older patients with a mean age of 61 years. Multilevel or bilateral cervical radiculopathy is more likely in patients with spondylotic changes, which result about a decade later from degeneration of intervertebral discs (Roth, 2009; Podnar, 2003). Furthermore, compression of two spinal nerve roots at the same time is less common in the cervical spine than lumbar. Cervical nerve roots run almost horizontally through the neuroforamen, whereas they run more vertically in the lumbar region, making it easier to compress two

roots at once (Brujin, 2020). The majority of patients with one level cervical radiculopathy are males ($p=0.00001$) in their 50s (average 52 ± 11 years). Results are consistent with findings of other epidemiologic studies, where higher incidence is reported in men (107.3 on 100.000 men and 63.5 on 100.000 women) between the ages of 40 and 60 (Radhakrishnan et al., 1994). The symptomatic side does not correlate with hand dominance (52% vs. 48%; $p=0.44$). Radhakrishnan et al. (1994) came to similar conclusions, where 47.4% of patients had right-sided and 47.6% left-sided compression. The main reported symptoms are neck (67%) and/or radiating arm pain (77%) with numbness (77%) in the upper limb. Mentioned symptoms were also well represented in the revised medical documentation (neck pain 71%, upper limb pain 80%, numbness 81%), while the information about pain in the pectoral and scapular region was missing in more than 80 and 90% of all cases, respectively. Henderson et al. (1983) found that pain in the pectoral region is present in 18%, while more than half of patients with CR experience pain in the scapular region. Symptoms are often unreliable for establishing the correct diagnosis and differentiating between affected spinal nerve root levels (Wainner et al., 2003). Nonetheless, the anatomic distribution of symptoms plays an important role in clinical reasoning, for example, pain in the scapular region combined with paraesthesia in the thumb and index finger are much more common in patients with C5, C6 spinal nerve root damage (Tanaka et al., 2006; Yoss et al., 1957). Although medical documentation should include positive and negative findings of a performed neurological clinical exam, we found several information about muscle trophy, muscle strength and sensory changes to be missing (trophy 35%, muscle strength 46%, sensory changes 51%). A similar pattern was also observed in the testing of myotatic reflexes (brachioradialis 47%, biceps 50%, triceps 52%, pronator 40%, finger flexors reflex 40%). On the other hand, there was a small percentage of diminished or absent reflexes (brachioradialis 7 %, biceps 13 %, triceps 15 %, pronator 1 % in finger flexors reflex 2 %), which does not correlate with findings of Yoss et al. (1957), who showed a direct correlation between diminished myotatic reflexes and pathological mid operative findings in 82% of patients. Sensory changes are not specific enough for establishing a diagnosis, but are, the same as the anatomic pain distribution, important for further clinical reasoning and testing. The same goes for manual muscle testing, where the absence of isolated muscle weakness does not exclude disorders and its presence does not necessarily confirm CR (Kopenhagen and Flynn, 2011; Weinner et al., 2003). Nevertheless, a thorough history and clinical examination remain a golden standard for the diagnostic procedure as it directs the examiner to further research (Weiss et al., 2016). The absence of anamnestic information and results of clinical testing leaves us with a piece of doubt. There is a possibility that the examiner did not perform each part of the clinical exam or weather normal findings were not reported in medical documentation. We suggest for medical charts to always contain information on present symptoms and their distribution, muscle atrophy and strength, myotatic reflexes and sensory changes in patients with clinical suspicion for CR. We didn't find anamnestic (gender, affected side) and clinical differences (neck and arm pain, numbness) between patients with different levels of spinal nerve root compression. Pain in the scapular region was only present in patients with electrophysiologically confirmed compression of C7 (22%) and C8, Th1 (20%). This is in accordance with the statements of other researchers. Pain as a result of C5, C6 compression is mostly located above the scapula, whereas compression of C7, C8 spinal nerve root causes pain directly in the scapular region (Kang, 2020). Results of clinical testing between different affected spinal nerve root levels were comparably represented. Myotatic reflexes were looked at in over 50% of patients, most frequently (>65%) in those with compression of C5, C6 spinal nerve root. Ratio of clinically checked myotatic reflexes typical for each level of impingement versus the ratio of atypical reflexes is comparable (C5-6, Bra 65 % and Bic 74 % vs. Tri 61 %, Pro 52 % and Flex 52 %; C7, Tri 49 % and Pro 35% vs. Bra 41 % and Bic 43 % and Flex 36 %; C8-Th1, Fle 49 % vs. Bra 51 % and Bic 54 % and Tri 55 %

and Pro 46 %). This is due to the fact that myotatic reflex testing comes before neurophysiological examination. Interestingly, we found a low percentage of patients with diminished or absent myotatic reflexes of the upper limb typical for the damaged level of spinal nerve root (C5-6: Bra 23 %, Bic 45 %; C7: Tri 21 %, Pro 1 % and C8-Th1: Flex 3 %). The absence of biceps reflex seems to be more specific in C5, C6 levels of compression versus the brachioradialis reflex (absence: 45 vs. 23%, presence: 29 vs 42%). The specificity of triceps and pronator reflex in compression of C7 is lower than we presumed (absence: 21 vs 1%; presence: 29 vs. 34%). This can also be seen in finger flexor reflex in compression of C8, Th1 spinal nerve roots (absence: 3%, presence: 46%). There were no significant differences in EMG characteristics among different levels of cervical spinal nerve root compressions. Sensory nerve conduction studies were found to have lower sensitivity in diagnosing cervical radiculopathy compared to motor nerve conduction parameters (5-28% vs 23-64%), however, both methods are useful diagnostic tools (Pawar et al., 2013). Sensory conduction parameters are normally within the normal range in case of a mild, as well as more extensive nerve damage. Lesions distal from the dorsal ganglion must be ruled out in case of found abnormalities (Weiss in sod., 2016; Pawar in sod., 2013).

We found a high number of missing sensory conduction studies done on typical sites of the affected cervical nerve root (C5-6, Cutaneus antebrachii lateralis 90 %, Radialis thumb 94 %; C7, Medianus middle finger 91 %; C8-Th1, Ulnaris little finger 81 %). We also found an interestingly high coincidence of Carpal Tunnel Syndrome in patients with C7 radiculopathy and Ulnar Neuropathy in those with C8 radiculopathy (26 and 9% respectively). We highly suggest consistent use of neurophysiological protocols and exclusion of coexisting compression of the Median nerve in the wrist in suspected C7 radiculopathies. In 1973 Upton and McComas were able to show some evidence for the presence of "double crush" syndrome, but their theory was later on discredited by a number of researchers. A larger study showed only 0.8% of patients had Carpal Tunnel Syndrome or Ulnar Neuropathy with simultaneously present lesions on a corresponding cervical spinal nerve root (Morgan and Wilbourn, 1998). We presume that a high incidence of CTS found in patients with compression of the 7th cervical spinal nerve root is a consequence of a high incidence of CTS in the general population (3.8%, higher prevalence in women) (Atroshi et al., 1999).

In the second part of our study, we compared the long-term effectiveness of surgical and conservative treatment and a group of untreated patients. Patients were enrolled based on the completed questionnaire (n=107). There were no significant differences in gender and patients' occupation. A few studies have reported a higher incidence of disk herniation among army aviators, professional divers, and heavy workers operating with vibrational devices (Wong et al., 2015; Mason et al., 1996), however, there are no studies to confirm a direct influence of occupation on cervical radiculopathy occurrence. Most of the enrolled patients were right-handed (88%), but no side was more frequently affected (p=0.44). Swedish scientists came to a similar conclusion and were not able to find a correlation between handedness and the affected side of the cervical spine (Persson et al., 1997). A third of patients were regular or occasional cigarette smokers. Smoking is a risk factor for degenerative changes of intervertebral disks and thus related problems (Iyer and Kim, 2016). A large number of patients with chronic circulatory diseases was expected as its high incidence in the Slovenian population has already been reported, furthermore, it is stated as a primary cause of death (NIJZ, 2019). Most participants were treated conservatively (62%) and 19% underwent a surgical procedure in the cervical spine. There were 20% of patients who have not received any treatment. Podnar and Rigler (2006) observed a similar ratio in used treatments. In the first four months of 2002 there were 20% of Slovenian patients with electrophysiologically confirmed lumbar or cervical radiculopathy were treated surgically, 66% conservatively and 14% were left untreated. The structure of the questionnaire used in this study enabled us to show the percentage of surgically treated patients who received physiotherapy before the procedure. It's supposed to be 20%, but due to the worldwide excepted treatment guidelines (operation after failed conservative treatment or progressive neurological impairment), the number is presumably much higher. Meanwhile, the number of patients who were given physiotherapy after

surgical treatment is reliable. Almost all of those patients (95%) received rehabilitation in medical thermal resorts. There is a lack of scientific research on post-operative physiotherapy. Wibault et al. (2018) compared structured physiotherapy (max. 20 weeks long physiotherapeutic treatment with progressive specific exercises for neck musculature and cognitive behavioural approach for stress and pain management) and standard physiotherapy (no additional therapies after hospital physiotherapy care) in previously operated patients with discogenic CR. They didn't find any differences between the two groups, both methods were successful in reducing problems ($p < 0.001$). Structured physiotherapy was slightly more effective 6 months post-surgery compared to standard care. More than half of the standardly treated patients expressed a need for additional physiotherapy, probably due to reoccurring symptoms, and received it later on. There is a clear indication for long-term conservative care of surgically treated patients. The authors conclude, that there is a need for more studies on postoperative physiotherapy to widen clinical guidelines for CR patients (Wibault et al., 2018). Results are consistent with our findings where 67% of physiotherapeutically treated patients needed additional physiotherapies, a quarter of them even once or more per year (26%). Moreover, reoccurrence of symptoms is quite frequent in CR patients (29-32%) (Lees and Turner, 1964; Radhakrishnan et al., 1994). Output measurements were analysed in patients with physiotherapeutic (55%), surgically (22%) treated and untreated patients (23%). There were no statistical differences in age between mentioned groups ($p=0.174$). Men are less likely to undergo a surgical procedure (25 %) and mostly do not get treatment at all (66%). We could not find a similar pattern in revised literature (Radhakrishnan, 1994). It also seems that patients were waiting longer for physiotherapy. This confirms concerning long waiting lists in the public health system. Ideally, patients should get physiotherapy faster, as failure to respond to conservative treatment is one of the main indications for operation. Furthermore, we believe that quality and well-timed physiotherapy would hold off the need for surgery. The probability of an operation increases with a higher number of affected cervical nerve roots. We found a significantly higher number of operated patients with multilevel and/or bilateral compression of cervical nerve roots ($p=0.002$), who, based on the reviewed literature, probably had spondylotic changes (Roth, 2009) or a combination of multiple degenerative changes. Surgically treated patients were also sent to control EMG testing more frequently compared to the rest of the participants ($p=0.006$). There were no significant electromyographic differences between differently treated patients with one cervical nerve root compression ($n=76$). Because of the small number of patients with control EMG testing (22%), we concluded there was no meaning in comparing electromyographic results before and after treatments. In addition, there was a significant difference in the ratio of patients who had control EMG testing and were surgically treated, compared to physiotherapy ($p=0.004$) and no treatment group ($p=0.006$). Electrophysiological tests play an important role in diagnostics and evaluation of neurological, neuromuscular, or muscular diseases (AANEM, 2015). Its findings also direct choice of treatment, considering it was shown that those who had pathological EMG results were more frequently treated and their 3-year outcome was better (Podnar in Rigler, 2006). We suggest a prospective study comparing outcomes of patients with clinical suspicion for CR and patients with electrophysiologically confirmed cervical spinal nerve root compression.

Analysis of output measurements between different treatments is interesting. Untreated patients are characterized by minor neck and upper limb pain. Podnar and Rigler (2006) showed that patients with later diagnosed CR experience a higher level of pain than other patients treated in the EMG laboratory. This correlates with our findings. Surgically and physiotherapeutic treated patients assessed their level of pain on a Visual Analog Scale with a 7 and 8, respectively, before treatment, while untreated patients assessed it with a 4-5. Both treatments successfully reduced pain. There were no significant differences in the average level of the neck and arm pain patients experience at the moment ($p=0.07$ vs. 0.25 , respectively), nonetheless, post-treatment pain improvement is greater in surgically and physiotherapeutically treated patients. There was a high percentage of untreated patients with unchanged or even worsened neck (62%), as well as, arm pain (57%). A similar pattern can be seen in the reoccurrence of patients' problems (pain, numbness, muscle weakness), where the ratio of patients with none or occasional problems was comparable, meanwhile, the untreated group of patients experiences symptoms every day or are they even constant (52% vs. 30-37%). On the other hand, the largest proportion of patients with no problems at all also happens to be in the untreated group (19%)

and is significantly higher than in patients with physiotherapy treatment ($p=0.01$). We presume these patients experienced a spontaneous improvement because of mild nerve damage. Netherlandish authors report good improvement with the "wait and see" method with no use of structured treatment (Kuijper et al., 2009), but a decrease in pain is slower and smaller compared to patients who received physiotherapy. 75 to 80% of surgically or conservatively treated patients, respectively, have no problems or are partially still present in their lives, while the percentage is half smaller in untreated patients (42%). Patients' expectations were mostly met in surgically treated patients. The no-treatment approach does not generally meet patients' expectations (>50%).

Based on the results of this research, the long-term effects (>1 year) of surgical and physiotherapeutic treatments of patients with electrophysiologically confirmed compression of a cervical spinal nerve root are comparatively successful. Both methods significantly reduce patients' level of neck and arm pain, lower the reoccurrence and intensity of problems, and fulfil patients' expectations. On the other hand, untreated patients are characterized by a minor neck and upper limb pain, which in most cases does not change or even worsens and remains present in their everyday life. This approach does not meet patients' expectations. Enguist et al. (2013) did a prospective randomized study where they compared physiotherapeutic treatment and a combination of a surgical procedure and physiotherapy. They found a significant decrease in Neck Disability Index score and neck and arm pain no matter the chosen treatment ($p=0.001$). Statistical significant differences were only found in subjective assessment of current problems and lower pain intensity one-year post surgery ($p<0.05$), while outcome measures were comparative after two years. We can conclude that patients who undergo a surgical procedure see improvement faster than others, but there are no long-term benefits compared to conservative treatment. Peolsson et al. (2013) found similar results that showed no significant long-term (2 years) differences in physical function outcome in cervical radiculopathy patients after physiotherapy alone compared with anterior surgery followed by physiotherapy. Both methods improved neck active range of motion (flexion: $p=0.01$; extension: $p=0.006$), hand-related function ($p=0.0001-0.03$) and hand grip strength (0.01). Authors Podnar and Rigler (2006) did not find any correlation between the choice of treatment and clinical outcome ($p=0.28$), yet the study demonstrated a better clinical outcome in patients with spontaneous improvement before the EMG examination. Based on the results of the present study, we conclude both surgical and physiotherapeutic treatments are comparatively successful. Care must be taken in interpreting results of operated patients, who probably had progressive worsening of neurological symptoms, which we were not able to clearly show due to the lack of clinical exam results and a retrospective study design. We believe there are too many patients left untreated, mostly stereotypically men, which is unacceptable in today's society. Those patients with reoccurring problems should receive appropriate conservative treatment since the importance and effectiveness of physiotherapy are clear.

The retrospective study design was our main limitation, as it enables control of research factors, for example, the course of treatment. Therefore, we cannot know which methods and techniques were used in conservative treatments and their true impact on patients' problems. The measured effectiveness was also completely subjective and no other objective measurements were analysed due to the retrospective design. On the other hand, this approach allows us to have a clear insight into the not ideal clinical environment, where the execution of recommended protocols might differ from laboratory conditions. In addition, a smaller number of patients participated in this research because of the long time that has passed since their diagnosis, and, mostly the elderly, were therefore unable to answer asked questions. We suggest further prospective clinical studies to additionally analyse the effectiveness of different treatments for patients with electrophysiologically confirmed cervical spinal nerve root compression in different stages.

5. CONCLUSION

Neck pain has become a common problem within the adult population. Supposedly, up to half of United States adult residents will experience it at least once in a given year, however, it rarely occurs due to a neurological disorder. Cervical radiculopathy is most commonly caused by a cervical disc herniation, osteophytes, spondylosis or a combination of multiple mechanisms that ultimately result in nerve root

compression. Treatment guidelines suggest patients to be treated conservatively and undergo a surgical procedure after inefficient conservative treatment or worsening condition. We found an increasing number of studies regarding the efficiency of different methods of treatment, but the quality seems to be low. Moreover, the majority of researchers focus only on short-term effects over one year. Based on the results of our retrospective study, the 7th cervical spinal nerve root (C7) is most frequently affected and the majority of patients are males in their 50s. The symptomatic side does not correlate with hand dominance. The main symptoms are neck and arm pain with numbness in the upper limb. Patient's history and clinical findings are not specific for establishing a diagnosis or involved nerve root and are poorly represented in revised medical documentation. Electrophysiological studies are used to identify the affected nerve root level and confirm a clinical suspicion. Due to the given clinical circumstances, their execution differs from recommended electromyographic protocols and standards of care. Surgical and physiotherapeutic treatments are comparatively successful. Both methods significantly reduce patients' level of neck and arm pain, lower the reoccurrence and intensity of problems, and fulfil patients' expectations. On the other hand, untreated patients are characterized by minor neck and upper limb pain, which in most cases does not change and remains present in their everyday life. This approach does not generally meet patients' expectations. We suggest a standardization of patient's history and clinical findings of neurological examination, as well as the electrophysiological parameters. The importance and effectiveness of physiotherapy are clear, yet patients wait for it too long. Although shortening waiting times is complex, the accessibility of physiotherapists is crucial. We believe this would significantly improve the health status of CR patients. Furthermore, there is a need for high-quality prospective studies with thoroughly thought out protocols and controlled treatment methods, and outcome measures. We believe that the findings of this retrospective study could improve the overall treatment of patients with cervical radiculopathy and show useful information for further research.

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