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The effectiveness of soft and semi-rigid cervical collars on acute cervical radiculopathy

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ABSTRACT

Objective. Cervical radiculopathy is one of the common causes of the neck pain. Medical devices in the form of cervical collars are frequently recommended in acute cervical radiculopathy. We aim to investigate and compare the effect of soft and semi-rigid cervical collars on neck pain, disability and daily life activities in the patients with acute cervical radiculopathy. ***Methods.*** We designed a prospective, single-blind, randomized controlled study. This study was conducted on 101 patients who were diagnosed with clinical features of radiculopathy and imaging showing cervical disc herniation. Visual Analog Scale (VAS), Neck Disability Index (NDI) and SF-36 were applied to the subjects. Evaluation of the patients was done before the treatment and 2 weeks and 6 weeks after the start of the treatment. Patients were divided into three groups according to the computer-generated randomization table: Soft cervical collar, semi-rigid cervical collar and control group. The patients in collar groups were asked to wear the collars for 8 hours during the day for the first 2 weeks. ***Results.*** Comparison of the soft cervical collar group with the control group showed significantly better improvement in the former in VAS and NDI scores at week 2 and 6 ($p < 0.05$), in SF-36 pain perception subunit at week 2 ($p < 0.05$), and in SF-36 physical component score at week 6 ($p < 0.05$). Comparison of the semi-rigid cervical collar group with the control showed significantly better improvement in the former for NDI scores and SF-36 pain perception subunit at week 2 and 6 ($p < 0.05$). ***Conclusions.*** The results of our study have indicated that the use of soft and semi-rigid cervical collars was more effective than conservative treatment in treatment of neck pain and disability in acute cervical radiculopathy in the short term. Soft cervical collars were also found to be more effective for pain management than semi-rigid cervical collars.

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Keywords: Acute cervical radiculopathy, cervical collar, neck disability

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Introduction

The incidence of neck problems has steadily increased as a result of the burden of the modern lifestyles on the musculoskeletal system [1, 2]. As people rapidly became accustomed to spending long hours at their computers, smartphones, and other devices in a disadvantageous posture, not only in the workplace but practically everywhere, neck pain has become a frequently recurring complaint which may cause substantial disability and socio-economic problems in the society [1-3]. It is predicted that approximately one-third of adults'experience neck pain within one year [2-4]. Cervical radiculopathy is one of common causes of neck pain. Radiculopathy is the result of mechanical pressure on the nerve root exerted by disc protrusion, spondylotic spurring or a combination thereof, and the ensuing inflammatory response [5, 6]. Conservative treatment of acute cervical radiculopathy is primarily focused on reduction of pain and improvement of function and quality of life. The standard therapeutic regimen used in patients with acute cervical radiculopathy comprise medical treatment (non-steroidal anti-inflammatory drugs [NSAIDs], myorelaxants), patient education (posture, behavior, and ergonomics training), home-exercise program (stretching, posture, mobilization, functional and proprioceptive exercises), physiotherapy (TENS, hotpack, theurapeutic ultrasound, etc,.) and orthoses (cervical collar) [6-10].

Medical devices in the form of cervical collars are frequently recommended in acute cervical radiculopathy [11, 12]. Although debate on the precise mechanism of action of cervical collars continues, there is consensus on their positive effect on treatment of these patients by limiting cervical range of motion and neck muscle activity, providing kinesthetic feedback, and increasing proprioception. Soft cervical collars are exothermic, psychologically reassuring, and effective as a kinesthetic reminder to restrict cervical range of motion; yet they can not provide structural support [11, 12]. Reports have estimated that soft cervical collars may decrease full, active cervical range of motion (ROM) by only 10-25%. Rigid cervical collars are made of plastic material and have been suggested as an effective tool to markedly restrict the ROM. However, multiple studies have shown that the latter type of orthoses fail to completely eliminate motion and may indeed allow up to 50% of full, active ROM in most cases [12, 13].

Despite the popularity of cervical collars, there are very few randomized controlled studies assessing their efficacy in acute cervical radiculopathy [12]. To our knowledge, the comparative effectiveness of soft cervical collars versus semi-rigid cervical collars (Nelson) has not been previously investigated. The aim of this study is to investigate and compare the effect of soft and semi-rigid cervical collars on neck pain, disability and daily life activities in the patients with acute cervical radiculopathy.

Methods

We designed a prospective, single-blind, randomized controlled trial in patients with cervical radiculopathy. This study was conducted on 101 patients who were diagnosed with cervical radiculopathy by the Department of Physical Medicine and Rehabilitation. Before the study, patients filled out a consent form. Local Ethical Committee approval was obtained for the study.

Inclusion criteria for the study were: Age of 18-65 years, neck pain on a Visual Analog Scale (VAS) of 4 or more (radicular arm pain), diagnosis of cervical radiculopathy evident clinically by physician and confirmed with magnetic resonance imaging. Exclusion criteria were: Previous surgical operation on the cervical spine, another systemic, neurological or psychiatric problem, rheumatic and infectious disease, current malignancy, motor deficit in the upper extremity, previous treatment with cervical collar, and neck and arm pain that lasted for longer than 12 weeks.

Treatment protocol

Patients were allowed to take NSAIDs (etodolak 600 mg) at a stable dose throughout the study whenever necessary. The patients were instructed to do the home exercises comprising cervical isometric, cervical mobilization (ROM), and shoulder protraction and retraction exercises. They performed the exercises twice with 10 repetitions at each session in the morning and the evening everyday for 6 weeks. They were advised to avoid holding their neck in prolonged flexion or extension during daily activities and to use a suitable pillow during sleep. Monitoring of home exercises and education of the patients were performed by the same physician in the research team.

Patients were divided into three groups according to the random table. Group 1: Soft cervical collars (anatomic cut of the soft sponge collar) (Figures 1A

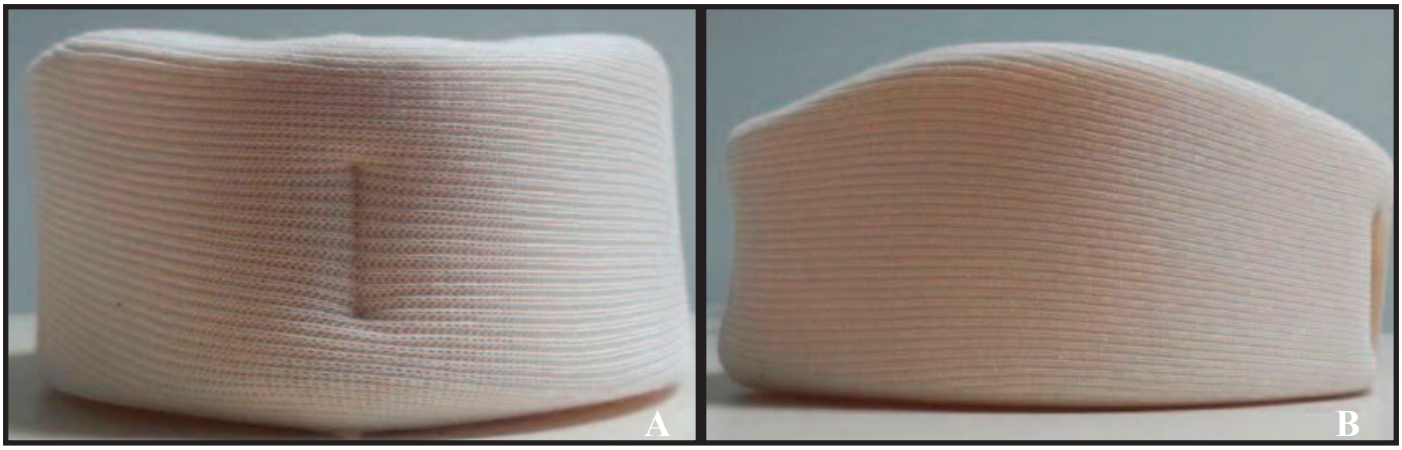

Figure 1. Soft cervical collars (A and B).

and 1B) plus exercise (n = 34); Group 2: Semi-rigid cervical collars (Nelson type plastozote, anatomically designed collar, manufactured from plastazote foam material) (Figures 2A and 2B) plus exercise (n = 33); and Group 3: Control; only exercise (n = 34).

The patients in groups 1 and 2 were asked to wear the collars for 8 hours during the day for the first 2 weeks, then reduce the collar time by one hour every other day for the next 2 weeks, and finally quit the collar at the end of the fourth week. Evaluation of the patients in all 3 groups was done by the same physician before the treatment and 2 weeks and 6 weeks after the start of the treatment who was blind to the study.

Main Outcome Measures

Visual analog scale (VAS): Pain intensity was assessed by the patient in a 10 cm horizontal line numbered from 0 to 10. The meaning of the numbers from 0 to 10 was explained to the patients as 0 = no pain, 5 = moderate pain, and 10 = unbearablepain. Patients were asked to rate their pain by choosing the best representing numerical value on the line [14].

Neck Disability Index (NDI): NDI is a self-report questionnaire used to determine how neck pain affects a patient's daily life and to assess the self-rated disability of patients with neck pain. NDI has a total of 10 sections each of which has six possible answers. Each item is scored from 0 (no disability) to 5 (complete disability). The total score ranges from 0 (no disability) to 50 (total disability), or, in percentage terms, between 0 and 100. Disability increases with increasing score. Items of the scale are: 'intensity of pain', 'personal care', 'lifting', 'reading', 'headaches', 'concentration', 'work', 'driving', 'sleeping' and 'recreation'. The Turkish version of this index was used in this study [15-17].

Short Form-36 (SF-36): SF-36 scale designed by Ware *et al.* [18, 19] evaluates the effects of the disease on quality of life. The scale is not specific to any disease or treatment group. It consists of 36 items and includes eight health concepts: pain, physical function, vitality/ energy, social function, disabilities caused by mental health, vitality/ energy, social function, disabilities caused byphysical problems (physical role) and emotional problems (emotional role), and general

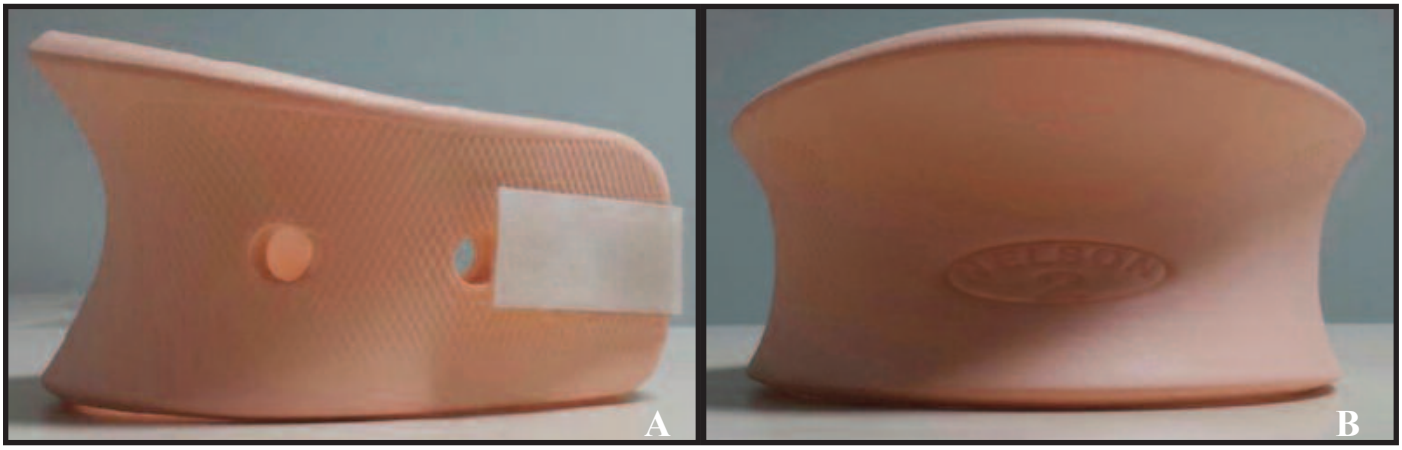

Figure 2. Semi-rigid cervical collars (A and B)

health. Questions were coded for each health concept. Score distribution was determined between 0 (worst) and 100 (best). The Turkish version of the survey was used in the study [20].

Statistical Analysis

Data analysis was performed by using IBM SPSS 22.0 statistical software package. The chi-square test and Fisher's exact test were used for comparison of categorical variables. Normal distribution of the data was assessed by the Shapiro-Wilk test. Wilcoxon Signed Rank test was used for comparison within groups and Kruskall-Wallis test was used to compare more than two independent groups. The Mann-Whitney U test was used to compare meaningful outcome variables. The values of $p < 0.05$ were accepted as significant.

Results

Two patients from soft cervical collar group, 7 patients from semi-rigid cervical collar group, and 5 patients from the control group failed to complete the study. Two patients from soft collar group and 5 patients from semi-rigid group reported discomfort such as hot flashes, skin erythema, and irritation as the reason to quit while the others abandoned the study without an excuse. The study was completed with the remaining 85 patients (30 patients from group 1, 26 patients from group 2, and 29 patients from group 3). The flow diagram of the study is presented in Figure 3.

There was no statistically significant difference between the three groups in demographic data, initial

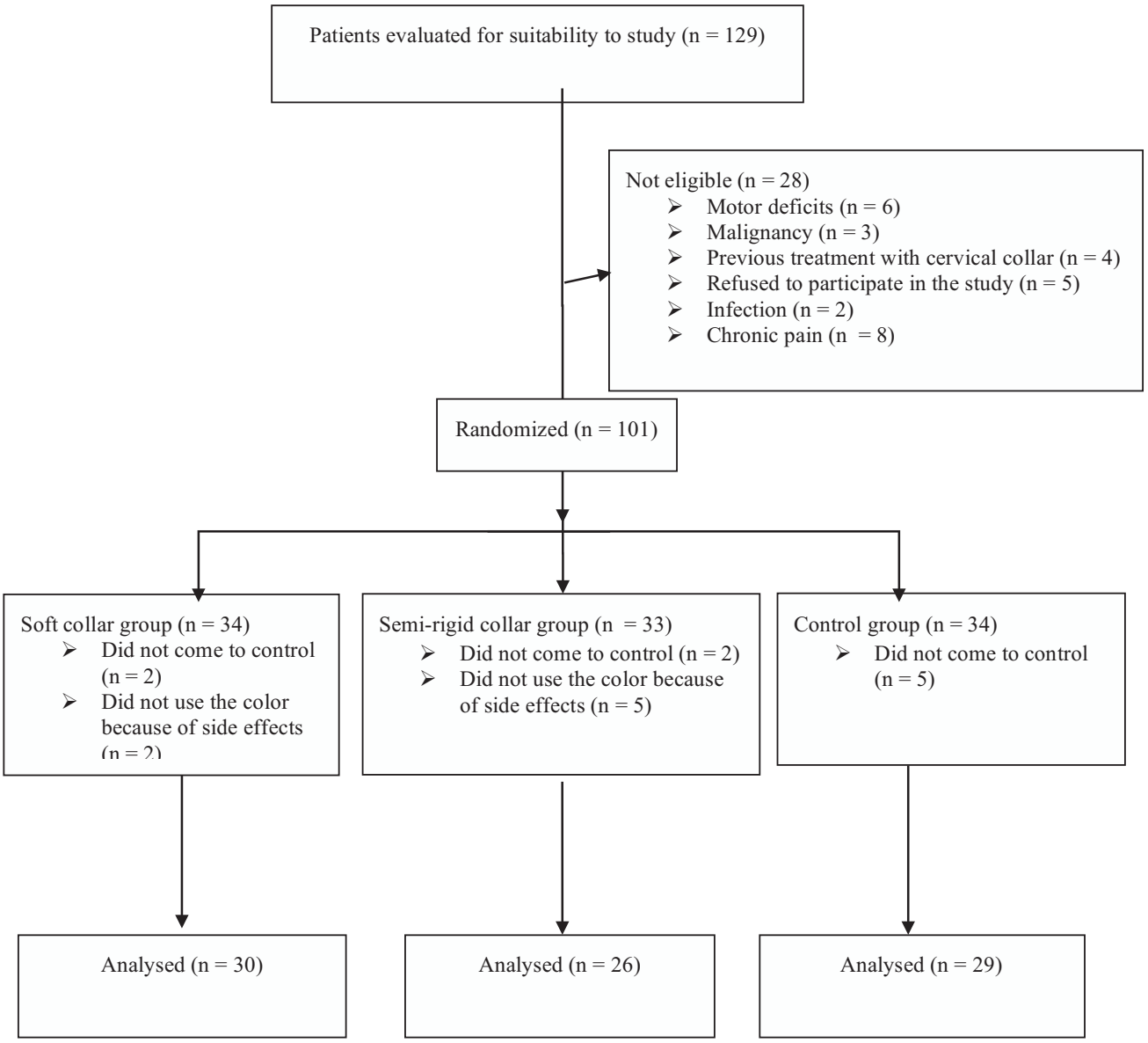

Figure 3. Study flow diagram.

VAS, NDI, and SF-36 subscores ($p > 0.05$) (Table 1). In soft cervical collar group, statistically significant improvement was found in all evaluation parameters at week 2 and week 6 ($p < 0.05$) (Table 2). In semi-rigid cervical collar group, there was statistically significant difference in all parameters at week 2 and week 6 ($p < 0.05$) except for SF-36 general health and mental health subunits ($p > 0.05$) (Table 2). In the control group, there was statistically significant improvement in all parameters at week 6 and in all but SF-36 general health and mental health subunits at week 2 ($p < 0.05$) (Table 2).

Comparison of the soft cervical collar group with the control group showed significantly better improvement in the former in VAS and NDI scores at week 2 ($p = 0.010$ and $p = 0.002$; respectively) and week 6 ($p < 0.001$ and $p = 0.002$; respectively), in SF-36 pain perception subunit at week 2 ($p = 0.003$), and in SF-36 physical component score at week 6 ($p = 0.013$) (Table 3).

Comparison of the semi-rigid cervical collar group with the control showed significantly better improvement in the former for NDI scores ($p = 0.003$, $p = 0.027$; respectively) and SF-36 pain perception subunit ($p = 0.030$, $p < 0.001$; respectively) at week 2 and 6 (Table 3).

Comparison of the two collar groups showed significantly better improvement in the soft collar group in VAS and SF-36 physical component scores at week 6 ($p = 0.023$, $p = 0,038$, respectively) but no significant difference between the groups for other parameters ($p > 0.05$) (Table 3).

Discussion

Cervical radiculopathy is among the leading causes of neck pain, which is one of the most prevalent and costly health problems encountered in the industrialized societies [21]. Cervical radiculopathy can usually be treated without surgery [10, 21]. The epidemiologic study by Radhakrishnan *et al.* [22] showed that at 14-year follow up, nearly 90% of patients with cervical radiculopathy were either asymptomatic or only mildly symptomatic.

A brief period of immobilization of the neck is a standard approach following the onset of symptoms of cervical discopathy [6, 12, 21, 23]. A cervical collar is usually sufficient to provide adequate immobilization required to reduce motion and nerve root irritation. Such collars do not completely eliminate motion and indeed may allow an active cervical ROM of up to 50% ofnormal in the semi-rigid and up to 75 to 90% of the normal in the soft collar type [11].

The results of our study showed that both soft and semi-rigid collars were effective in reducing pain and disability caused by acute cervical radiculopathy. While both soft and semi-rigid collars have been recommended frequently in management of these patients, there are in fact, few randomized, controlled studies evaluating the use of cervical collars in treatment of acute cervical radiculopathy. It should also be noted that cervical collars have only been used supplementary to the other conservative treatment modalities in the majority of the reported studies. Saal

Table1. Comparison of the demographic characteristics of the patients and pre-treatment evaluation parameters

		Group 1 (n=30)	Group 2 (n=26)	Group 3 (n=29)	*p* value
Age (year)		41 (25-57)	40 (25-61)	46 (25-62)	0.149
Gender	Female	23 (76.7%)	14 (53.8%)	18 (62,1%)	0.195
	Male	7 (23.3%)	12 (46.2%)	11 (37.9%)	
VAS		8.26 (6-10)	8.30 (6-10)	7.72 (5-10)	0.131
BMI		25.71 (19.10-36.20)	25.07 (19.10-35.16)	26.34 (21.80-35.16)	0.477
NDI		66 (33-80)	64 (30-86)	55 (22-86)	0.136
SF-36 Physical function		46.70 (29.90-57.10)	46.70 (29.90-57.10)	48.80 (29.90-57.10)	0.724
SF-36 Physical role		35.00 (28.00-56.20)	35.00 (28.00-56.20)	42.10 (28.00-56.20)	0.188
SF-36 Pain		32.80 (22.00-43.10)	29.30 (25.10-41.80)	33.20 (24.20-4650)	0.578
SF-36 General health		39.90 (24.20-57.90)	48.05 (21.90-57.90)	43.90 (21.90-60.30)	0.413
SF-36 Energy-vitality		39.60 (15.00-63.30)	39.60 (30.10-63.30)	44.30 (34.90-60.90)	0.538
SF-36 Social function		35.40 (19.10-46.30)	35.40 (24.60-40.90)	35.40 (24.60-51.70)	0.295
SF-36 Emotional role		34.30 (23.70-100)	34.30 (23.70-55.30)	44.80 (23.70-55.30)	0.324
SF-36 Mental health		34.30 (11.80-55.00)	36.80 (11.80-59.50)	36.80 (20.90-59.50)	0.528
SF-36 Physical component score		39.20 (28.10-49.30)	40.70 (24.30-52.10)	41.00 (24.00-52.70)	0.480
SF-36 Mental component score		36.80 (19.90-51.90)	37.35 (19.90-52.30)	38.20(26.60-54.80)	0.608

Data are shown as median (min–max) or number (%). VAS = Visual analog scale, NDI = Neck disability index, BMI = Body mass index, SF-36 = Short form-36. Chi-square and Fisher's exact test and Kruskal-Wallis test was used.

Table 2. Comparison of VAS, NDI and SF-36 subunit values of the groups at 2nd and 6th week.

		W2	W6	(W0-W2) *p* value	(W0-W6) *p* value
VAS	Grup 1 (n = 30)	4.46 ± 1.19	3.40 ± 1.37	< 0.001	< 0.001
	Grup 2 (n = 26)	4.84 ± 1.68	4.15 ± 1.68	< 0.001	< 0.001
	Grup 3 (n = 29)	4.79 ± 1.34	3.89 ± 1.51	< 0.001	< 0.001
NDI	Grup 1 (n = 30)	28.00 (18-49)	24.50 (17-48)	< 0.001	< 0.001
	Grup 2 (n = 26)	34.50 (14-55)	31.00 (14-52)	< 0.001	< 0.001
	Grup 3 (n = 29)	36.00 (14-55)	30.00 (14-52)	< 0.001	< 0.001
SF-36 Physical function	Grup 1 (n = 30)	52.90 (34.10-57.10)	55.00 (44.60-57.10)	< 0.001	< 0.001
	Grup 2 (n = 26)	52.90 (34.10-57.10)	53.95 (42.50-57.10)	< 0.001	< 0.001
	Grup 3 (n = 29)	52.90 (40.40-57.10)	57.10 (42.50-57.10)	0.021	< 0.001
SF-36 Physical role	Grup 1 (n = 30)	49.20 (28.0-56.20)	56.20 (42.10-56.20)	< 0.001	0.020
	Grup 2 (n = 26)	49.20 (35-56.20)	56.20 (42.10-56.20)	< 0.001	< 0.001
	Grup 3 (n = 29)	49.20 (28-56.20)	56.20 (42.10-56.20)	< 0.001	0.017
SF-36 Pain	Grup 1 (n = 30)	44.35 (29.30-55.90)	46.50 (37.50-55.90)	< 0.001	< 0.001
	Grup 2 (n = 26)	42.20 (29.30-55.90)	46.50 (33.20-55.90)	< 0.001	< 0.001
	Grup 3 (n = 29)	42.20 (29.30-55.90)	46.50 (33.20-62.70)	< 0.001	< 0.001
SF-36 General health	Grup 1(n = 30)	42.40 (24.20-57.90)	43.90 (24.20-57.90)	0.003	< 0.001
	Grup 2 (n = 26)	45.05 (24.20-57.90)	45.05 (24.20-57.90)	0.937	0.916
	Grup 3 (n = 29)	41.90 (25.10-60.30)	43.90 (25.10-60.30)	0.218	0.012
SF-36 Energy-vitality	Grup 1 (n = 30)	45.50 (34.90-63.30)	46.70 (34.90-63.30)	0.003	< 0.001
	Grup 2 (n = 26)	44.35 (34.90-63.30)	44.35 (34.90-63.30)	0.021	0.012
	Grup 3 (n = 29)	46.70 (37.20-60.90)	49.10 (37.20-63.30)	0.004	0.002
SF-36 Social function	Grup 1 (n = 30)	40.90 (35.40-51.70)	46.30 (35.40-57.10)	< 0.001	< 0.001
	Grup 2 (n= 26)	40.90 (30.0-46.30)	46.30 (35.40-57.10)	< 0.001	< 0.001
	Grup 3 (n = 29)	40.90 (30.0-57.10)	46.30 (35.40-57.10)	0.002	< 0.001
SF-36 Emotional role	Grup 1 (n =3 0)	44.80 (34.30-55,30)	55.30 (44.80-55.30)	0.010	0.001
	Grup 2 (n = 26)	44.80 (23.70-55,30)	55.30 (34.30-55.30)	0.002	< 0.001
	Grup 3 (n = 29)	44.80 (23.70-55.30)	44.80 (34.30-55.30)	0.017	0.004
SF-36 Mental health	Grup 1 (n = 30)	36.80 (14.10-55.0)	41.35 (16.40-55.00)	0.017	0.004
	Grup 2 (n = 26)	39.10 (14.10-59.50)	40.25 (16.40-59.50)	0.094	0.062
	Grup 3 (n = 29)	39.10 (20.90-55.0)	43.60 (20.90-55.00)	0.453	0.012
SF-36 Physical component score	Grup 1 (n = 30)	46.20 (33.80-55.40)	50.20 (42.80-57.90)	< 0.001	< 0.001
	Grup 2 (n = 26)	47.50 (33.70-54.10)	48.30 (35.50-56.70)	< 0.001	< 0.001
	Grup 3 (n = 29)	46.10 (33.70-56.60)	50.80 (35.50-58.20)	< 0.001	< 0.001
SF-36 Mental component score	Grup 1 (n = 30)	41.75 (26.70-54.50)	41.80 (32.60-54.00)	< 0.001	< 0.001
	Grup 2 (n = 26)	41.95 (26.70-54.50)	44.00 (30.60-54.00)	0.003	< 0.001
	Grup 3 (n = 29)	41.20 (26.70-53.30)	45.60 (30.60-52.90)	0.031	< 0.001

Data are shown as median (min–max). W0 = Week 0, W2 = Week 2, W6 = Week 6, VAS = Visual analog scale, NDI = Neck disability index, SF-36 = Short form-36. The Wilcoxon signed rank test was used for intra-group comparisons.

et al. [24] employed in 26 patients with cervical disc hernia hard cervical collar in addition to traction, ice, NSAID, exercise, and oral steroid and epidural injection when necessary and reported good to excellent recovery in 83% of the patients. However, since they did not attempt to delineate the specific role of either modality in the favorable outcome, it is not possible to infer the definitive impact of the collar in that study. In another study where either surgery, physiotherapy, or collar were used in 3 separate groups

Table 3. Comparison of the difference scores between the groups

		Group 1 n = 30	Group 2 n = 26	Group 3 n = 29	*p value*
VAS	W2-W0	-3.80 (-6.00--1.00)	-3.46 (-6.00--1.00)	-2.93 (-6.00--1.00)	0.029
	W6-W0	-4.86 (-6.00--3.00)	-4.15 (-6.00--2.00)	-3.82(-6.00--2.00)	< 0.001
NDI	W2-W0	-29.13 (-48--8)	-27.50 (-46--10)	-18.27 (-36--2)	0.002
	W6-W0	-34.10 (-51--9)	-30.46 (-51--12)	-23.58 (-37--1)	0.005
SF-36 Physical function	W2-W0	6.39 (0-14.70)	4.98 (-12.50-14.70)	4.15 (-12.50-25.10)	0.499
	W6-W0	3.54 (0-10.50)	2.34 (0-10.50)	3.52 (-0-14.60)	0.183
SF-36 Physical role	W2-W0	9.17 (-7.0-28.20)	8.96 (-14.10-21.20)	8.32 (-5.60-28.20)	0.784
	W6-W0	6.59 (-7.0-28.20)	4.07 (-7.10-7.10)	2.92 (-7.10-28.20)	0.133
SF 36 pain	W2-W0	11.28 (3.90-18.00)	10.44 (0-18)	6.36 (-12.50-17.60)	0.010
	W6-W0	2.98 (-5.10-14.10)	1.17 (-5.10-9.00)	6.47 (-4.70-26.60)	0.004
SF 36 General health	W2-W0	2.60 (-2.30-16.90)	-0.98 (-24.30-11.70)	2,00 (-10.30-22)	0.185
	W6-W0	2.78 (-2.30-11.80)	-0.86 (-24.30-11.70)	3.16 (-7.00-24.30)	0.064
SF-36 Energy-vitality	W2-W0	3.84 (-18.10-34.10)	1.82 (-9.50-14.20)	2.69 (-9.50-14.10)	0.646
	W6-W0	4.95 (-16.60-31.70)	2.10 (-9.50-14.20)	5.23 (-9.50-14.20)	0.163
SF 36 Social function	W2-W0	6.91 (-5.40-16.30)	6.88 (0-10.90)	5.61 (-10.90-21.70)	0.787
	W6-W0	10.71 (-2.10-21.80)	11.06 (5.40-21.70)	10.86 (-5.40-27.10)	0.978
SF 36 Emotional role	W2-W0	4.73 (-55.20-31.60)	10.11 (-21.80-31.60)	5.07 (-10.60-31.60)	0.090
	W6-W0	9.63 (-55.20-31.60)	14.16 (-10.50-31.60)	9.43 (0-31.60)	0.202
SF 36 Mental health	W2-W0	2.86 (-2.30-25.00)	1.48 (-9.10-25.00)	0.47 (-15.90-11.30)	0.941
	W6-W0	3.96 (-4.50-24.70)	1.73 (-9.10-25.00)	3.84 (-15.90-13.70)	0.226
SF-36 Physical component score	W2-W0	8.15 (-0.90-16.80)	6.4 (-10.40-14.00)	6.21 (-16.50-29.60)	0.110
	W6-W0	12.14 (0.90-21.90)	8.45 (-8.90-16.80)	9.87 (0.40-33.60)	0.027
SF-36 Mental component score	W2-W0	3.64 (-2.80-9.80)	3.90 (-10.20-15)	1.82 (-11.40-15)	0.113
	W6-W0	5.22 (-4.60-14.40)	5.74 (-5.70-14.40)	5.32 (-4.60-14.10)	0.849

Pairwise comparisons

		Group 1-Group2	Group 1-Group 3	Group 2-Group 3
VAS	W2-W0 (*p* value)	0.354	0.010	0.090
	W6-W0 (*p* value)	0.023	< 0.001	0.257
NDI	W2-W0 (*p* value)	0.633	0.002	0.003
	W6-W0 (*p* value)	0.226	0.002	0.027
Sf 36 pain	W2-W0 (*p* value)	0.602	0.003	0.030
	W6-W0 (*p* value)	0.120	0.056	< 0.001
SF-36 Physical component score	W6-W0 (*p* value)	0.038	0.013	0.667

Data are shown as median (min–max). W0 = Week 0, W2 = Week 2, W6 = Week 6, VAS = Visual analog scale, NDI = Neck disability index, SF-36 = Short form-36. Kruskal-Wallis and Mann-Whitney U test was used for intra-group comparisons.

of patients who were symptomatic for more than 3 months with a diagnosis of cervical radiculopathy confirmed by MRI, Perrson *et al.* [25] found no difference between the groups at the end of 12 months according to the evaluation criteria of pain, function, and mood assessed by VAS, Sickness Impact Profile, and Mood Adjective Checklist, respectively. While the results of that study have a clear implication for the role of the isolated collar application, it does not provide information as to what type of collar was more effective since a combination of a shoulder-resting rigid collar and a soft collar was used. We used soft and semi-rigid collars but no rigid collar and only for 2 weeks versus 3 months in acute versus chronic cervical radiculopathy patients.

Kuijper *et al.* [26] compared effectiveness of physical therapy accompanied by home exercise (PT), cervical collars (semi-rigid), and wait-and-see strategy in alleviating symptoms of acute cervical radiculopathy. They found significant improvement in

the parameters of NDI in the collar group compared to the group where wait and see policy was employed. Although both the cervical collar group and PT groups had significantly less pain at week 3 and 6, all three groups showed equal improvement at the end of the study. They concluded that cervical collar was at least as effective as PT in treatment of cervical radiculopathy, yet its cost was much lower than that of the latter. In our study, we used both soft and semi-rigid cervical collars to assess and compare their effectiveness and limited the duration of application to 4 weeks to avoid counterproductive effects of prolonged immobilization of the neck. The results of our study indicated significantly better pain relief and SF-36 physical component score with the soft collar compared to the semi-rigid collar whereas both collar types were found to be more effective than the control group.

Semi-rigid collars have usually been suggested as a more convenient type since they cause less limitation of ROM than rigid collars. It has been shown by electro goniometric measurements that the extent of limitation of flexion/extension, lateral bending, and rotation was 27.1%, 26.1% and 29.3%; respectively, with soft collar, and 53.7%, 34.9%, and 59.2%; respectively, with rigid collar. However, no significant difference between two collar types was detected in the limitation of a series of 15 daily life activities in the same study. In other words, electro goniometric limitation did not directly translate into limitation of daily life activities. As an explanation for these findings, the authors suggested the role of both collars as proprioceptive guides allowing patients to regulate their own cervical motion based on their level of comfort [13]. We believe the improvement for all parameters observed in the soft collar group in our study supports the above explanation that kinesthetic feedback plays a more important role in the recovery than physical limitation.

Although cervical collar application has been shown to be effective in the treatment of radiculopathy in several studies [23, 25, 26, 29], the literature is still lacking in objective data and a standard protocol as to the ideal collar wearing time. The lack of such data precludes any correlation between collar wearing time and clinical outcomes obtained in various studies in which these times seem to have been rather arbitrarily used. It is a well-known fact that collar application for longer periods may have a negative effect on the symptoms by creating weakness in the cervical muscles [27]. Atrophy-related secondary damage due to immobilization in closed plaster casts has been detected in muscle, bone, capsular, and tendinous tissue. Animal experiments have shown that structural changes can be detected in healthy muscle tissue after immobilization for a period of as short as 1 week [27]. While it is reasonable to assume that the magnitude of this problem would be the least with soft collars which allow a substantial range of motion, it should also be remembered that physiologic mechanisms developed for avoiding from pain regardless of the degree of immobilization may also cause muscular changes [28]. To avoid the latter effect, we designed collar wearing time as only 8 hours in the first 2 weeks, gradually decreased it during the next 2 weeks, and discontinued the collar at the end of the fourth week. The wearing time in our study is obviously much shorter than in several studies where it varied between 6 weeks and 3 months. We also added home exercises in the treatment protocol as a supplementary precaution against muscular atrophy. Since we observed significant improvement in most parameters in all groups in our study, we think our treatment protocol has been effective in mitigating atrophy-related muscular damage.

The Limitations of the Study

This is not a double-blind study, and this is one of the shortcomings of the study. It is not possible for patients who wear cervical collar to be blind study. The doctors who treat the patients and who evaluate the clinical conditions are different, which has reduced this shortcoming a little. One of the other limitations of this study is that NSAID is given to this patients. NSAIDs relieve pain and reduce inflammation on acute radiculopathy. The significant improvement observed in the control group at the end of 6th week in our study can be attributed to the fact that it was not a no-intervention group but the patients were given both NSAID and exercise due to ethical and methodological reasons. All our patients had substantial neck and arm pain due to the radiculopathy and it would have been unethical to deprive the patients in the control group of active treatment. Since neither collars nor exercise was enough to alleviate the pain in the acute setting, we decided to give a stable dose of NSAID to all patients despite our awareness that NSAID would make a substantial contribution to recovery via its anti-inflammatory effect on the compressed nerve root and the surrounding tissue. However, significant superiority of the results in both collar groups compared to the control group is

supportive of the specific contribution of collar application to improvement. Kuijiper *et al.* [26] allowed the patients to receive paracetamol, NSAID, or even opioid during the study, but did not employ a standard drug protocol and requested the patients to keep a diary of their drug intake. In other studies, mentioned above, no details regarding such medication have been reported by the authors.

Conclusions

The results of our study have indicated that the use of soft and semi-rigid cervical collars given in addition to home exercise program and NSAID was more effective than exercise plus NSAID without collar application in treatment of neck pain and disability in acute cervical radiculopathyin the short term. Soft collars were also found to be more effective for pain management than semi-rigid collars. In the light of the results of our study, we suggest soft collars as an effective, less expensive, and more comfortable orthotic device choice in treatment of acute cervical radiculopathy and disability. However, it should also be noted that there is still need for more studies that would focus on optimizing collar wearing time and delineating specific effects of various collar types with longer follow-up periods.

Authorship declaration

All authors listed meet the authorship criteria according to the latest guidelines of the International Committee of Medical Journal Editors, and all authors are in agreement with the manuscript.

Conflict of interest

The authors disclosed no conflict of interest during the preparation or publication of this manuscript.

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