ORIGINAL STUDY

Comparative Study Between the Results of Anterior Cervical Discectomy and Fusion Using Philadelphia or Soft Collar Postoperatively

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Abstract

Background data: **Anterior cervical discectomy and fusion (ACDF) is a well-known operative technique for treating cervical disc diseases causing myelopathy and/or radiculopathy. Postoperative immobilization with a rigid cervical brace is widely followed after ACDF using a standalone cage and soft braces frequently. Some authors have recommended using postoperative cervical braces, whereas others do not, and among surgeons who agree with postoperative collar usage, the type of cervical orthoses and the duration of use are also issues of debate.**

Purpose: **This study aims to compare between results of ACDF by using the Philadelphia collar and soft collar postoperatively.**

Study design: **A prospective study was conducted.**

Patients and methods: **This study included 60 patients with ACDF: 28 used Philadelphia collar (group I) and 32 used soft collar (group II). Cases with single-level ACDF to four levels were included, and revision and deformity cases were excluded. For 1 year, both groups were followed up regarding fusion rate, subsidence, cage migration, neck disability index (NDI), and visual analog scale of the neck and arm pain.**

Results: **Neck and arm pains using visual analog scale scores preoperatively and 3, 6, and 12 months postoperatively also showed no significant difference between both groups. Subsidence was noticed among two (7.1%) patients in group I and one (3.1%) patient in group II. No significant differences in fusion rates were found between both groups. After a 12-month follow-up in more than two-level procedures, the NDI score among group II was significantly lower ($P = 0.045$). Linear regression analysis revealed that preoperative NDI, age, BMI, and operation level were the predictors of postoperative NDI, excluding the presence of diabetes mellitus and brace type.**

Conclusion: **Cervical brace after ACDF by either Philadelphia or soft collar does not affect the fusion rate, cage subsidence, or outcomes of the neck and arm pain (2021ESJ255).**

Keywords: Anterior cervical discectomy and fusion, Cervical brace, Cervical spondylosis, Philadelphia collar, Soft collar

Introduction

The complication rate following anterior cervical spine discectomy and fusion (ACDF) is reported to be higher with cases of multilevel compared with the single level. Cervical bracing/collar is usually utilized after ACDF [1,2]. In earlier decades, bracing was used in cases of multiple-level procedures [3–5].

Anterior plating has become adopted because of its success in fusion rates, reduced rates of extrusion of graft and subsidence, and improved postoperative outcomes, paying little attention to the fused levels [6–10]. Because of the increased use of standalone cages in ACDF, many authors have used

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postoperative neck collars that reduce the pressure and axial overload on the construct, in turn improving fusion rates [4,11].

Different neck collars are frequently used: rigid, semirigid, and soft. Although the Philadelphia rigid collar controls neck movements, it is not well tolerated by the patients and may cause neck stiffness. On the contrary, soft collars do not control rotational movement but are better tolerated. Anterior plating showed successful results after ACDF; there are certain complications related to anterior plating, such as hardware problems and adjacent segment decompensation, which could be limited by using a rigid cervical collar that remains a good option for limiting cervical movement after cervical procedures [12–15].

The benefits of using cervical collars postoperatively in different studies are limited and variable. Some have stated that collars limit the movement, so they offer a good environment for fusion, improve outcomes, and decrease the rate of complications, which in turn affect the quality of life for patients. On the contrary, other studies have reported contradictory results of no relationship between the use of collars and improved outcomes [9,16–21]. Other concerns related to cervical collars include efficacy and safety as cervical collars have been reported to cause airway obstruction, dysphagia, pressure ulcers, and reduction of range of movement [2,22–24].

The present work aimed to assess the effectiveness of two different cervical collars on postoperative care following different levels of ACDF.

Patients and methods

A total of 60 patients were enrolled in the study using a nonrandomized experimental study. Patients were assigned into two groups: 28 patients in the Philadelphia collar group (group I) and 32 patients in the soft collar group (group II) during the period from August 2019 till January 2021 and follow-up till January 2022.

Inclusion criteria were patients with cervical disc degenerative diseases with persistent or progressive cervical radiculopathy after failed medical treatment for at least 3 months and/or persistent or progressive myelopathy attributed to cervical disc disease. Exclusion criteria were patients older than 70 years old, revision cervical surgeries, patients who underwent previous cervical laminectomy or posterior lateral mass fixation, and cervical spine infections.

All patients were subjected to single-level, double-level, three-level, or four-level ACDF using the standalone cage technique. Discectomy and decompression were done under illumination and magnification of the operative microscope. The cages used were polyetheretherketone cages filled with bone grafts collected during decompression. Postoperatively, 28 patients were immobilized by a Philadelphia collar and 32 were immobilized all time by the soft collar for 2 months.

Clinical assessment

Clinical outcomes were measured for both groups with documentation of neck disability index (NDI) [25]. Neck pain and arm pain were assessed using a visual analog scale (VAS) from 0 to 10. NDI and VAS were assessed preoperatively and at 3, 6, and after 12 months postoperatively. The NDI was measured as a quantitative value out of 50 points.

Radiological assessment

Radiographical outcomes were assessed such as cage subsidence, cage migration, and fusion rate assessed after a 12-month follow-up. Subsidence was measured as changes in the middle distance of vertebrae (the distance between the middle of the superior endplate of the superior operative vertebra to the middle inferior endplate of the operative inferior one) between immediately postoperative and 3, 6, and 12-month follow-up lateral cervical radiographs taken as standing films to accurately assess the subsidence and provide internal consistency. Fusion (bridging trabeculae, from one endplate to another, through or around the graft) was evaluated using a computed tomography scan at 12 months postoperatively [26]. The extent of cage subsidence was determined by comparing immediately postoperative (within 1 week) with final follow-up radiographs. Cage subsidence was defined as the sum of subsidence of the superior and inferior part of the cage into the vertebral body. Mild and major cage subsidence was defined as less than or equal to 2 mm and more than 2 mm, respectively [27].

Ethical considerations

This study was approved by the Research Ethics Committee, Faculty of Medicine, Alexandria University. The study complied with the International Guidelines for Research Ethics. All participants were informed that their participation was voluntary, and informed consent was obtained before undergoing the operation and research to ensure and confirm their understanding of the outcomes of the operation and the risks they might be subjected to during the intervention [28].

Statistical analysis

The collected data were revised, coded, tabulated, and analyzed using SPSS, version 25 (IBM, Chicago, Illinois, USA). Qualitative variables were expressed as frequency and percentage, and quantitative variables were expressed as mean and SD. The normality test was conducted using Kolmogorov–Smirnov test to test the normal distribution of data. Categorical variables were analyzed using χ^2; whenever χ^2 was not valid, Fisher's exact probabilities were used. Parametric quantitative variables were analyzed using Student's *t* test, whereas nonparametric variables were analyzed using the Mann–Whitney test. Friedman's test was also used for the neck pain, arm pain, and NDI assessment preoperatively, postoperatively, and during follow-up. Differences at *P* value less than 0.05 were statistically significant. Stepwise linear regression was done to detect predictors of 12-month postoperative NDI scores. Independent variables entered the model were preoperative NDI, age, BMI, operation level, diabetes mellitus (DM), and collar type. The reported model excluded the variables that did not influence the 12-month postoperative NDI scores; therefore, only the significant variables were reported in the final model.

Results

A total of 60 patients were studied at the final follow-up: 28 patients in group I and 32 patients in group II. The mean patients' age was 49.8 ± 12.3 years (range, 29–70 years). In total, 32 (54%) patients were females and 28 (46%) were males. Operated levels included 24 (40%) patients who had one-level, 16 (27%) had two-level, nine (15%) had three-level, and 11 (18%) had four-level ACDF. Table 1 shows that 53.6% of patients in group I were males, whereas 59.4% of group II were females, with a mean age of 52.4 ± 11.4 and 47.2 ± 10.3, respectively.

Table 1. Epidemiological characteristics of the study patients.

Parameters	Group I (N = 28)	Group II (N = 32)	P
Sex [n (%)]			
Male	15 (53.6)	13 (40.6)	0.316
Female	13 (46.4)	19 (59.4)	
Age (years)	52.4 ± 11.4	47.2 ± 10.3	0.068
Operative level [n (%)]			
One level	11 (39.3)	13 (40.6)	0.803
Two levels	8 (28.6)	8 (25.0)	
Three levels	3 (10.7)	6 (18.8)	
Four levels	6 (21.4)	5 (15.6)	
BMI	29.6 ± 3.3	30.9 ± 5.5	0.248
Smoker [n (%)]	14 (50.0)	14 (43.8)	0.628
Hypertension [n (%)]	7 (25.0)	5 (15.6)	0.327
Diabetes [n (%)]	6 (21.4)	4 (12.5)	0.491
CAD [n (%)]	2 (7.1)	0	0.214
COPD [n (%)]	2 (7.1)	0	0.214
CHF [n (%)]	1 (3.6)	0	0.467

*P value at a 95% confidence interval is less than 0.05, statistically significant.

Visual analog scale

Both groups showed a significant improvement in neck pain and arm pain ($P < 0.001$ for each) throughout the course of treatment to the final follow-up. Neck and arm pain scores preoperatively and 3, 6, and 12 months after surgery also showed no significant difference between both groups (Table 2).

Neck disability index

Both groups showed a significant improvement in NDI. NDI scores preoperatively and 3, 6, and 12 months postoperatively between the two groups showed no significant difference except for after 12-month follow-up in more than two-level procedures as the NDI score among group II was significantly lower ($P = 0.045$) (Table 2). A stepwise multiple linear regression was conducted with independent variables: preoperative NDI, age, BMI, operation level, DM, and collar type. The dependent variable was the 12-month postoperative NDI score. The overall model fit was $R^2 = 0.723$ with statistically significance ($P = 0.003$), and the final independent variables were preoperative NDI score, age, BMI, and operation level, as they were the only variables that improved the model fit and had a statistically significant effect on the 12-month postoperative

Table 2. Summary of preoperative and postoperative neck disability index, neck pain, and arm pain visual analog scale.

Parameters	Group I (N = 28)	Group II (N = 32)	P value
NDI			
Preoperatively	34.1 ± 6.5	31.7 ± 6.6	0.165
After 3 months	14.3 ± 6.1	12.9 ± 5.0	0.353
After 6 months	12.9 ± 5.9	11.2 ± 5.1	0.232
After 12 months	12.6 ± 6.4	10.0 ± 5.2	0.087
P value	<0.001[a]	<0.001[a]	
Neck pain			
Preoperatively	4.4 ± 1.5	4.3 ± 1.2	0.761
After 3 months	2.8 ± 1.0	2.9 ± 0.6	0.391
After 6 months	1.6 ± 1.0	1.8 ± 1.0	0.579
After 12 months	1.6 ± 0.8	1.6 ± 0.9	0.820
P value	<0.001[a]	<0.001[a]	
Arm pain			
Preoperative	5.2 ± 1.3	4.9 ± 1.6	0.461
After 3 months	1.4 ± 0.9	1.5 ± 0.9	0.541
After 6 months	1.6 ± 0.7	1.4 ± 1.0	0.298
After 12 months	1.5 ± 0.6	1.4 ± 1.1	0.707
P value	<0.001	<0.001	
Subsidence	2 (7.1)	1 (3.1)	0.594
Cage migration	0	1 (3.1)	1.00
Fusion rate	27 (96.4)	29 (90.6)	0.616

NDI, neck disability index.
[a] Significant (P < 0.05).

Table 3. Stepwise multiple linear regression model for predicting postoperative neck disability index score.

Parameters	Beta	SE	P
Constant	−4.096	3.784	0.284
Preoperative NDI	0.412	0.072	<0.001*
Age	0.134	0.043	0.003*
BMI	−0.299	0.097	0.003
Operation level	2.004	0.415	<0.001*

NDI, neck disability index.
The overall model had an R^2 value of 0.723, which was statistically significant ($P = 0.003$).
* P value at a 95% confidence interval is less than 0.05, statistically significant.

NDI score ($P < 0.001$, 0.003, 0.003, and <0.001, for the independent variables, respectively) (Table 3).

Cage subsidence, migration, and fusion rate

Mild subsidence less than 2 mm was noticed among two (7.1%) patients in group I and one (3.1%) patient in group II with no statistically significant difference ($P = 0.594$, Table 1). In group I, one patient underwent the operation at a single level and the other at two levels. In group II, the patient underwent the operation at three levels. Cage migration occurred in one case of group I ($P = 1$). This patient underwent the procedure at a single (C5–C6) level. The 1-year follow-up fusion rate for all levels for group I was 96.4%, whereas for the soft collar group, it was 90.6% ($P = 0.616$) and this was found to be statistically insignificant (Table 2 and Figs. 1 and 2).

Discussion

Limitation of neck movement is one of the essential methods used to improve the fusion rate and postoperative outcomes of patients [8]. There are a few recent studies aimed to address post-ACDF bracing [29].

Among many types of cervical collars used following ACDF, there is no evidence which one is better in providing such protection, and all of them have various abilities to restrict movement [20,30,31]. Studies have analyzed the three-dimensional motion restriction by different cervical braces and found that all types of braces effectively restrict the motion with minimal variations in comfort and effectiveness between these types in each form of motion. Moreover, one of these studies has divided these braces into cervical and cervicothoracic with better action of cervicothoracic ones [20,30]. Sandler et al. [32] concluded that cervical collars varied between patients, and all of them had a limited restriction of motions. Moreover, they also stated that the difference between collars is not enough to justify which one is more comfortable than the others.

The present work showed no difference between two brace types on NDI, which indicates the importance of cervical bracing postoperatively regardless of the type of brace used for patients. However, after 12 months postoperatively, NDI was significantly higher in the Philadelphia collar group in more two-level procedures than in the soft collar group, which might be related to the multilevel operation itself. In other words, using a soft cervical brace might be better in reducing NDI in case of more than two-level affection. However, there was no conclusive evidence about the effectiveness and benefits of using different cervical collars for better cervical immobilization and outcome. Other possibilities of this difference are the effect of more than two levels of the operation itself, higher NDI scores

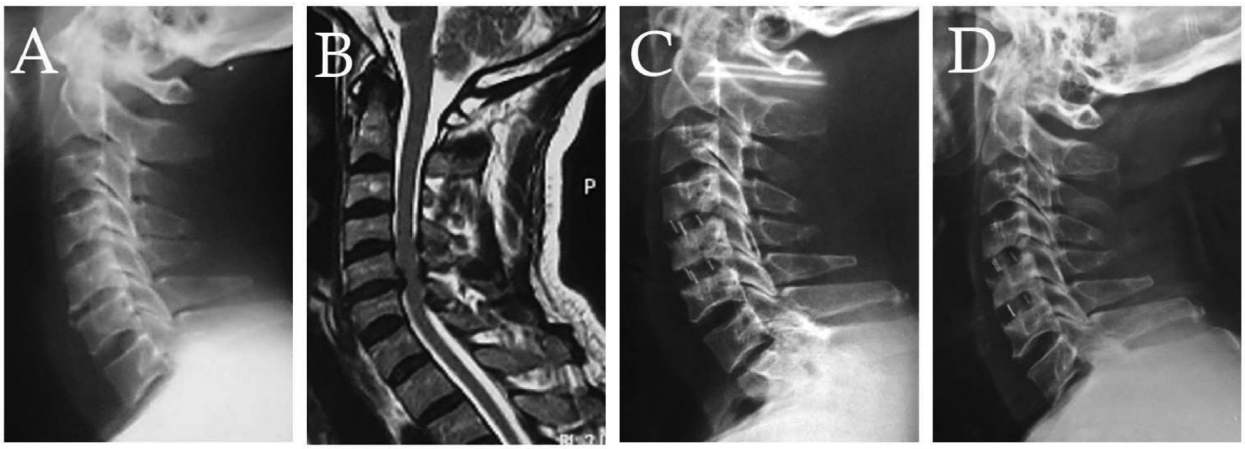

Fig. 1. (A) Preoperative lateral plain radiograph of a 50-year-old male patient. (B) Preoperative sagittal T2 MRI showing C4–C5–C6 discostenotic lesion. (C) Three-month postoperative plain radiograph lateral view. (D) Six-month postoperative plain radiograph lateral view showing good cage position and alignment.

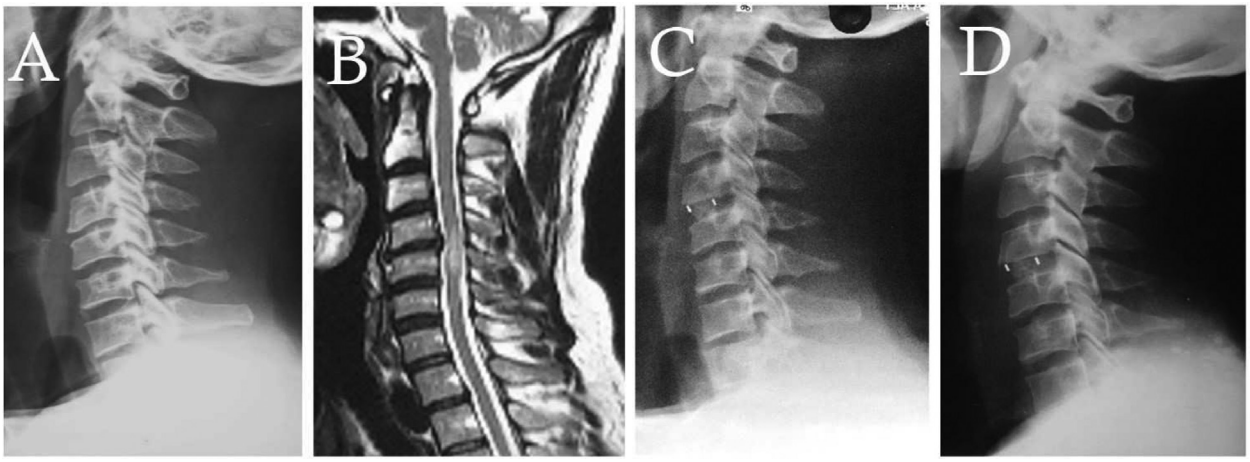

Fig. 2. (A) Preoperative lateral plain radiograph of a 49-year-old female patient with cervical myelopathy. (B) Preoperative sagittal T2 MRI showing C4–C5 discostenotic lesion. (C) Three-month postoperative lateral radiograph. (D) Six-month postoperative lateral radiograph showing good cage position and alignment.

preoperatively among the Ph group of patients (4.6 points higher in the Ph group), and the presence of other contributed factors such as age and comorbidities; all of these factors might cause this difference rather than the type of collar itself. Overley et al. [8] have reported a difference between using cervical collars and no collars in the NDI index but at not all times, and it was only in the second and 6 weeks of follow-up; however, this difference was in the form of a significant reduction of NDI score among nonbraced patients.

In our study, both collars reduced neck and arm pain following surgery with no difference between them in all levels. Dmytriv et al. [33] have demonstrated a rapid resolution of the neck and arm pain following two types of approaches over the control. They used a semihard cervical collar in one of their treatment groups. Literature has suggested that the use of soft cervical collars plays a role in conservative neck pain reduction of cervical radiculopathy but still lacks sufficient evidence of routine usage [34].

Linear regression analysis revealed that preoperative NDI, age, BMI, and operation level were the predictors of postoperative NDI, excluding the presence of DM and brace type. Overley et al. [8] has agreed with our results as they had the same predictors and excluding postoperative brace and presence of DM. Peolsson et al. [31] have found that normal rating on the Distress and Risk Assessment Method was the most important predictor of a high function of postoperative NDI.

Fusion rates showed an acceptable level in the present work exceeding 90% of both soft collar and Philadelphia collar. However, the Philadelphia collar showed higher fusion rates than the soft collar, which indicated its preference over soft braces, especially in single-level and more than two-level procedures. This might raise the concern about which type of collar to be used in the case of more than two-level procedures, as soft collars showed better outcomes in NDI scores, whereas Philadelphia collars showed better outcomes in fusion rates. On the contrary, a literature review has recommended not using external cervical bracing in cases of ACDF surgery as they are associated with lack of improvement in the fusion rates [35]. Other studies have also reported no significant effect of cervical braces on the improvement of fusion rate or subsidence [8,18,36,37].

Limitations of this study include absence of a control group with no brace, small populations size, and short follow-up period. It is recommended to take a larger number of patients to overcome confounding factors, especially the level variable, to follow up the patient for a longer period, and to comment on cervical sagittal profile preoperatively and postoperatively in both groups.

Conclusion

Our results suggest that the type of cervical brace post-ACDF does not affect the postoperative outcomes of the neck and arm pain, NDI, subsidence, or fusion rate. In conclusion, we recommend choosing the type of brace according to the other factors related to the patient and surgeon's choice rather than which brace has better outcomes.

Conflict of interest

There are no conflicts of interest.

Abbreviation list

ACDF	Anterior Cervical Discectomy and Fusion
BMI	Body Mass Index
DM	Diabetes Mellitus
NDI	Neck Disability Index
PEEK	Polyetheretherketone
VAS	Visual Analog Score

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الملخص العربي

دراسة مقارنة بين نتائج استئصال القرص العنقي الأمامي والاندماج بين الفقرات باستخدام طوق فيلادلفيا والطوق اللين بعد الجراحة

البيانات الخلفيه يتم تحجيم حركة العنق بواسطة الاطواق الصلبة على نطاق واسع بعد استئصال القرص العنقي الأمامي والدمج. يوصي بعض الأطباء باستخدام أجهزة تثبيت اللعنق بعد الجراحة في حين أن البعض الآخر لا يفعل ذلك ، وبين الجراحين الذين يتفقون مع استخدام طوق بعد العملية الجراحية نوع الطوق العنقى ومدة الاستخدام هي أيضًا موضوعات نقاش.

الغرض للمقارنة بين نتائج استئصال القرص العنقي الأمامي والاندماج باستخدام طوق فيلادلفيا وطوق لين بعد الجراحة.

تصميم الدراسة دراسة متابعة اكلينيكية مستقبلية.

المرضى والطرق اشتملت هذه الدراسة على 60 مريضًا اجرى لهم استئصال القرص العنقي الأمامي والاندماج سيتم تثبيت 28 منهم بواسطة طوق فيلادلفيا و 32 بواسطة طوق لين ، ثم ستتم متابعة كلا المجموعتين لمدة عام واحد فيما يتعلق بمعدل الاندماج والهبوط وهجرة القفص ومؤشر الإعاقة في الرقبة (NDI). تم تضمين الحالات مع مستوى واحد إلى 4 مستويات من الغضاريف. تم استبعاد حالات المراجعة والتشوه.

النتائج لا توجد فروق ذات دلالة إحصائية بين المجموعتين فيما يتعلق بالجنس والعمر ومؤشر كتلة الجسم والتدخين ووجود الأمراض المصاحبة. بعد 12 شهرًا من المتابعة في أكثر من مستويين من الإجراءات حيث كانت درجة مؤشر الإعاقة في الرقبة بين مجموعة ذوي الاطواق اللينة أقل بكثير (ع = 0.045). لوحظ هبوط القفص بين مريضين (7.1٪) في مجموعة ذوي اطواق فيلادلفيا ومريض واحد في مجموعة الاطواق اللينة (3.1٪).

الخلاصه لا يؤثر نوع الطوق العنقى على نتائج ما بعد الجراحة لآلام الرقبة والذراع ومؤشر الإعاقة في الرقبة.