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Utility of Cervical Collars Following Cervical Fusion Surgery. Does It Improve Fusion Rates or Outcomes? A Systematic Review

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Key words
- Anterior cervical
- Cervical collar
- Cervical fusion
- Posterior cervical

Abbreviations and Acronyms
ACDF: Anterior cervical discectomy and fusion
NDI: Neck disability index
PCF: Posterior cervical fusion

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BACKGROUND: **The use of postoperative cervical collars following cervical fusions is common practice. Its use has been purported to improve fusion rates and outcomes. There is a paucity in the strength of evidence to support its clinical benefit. Our objective is to critically evaluate the published literature to determine the strength of evidence supporting the use of postoperative cervical collar use following cervical fusions.**

METHODS: **A systematic review using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (also known as PRISMA) was performed. An online search using Medline and Cochrane Central Register of Controlled Trials databases was used to query prospective and retrospective clinical trials evaluating cervical fusions with or without postoperative collar.**

RESULTS: **The search identified 894 articles in Medline and 65 articles in the Cochrane database. From these articles, 130 were selected based on procedure and collar use. Only 3 studies directly compared between collar use and no collar use. Our analysis of the mean improvement in neck disability index scores and improvement over time intervals did not show a statistically significant difference between collar versus no collar ($P = 0.86$).**

CONCLUSIONS: **We found no strong evidence to support the use of cervical collars after 1- and 2-level anterior cervical discectomy and fusion procedures, and no studies comparing collar use and no collar use after posterior cervical fusions. Given the cost and likely impact of collar use on driving and the return to work, our study shows that currently there is no proven benefit to routine use of postoperative cervical collar in patients undergoing 1- and 2-level anterior cervical discectomy and fusion for degenerative cervical pathologies.**

INTRODUCTION

Anterior cervical discectomy and fusion (ACDF) and posterior cervical fusions (PCF) constitute the most commonly performed procedures for cervical spine pathology.[1] Cervical collars are often routinely used after these procedures, although wide variation in use of collars has been reported.

Collar use is purported to help prevent postsurgical complications such as graft subsidence, graft extrusion, focal kyphosis, and screw or plate loosening.[2,3] The use of collars predates the widespread use of instrumentation such as anterior cervical plating.[4-7] Although studies have shown that the addition of an anterior plate enhances fusion rates and prevents interbody graft subsidence and extrusion by limiting motion between the graft and the vertebral endplate,[8-10] cervical collars are still commonly prescribed following cervical fusions.[11]

Despite this clinical practice, the benefit of cervical collars (fusion rate and clinical outcomes) remains unclear. The inherent risks and socioeconomic impact of cervical collars (e.g., driving performance, missed work) warrant a thorough review on the clinical benefit of cervical collars.[12] The goal of this systematic review was to evaluate the existing literature about the use of postoperative cervical collars following cervical fusions to determine the strength of evidence.

MATERIALS AND METHODS

Preferred Reporting Items for Systematic Reviews and Meta-Analyses Guidelines

For this systematic review, we followed the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (also known as PRISMA).[13] The protocol for the online research was submitted and accepted by the international prospective register for systematic reviews (also known as PROSPERO).[14]

Online Research

The search was performed in the Medline and Cochrane Central Register of Controlled Trials databases. The following

keywords were used to query the PubMed database; "cervical fusion," "anterior cervical fusion," "posterior cervical fusion," "postoperative collar immobilization," "cervical orthosis fusion," and "postoperative neck collar." The same keywords were used to search the Cochrane Library. The abstracts were reviewed and complete manuscript versions of relevant articles were obtained for an in-depth review.

Inclusion criteria included the following: 1) both prospective and retrospective clinical trials evaluating following ACDF or PCF with or without collar, 2) prospective or retrospective studies involving cervical collar following ACDF or PCF, and 3) assessment of clinical outcomes and fusion rates. Exclusion criteria included the following: 1) lack of assessment of outcomes or fusion rates, 2) studies that did not access impact of cervical collars post ACDF or PCF, and 3) language other than English. The risk of bias of the selected works was estimated according to guidelines in the Cochrane Handbook for Systematic Reviews of Intervention,[15] which assess the risk of bias in 7 domains, with each sorted subjectively as high risk, low risk, or uncertain risk.

All stages of this research were conducted independently by 2 investigators. Disagreements were resolved after discussion.

Statistical Analysis

Statistical analysis was done using R-studio software version 1.1.423 (R-Tools Technology, Richmond Hill, Ontario). Neck disability index (NDI) improvement mean values were combined based on time interval. Analysis of variance was used to calculate statistical significance ($P < 0.05$).

RESULTS

Literature Search

The search strategy identified 894 articles in Medline (in addition to 5 obtained by manual search) and 65 articles in the Cochrane Central Register of Controlled Trials (Figure 1). From these articles, 130 were selected based on procedure and collar use. Five studies (3 randomized and 2 retrospective studies) met the inclusion criteria (Table 1). The results of these 3 randomized studies that were considered low risk in all 7 domains for assessment of bias were combined to perform qualitative analysis (Table 2). All 3 randomized studies addressed collar use after ACDF.

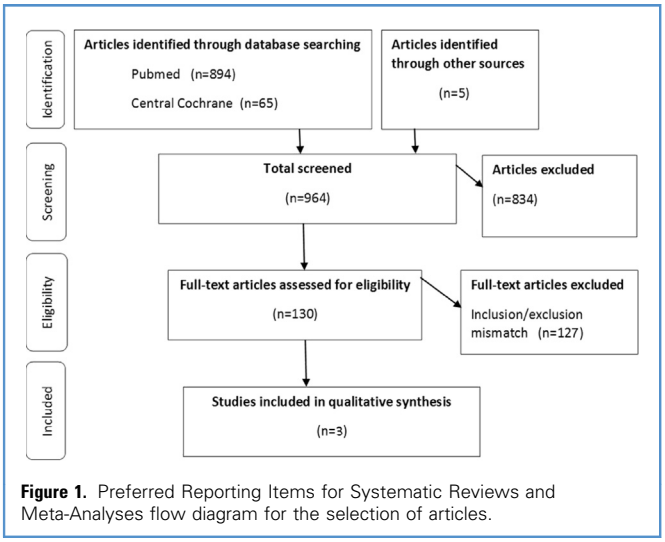

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram for the selection of articles.

Randomized Studies Comparing Collar Use Versus No Collar Use, ACDF Only. The first of the 3 studies that directly compared postoperative collar versus no collar was performed by Abbott et al.[1] The study was designed as a prospective randomized controlled pilot trial aimed at determining the feasibility in relation to prospective physical, functional, and quality of life related outcomes following 1- or 2-level ACDF with and without collar, thus, it was a pilot trial aimed at determining the feasibility of proceeding to a larger study. The trial randomized 17 patients with and 16 patients without cervical collars post ACDF. Their study found that the studied sample provided enough statistical power to detect an improvement at 6 weeks in NDI and neck pain in favor of patients wearing a collar. More importantly, the authors found that to investigate causal quality of life or fusion rate outcomes, sample size needed to be increased at least 4-fold, and optimally 6-fold, when accounting for data loss in prospective follow-up. Therefore, despite the randomized design of this study, the lack of sufficient numbers and the lack of blinding makes the interpretation of its results difficult and inconclusive.

The second study was performed by Campbell et al.[17] Patients undergoing a single-level ACDF were enrolled in a randomized control trial and evaluated for clinical outcomes and fusion rates. One hundred forty-nine patients with and 108 patients without collar were enrolled. The fusion rate at 24 months was 96.1% versus 100% in brace versus non-braced, respectively ($P = 0.55$). There was no statistically significant difference in any of the outcome measures (NDI, short form-36 PCS, neck pain).

The authors concluded that the use of a postoperative collar does not improve clinical outcomes or fusion rates in patients at 24 months undergoing 1-level ACDF with plating.

The third study was performed by Overley et al.[18] This prospective randomized control trial evaluated clinical outcomes, fusion rates and subsidence in 44 patients undergoing 1- or 2-level ACDF. Twenty-two patients were randomized in each group to bracing versus no bracing. At 12 months, the authors reported no statistically significant difference in NDI scores between the brace (9.30) and no-brace (6.95) groups ($P = 0.28$), in 6-month subsidence of all operative levels between the brace (0.85 mm) and no-brace (0.79 mm) groups ($P = 0.72$), or in the proportion of fused levels between the brace (89%) and no-brace (97%) groups ($P = 0.37$).

A qualitative analysis of the clinical outcomes of the 3 earlier mentioned studies is illustrated in Table 1 and

Table 1. Summary of Studies Evaluating the Impact of Cervical Collars Following Anterior Cervical Fusions

Study	Cauthen et al., 1998[16]	Jagannathan et al., 2008[3]	Campbell et al., 2009[17]	Abbott et al., 2013[1]	Overley et al., 2018[18]
Number of patients	514	170	257	33	50
Study design	Retrospective analysis of ACDF outcomes and outcome-relevant variables with a literature review (1975—1996) of non-instrumented ACFs	Retrospective review of a prospective database investigating fusion rates and outcome measures after single-level non-instrumented ACDF without postoperative rigid cervical immobilization	Randomized analysis of braced versus non-braced groups after ACDF with anterior cervical plate	Randomized controlled trial comparing ACDF with and without ECO	Randomized controlled trial comparing ACDF with and without ECO
Inclusion criteria	Cloward's ACDF procedure by the senior author for disc herniation or degeneration with intractable nerve or spinal cord compression from 1974—1994, with at least 2 years follow-up	Single level ACDF by the senior author for treatment of degenerative disease between June 1996 and June 2005	Symptomatic single-level radiculopathy or myelopathy	Age 18—65 years, ACDF procedure for nerve root compression refractory to conservative treatment >3 months; or diagnosis of cervical spondylosis, disc herniation, or degenerative disc disease	No prior attempted cervical arthrodesis; no prior posterior cervical foraminotomy; no prior anterior or posterior laminectomy with or without fusion; and persistent radiculopathy or myelopathy attributed to 1- or 2-level disease after a minimum of 6 weeks of non-operative management
Exclusion criteria	Patients lost to follow-up, death, incomplete medical records, cervical fractures, or posttraumatic instability	Traumatic or neoplastic disease, multilevel ACDFs, patients lost to follow-up	Unclear postoperative bracing status	Lack of understanding of the Swedish language and previous ACDF procedure	None
Population	Five hundred fourteen records originally reviewed with only 348 patients analyzed (based on inclusion or exclusion criteria) for a total of 21 outcome and outcome-relevant variables, including cervical collar use	One hundred seventy patients in a prospective database retrospectively evaluated for outcome relevant variables after ACDF	Two hundred fifty-seven operative cases retrospectively divided into 2 groups 149 with external orthoses, 108 without external orthoses	Thirty-three patients undergoing ACDF randomly assigned into 1 of 2 groups: 17 with cervical collar and 16 without cervical collar	Fifty patients receiving 1- and 2-level instrumented ACDF randomly assigned into 1 of 2 groups: 25 with bracing postoperatively and 25 with no brace
Demographics	Male 47%; Female 53% with an average age of 40 years, 202 (58%) 1-level fusions; 129 (37%) 2-level fusions; 14 (4%) 3-level fusions; 2 (0.6%) 4-level fusions; and 1 (0.3%) 5-level fusions. Graft source: allograft (70%) and autograft (30%)	Female 73 (43%); male, 97 (57%), with a mean age of 53 years (median 56 years, range 34—67 years). Seventy-eight (46%) had only degenerative spondylosis, 55 (32%) had disk herniation, and 37 (21%) had radiographic evidence of both. Ten patients had history of previous single-level posterior cervical discectomies (6%) and 5 (3%) had prior multilevel cervical laminectomies with recurrent or residual symptoms. The operative level was at C3-4 in 28 patients (16%), at C4-5 in 29 (17%), at C5-6 in 71 (42%), and at C6-7 level in 42 (25%). Fifteen (9%) had undergone prior posterior cervical fusion	Groups were same for age, sex, and Worker's compensation; dissimilar for litigation, smoking, and working	The randomization process produced even group distribution for background characteristics of the patients and baseline variables	There were no significant differences regarding sex, age, body mass index, smoking status, hypertension, or diabetes

ACDF, anterior cervical discectomy and fusion; ACF, anterior cervical fusion; ECO, external cervical orthoses; NDI, neck disability index.

Continues

Table 1. Continued

Study	Cauthen et al., 1998[16]	Jagannathan et al., 2008[3]	Campbell et al., 2009[17]	Abbott et al., 2013[1]	Overley et al., 2018[18]
Results	NDI scores assessment was not available. No significant correlation was found between fusion and use of postoperative orthoses (86% fusion rate with cervical collar vs. 81% fusion rate without collar)	NDI scores results: 72% with no disability, 18% with mild disability, 6% with moderate disability, 4% with severe disability, 0% incapacitated	The NDI scores in both groups showed statistically significant improvement when compared with preoperative scores ($P < 0.001$) in both the braced and non-braced groups at all time intervals. However, at 6 weeks after surgery, patients in the non-braced group had statistically significantly better NDI scores compared to the braced group. After 6 weeks, no statistically significant differences were noted between the groups	Both groups improved in all outcome measures and intermittently showed statistically significant improvements ($P < 0.05$) from baseline to 2 years after surgery. These results are reflected in the general medium (0.50—0.80) to large effect sizes (>0.80) for reduced neck and arm pain as well as the NDI for both groups. Notably large effect sizes occurred for the non-collar group in the reduction of neck pain (1.57) and NDI (1.75), likewise the collar group in the reduction of neck pain (1.34) after 2-year postsurgery	The preoperative versus postoperative NDI scores for both the brace ($P < 0.0001$) and no-brace ($P < 0.0001$) groups showed significant improvement over the course of treatment to final follow-up. Additionally, the preoperative and postoperative NDI scores at final follow-up between the 2 groups showed no significant difference
Study limitations	Some 166 of 514 (32%) patient records were unavailable for follow-up. The number of braced and unbraced patients were also not specified	No intra-study comparison can be made between ACDF with external immobilization and ACDF without external immobilization because all patients were treated without rigid external immobilization. Also, baseline NDI scores are not available to determine improvement after collar use	No limitations in the ability of this retrospective study to compare fusion rates between braced and unbraced groups. Groups were dissimilar for smoking	The study is substantially underpowered to detect differences between groups	Although the study was a prospective randomized trial by design, it was relatively low-powered. Also, although all patients had similar demographic information, there was no means of truly objectifying host status, which plays a significant role in any spinal fusion procedure
Conclusions	Fusion rate is statistically unrelated to cervical collar use. NDI scores not available for comparison	The results of the study suggest that use of postoperative cervical collar is unnecessary, as the immediate and long-term fusion rates did not appear to be affected by the lack of immobilization. A randomized controlled trial will be essential in determining the true benefit of external or internal fixation in patients who undergo single-level ACDF for cervical spondylosis	The use of cervical brace does not improve the clinical outcomes of patients undergoing single-level ACF with plating and is probably unnecessary. The results of this study should be confirmed by randomized clinical trials of bracing versus no bracing or other similar studies of patients enrolled in current clinical trials	The results of the study suggest that short-term cervical collar use post ACDF and interbody cage may help certain patients cope with initial postoperative pain and disability. Larger data collections are required to investigate health-related quality of life and fusion rates in patient with and without rigid collar use post ACDF surgery	The use of routine postoperative cervical bracing following 1- and 2-level ACDF, although widely practiced, has little high-level evidence to support its use. Additionally, results of this study suggest braced patients have worse NDI scores at the 2-week postoperative time point
Does ECO improve fusion rates after ACDF? (yes, no, unknown)	Unknown	No	No	Unknown	No

ACDF, anterior cervical discectomy and fusion; ACF, anterior cervical fusion; ECO, external cervical orthoses; NDI, neck disability index.

Table 2. Comparison of Mean Neck Disability Index Improvement Scores (Using Collar vs. not Using Collar) of the 3 Resulting Studies

	Campbell et al., 2009[17]	Abbott et al., 2013[1]	Overley et al., 2018[18]
2 weeks	n/a	n/a	5.38
6 weeks	3.4	−2.7	1.8
3 months	1.5	−1.4	−0.1
6 months	2.5	−1.2	0
12 months	1.7	−2.4	−1.4
24 months	0	2	n/a

Figure 2. A summary of all pertinent studies that evaluated the impact of collars following cervical fusions are shown in Table 2. The NDI was the sole consistent outcome measurement across all 3 studies and was chosen to perform the analysis. The mean improvement scores after using a cervical collar in comparison to not using a collar from each of the 3 resulting studies were extracted and combined (Table 1). The data were then visualized using box plots (Figure 2). Analysis of variance was used to compare between overall improvement means based on time interval. Our analysis of the mean improvement scores and improvement over time intervals did not show a statistically significant difference between collar versus no collar.

Non-Randomized Studies Comparing Collar Use Versus No Collar Use, ACDF Only. Two non-randomized studies that evaluated the effect of postoperative cervical collar use met our search criteria. These 2 studies reported either fusion rates and or clinical outcomes (Table 1).

The first study by Cauthen et al.[16] performed a retrospective analysis of 348 patients undergoing non-instrumented ACDF. They reported no statistically significant difference in achieving fusion rates in patients who wore a postoperative collar (86%) versus patients not wearing a collar (81%). Differences in clinical outcomes in patients with or without a postoperative collar were not specified in this study.

The second study by Jagannathan et al.[3] performed a retrospective review of 170 patients undergoing 1-level non-instrumented ACDF. All patients in this study did not wear a postoperative collar. After a mean follow-up of 22 months, the authors reported a 94% radiographic fusion rate, and 72% of patients reported no complaints referable to cervical disease and the mean postoperative NDI score was 3.2.

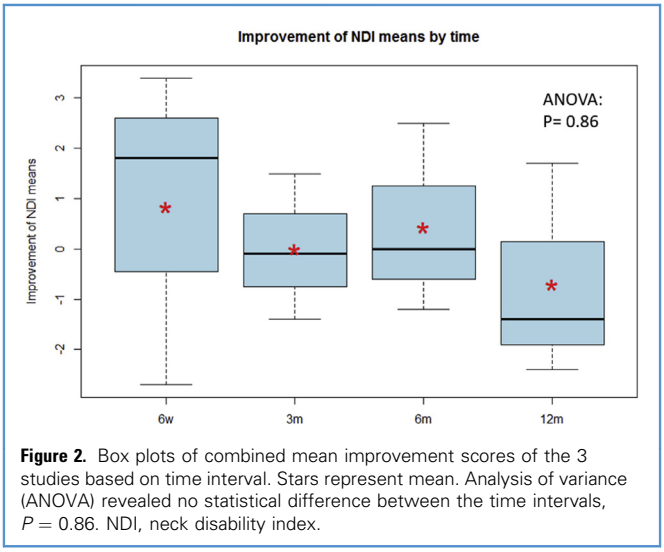

Figure 2. Box plots of combined mean improvement scores of the 3 studies based on time interval. Stars represent mean. Analysis of variance (ANOVA) revealed no statistical difference between the time intervals, $P = 0.86$. NDI, neck disability index.

Randomized or Non-Randomized Studies Comparing Collar Use Versus No Collar Use, PCF Only. No randomized or non-randomized studies comparing collar use versus no collar after PCF met our search criteria.

DISCUSSION

In this systematic review of collar use versus non-collar use after cervical spine fusions, we found no strong evidence to support the use of a collar following 1- or 2-level ACDF procedures.[1,17,18] There were limited numbers of studies (3 randomized trials and 2 cohort studies) that met search criteria. In addition, we found no studies comparing collar use following PCFs. These findings highlight both the lack of evidence to support collar use and the need for further studies in this area given the geographic practice variations in collar use and their cost and potential impact on return to work, driving, and quality of life.

Our study has several limitations. We reviewed only literature in English, and, potentially, there may be other publications of interest in the non-English literature. Because of the limited number of studies meeting search criteria, our ability to compare outcomes or to look at potential risk factors, such as osteoporosis and smoking, were limited. We specifically chose to study collar use after elective surgery for degenerative conditions, and we can make no conclusions about collar use after cervical fusions for trauma.

The use of postoperative cervical collars following cervical fusions is common practice with 55% of surgeons reporting its use in single-level surgeries and 76% in multilevel cervical fusions.[11] However, possible practice patterns may be continuing to change with widespread use of spinal instrumentation. Postoperative cervical immobilization following ACDF has been purported to improve fusion rates and outcomes.[1,6,7] Others believe it merely provides the patient a sense of security, pain relief, and comfort.[1]

With the recent healthcare emphasis on providing cost-effective patient care with decreased morbidity, it is imperative that

interventions, such as the routine use of cervical collars, be critically evaluated. Although relatively benign, cervical collars have been reported to be associated with some complications. Among these include wound and skin related complications, discomfort during swallowing, breathing, coughing, and the inability to drive or operative heavy machinery.[19-21] Routine use of a cervical collar also adds to the cost of procedure with some collars costing upward of $100.[18] An important and often overlooked effect of cervical collar use is its impact on driving performance, and, thus, ability to work for drivers. Barry et al.[12] studied this effect in a prospective randomized study in 23 volunteers. The authors reported that subjects wearing a cervical collar demonstrated decreased lateral acceleration and drove slower. More importantly, subjects in a cervical collar demonstrated suboptimal evaluation of intersection traffic and a statistically significant decrease in cervical axial rotation when approaching intersections. Further, the number of blind spots were increased in subjects wearing a cervical collar. The findings of this study highlight the potential safety hazards associated with wearing a collar while driving. In states where driving with a cervical collar is prohibited, one can deduce the social or economic impact on individuals who depend on their automobiles as their sole mode of transportation, and for workers who drive to earn a living (truck drivers, Uber, taxi, etc.). Preliminary data from the Cervical Spondylotic Myelopathy Surgical Trial suggests that use of cervical collar is associated with significant delay in return to work (abstract presented at Spine Section, 2018, Guan et al.)

The results in this systematic review highlights the lack of clinical benefit in the routine use of postoperative cervical collars following 1- or 2-level ACDF. This was corroborated in 3 randomized clinical trials.[1,17,18] The results of the study by Abbott et al.[1] should be interpreted with caution as the study was significantly underpowered and had a very short follow-up. The authors rightfully concluded that a much higher number of patients will be needed to determine a true impact of cervical collars on outcomes and fusion rates. Further, a number of retrospective reviews, although weaker in level of evidence, have found no benefit in the use of cervical collars.[3,16,22] For example, Cauthen et al.[16] performed a retrospective review comparing the impact of postoperative cervical collar use in 514 patients undergoing uninstrumented anterior cervical fusion, and found no difference in fusion rates in patients who wore a collar (86%) versus no collar (81%).[20] In a review of the literature study performed by Camara et al.,[22] aimed at determining whether a postoperative collar was necessary for fusion following ACDF, the authors did not find any strong evidence to support its use. The authors therefore recommended against the routine use of postoperative cervical collars following ACDF.[22] Moreover, a retrospective study performed by Jagannathan et al.[3] reported comparable fusion rates and clinical outcomes in a single surgeon retrospective review of 170 patients who underwent 1-level ACDF without a plate or a postoperative collar.[3] This study, and that of Cauthen et al.,[16] provide an interesting finding in that fusion rates and or clinical outcomes were not impacted by the addition of an anterior plate or a cervical collar. One can therefore infer, although with caution, from these studies that the additional biomechanical benefit of motion limitation provided by a plate could be sufficient to obviate the need for a cervical collar.

Although the results of this study does not support the use of a cervical collar following 1- or 2-level anterior cervical fusions performed for degenerative pathology, it behooves the treating surgeon to consider its use in certain clinical scenarios not evaluated in this study, and, thus a limitation of this study. Among those are anterior cervical fusions performed for unstable trauma with compromised posterior ligamentous complex, insufficient bone quality with poor fixation, multilevel corpectomies, patients with early radiographic signs of instrumentation loosening, and patients with severe or uncontrollable head tremors. Further, it is important to note that although the impact of a cervical collar on fusion rates was the focus of this study, the biological process of bony fusion is inherently dependent on multiple factors, such as adequacy of fusion bed preparation, graft type, and patient factors such as age and smoking.

CONCLUSIONS

We found no strong evidence to support the use of cervical collars after 1- and 2-level ACDF procedures, and no studies comparing collar use and no collar use after PCFs. Given the cost and likely impact of collar use on driving and the return to work, our study shows that currently, there is no proven benefit to routine use of a postoperative cervical collar in patients undergoing 1- and 2-level ACDF for degenerative cervical pathologies. Further studies of the utility of collar use after cervical spinal fusions should be performed.

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