

Degenerative Cervical Disorder—Stand-alone Cage Versus Cage and Cervical Plate: A Systematic Review

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Luis Fernando Ricci Boer¹ , Eduardo Zorzetto¹, Felipe Yeh¹,
Marcelo Wajchenberg^{2,3}, and Delio E. Martins^{1,2}

Abstract

Study Design: Systematic review.

Objectives: The objective of this study was to compare clinical and radiological outcomes following discectomy and anterior cervical fusion for the treatment of cervical degenerative disorder performed with stand-alone cages and anterior cervical plates.

Methods: Electronic searches were performed in the MEDLINE, LILACS, and Cochrane Systematic Reviews databases, according to PRISMA guidelines, with no language or date restriction. The review was registered in PROSPERO under number CRD42018109180.

Results: Six randomized clinical trials were selected, which evaluated at least one of the objectives of this work, such as pain control, bone consolidation, neurological symptoms, and cervical lordosis, thus satisfying the inclusion criteria. Articles that did not directly compare the 2 surgical techniques were excluded. A total of 309 patients were included and the results showed no significant difference in clinical (visual analogue scale and neck disability index) or radiological (cervical lordosis and fusion) outcome between the 2 groups. The operative time was shorter in the group with stand-alone cages (mean difference = -18.40; 95% CI = [-24.89, -11.92]; $P < .66$).

Conclusion: The stand-alone cages and anterior cervical plate techniques have similar clinical and radiological outcomes. Despite the significantly shorter operative time for one group, other randomized clinical trials are needed to establish conclusive evidence in favor of one of the comparative treatments.

Keywords

anterior cervical discectomy and fusion, cervical degenerative disc diseases, self-locking, stand-alone cage

Introduction

Cervical degenerative disorder (CDD) is part of the natural aging process.¹⁻³ It can be painful and occur in many forms, such as bulging disc, narrowing of the disc space, annular fissures, sclerosis of the terminal plates, and mucinous degeneration of the disc, in addition to herniated disks and stenosis of the cervical canal.⁴⁻⁸ The degree of degeneration is assessed through the use of magnetic resonance imaging, in addition to simple x-rays, which may not be related to the patient's symptoms.^{9,10}

Treatment of CDD is initially clinical, and surgery may be indicated if conservative treatment is unsuccessful or presents an important neurological deficit. Decompression by anterior cervical fusion stands out among the surgical techniques using the anterior approach. In this technique, various types of cages,

which can be self-locking (CAGE) or locked by a plate (PLATE), are used.¹¹ The present study compared works that evaluate the control of pain, neurological symptoms, and bone consolidation of these 2 techniques. In addition to an analysis of the maintenance of cervical lordosis, failure of implants, dysphagia, and cost.

¹ Universidade Anhembi Morumbi, São Paulo, SP, Brazil

² Hospital Israelita Albert Einstein, São Paulo, SP, Brazil

³ Universidade Federal de São Paulo, São Paulo, SP, Brazil

Corresponding Author:

Luis Fernando Ricci Boer, Universidade Anhembi Morumbi, Rua Itapiru 601, Saúde, São Paulo, SP, Brazil.
Email: fer_boer@hotmail.com



	Panchal 2017	Nemolo 2007	Nashian 2011	Loe 2016	Kim 2013	Dai 2008	
Random sequence generation (selection bias)	+	+	+	+	+	+	
Allocation concealment (selection bias)	+	+	+	-	-	-	
Blinding of participants and personnel (performance bias)	-	?	?	+	+	+	
Blinding of outcome assessment (detection bias)	?	?	?	?	?	+	
Incomplete outcome data (attrition bias)	+	+	+	+	+	+	
Selective reporting (reporting bias)	-	-	+	+	?	+	
Other bias	-	-	?	+	+	+	

Figure 1. Cochrane risk of bias.

Methods

This systematic review is registered in PROSPERO under the reference no. CRD42018109180.¹²

Search Strategy

This study followed PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.¹³ The electronic databases used were MEDLINE via PubMed, LILACS via Biblioteca Virtual em Saúde (BVS), Cochrane Central Register of Controlled Trials–CENTRAL and Cochrane/DARE, with no restrictions placed on language or dates published up to September 2, 2018. The search strategy for MEDLINE is represented in the following example: (((“Intervertebral disc degeneration” [mh] OR “Disc Degeneration” [mh] OR “Degenerative disc disease” [tw] OR “spinal stenosis” [tw] OR “zero profile” [tw] OR “self-locking” [tw] OR “anchored” [tw] OR “Degenerative disease” [tw] OR “myelopathy” [tw] OR “cervical spinal stenosis” [tw] OR “spinal cord compression” [mh] OR “neck pain” [mh] OR “neck pain” [tw] OR “cervical pain” [tw] OR “Intervertebral disk degeneration” [mh] OR “Spondylolysis” [mh] OR “spinal stenosis” [mh] OR hernia* [tw] OR prolapse* [tw] OR extru* [tw]) AND (ACDF [tw] OR “anterior cervical discectomy fusion” [tw] OR “stand-alone cage” [tw] OR “cervical cage” [tw] OR “anterior cervical plate” [tw] OR “anterior cervical fixation” [tw] OR “anterior cervical fusion” [tw] OR “anterior cervical arthodesis” [tw])) AND (((meta-analysis [pt] OR Systematic Reviews [tw] OR randomized controlled trial [pt] OR controlled clinical trial [pt] OR randomized controlled trials [mh] OR random allocation [mh] OR double-blind method [mh] OR single-blind method [mh] OR clinical trial [pt] OR clinical trials [mh])))).

Other electronic databases followed the same strategy, with minor adjustments. Manual searches were conducted in relevant journals, where the authors were contacted via email when

necessary for additional information. Reference lists for all the articles were independently reviewed by 3 researchers (EZ, FSY, and LFRB) and the articles identified as potentially relevant were systematically evaluated with regard to the inclusion and exclusion criteria. Inconsistencies were resolved through discussion and any disagreement was resolved by consensus.

Selection Criteria

The inclusion criteria used in this systematic review were (1) randomized and quasi-randomized clinical trials that employed stand-alone cages in the treatment of CDD; (2) adult patients aged 18 years or older, of both sexes, with degenerative diseases of the cervical column such as discopathy, arthritis, herniated disc, and cervical stenosis; (3) reported one of the following outcomes: visual analogue scale (VAS) score, Japanese Orthopaedic Association (JOA) score, cervical incapacity (neck disability index [NDI]) score, bone consolidation, operative time, blood loss, cervical lordosis, segmental kyphosis, presence of dysphagia, loosening of plate, and treatment costs. The exclusion criterion applied to all the articles was studies with patients that presented a nondegenerative indication for ACDF (anterior cervical discectomy and fusion), such as trauma or tumor.

Data Extraction and Critical Appraisal

Bibliographical research articles were critically reviewed by 2 authors (EZ, LFRB) with regard to their suitability for inclusion in the study, in accordance with the critical review list by Cochrane Collaboration.¹⁴ All data was extracted from the texts, tables, and figures of the articles, with estimates based on the data and numbers presented. The critical appraisal of risk of bias for clinical trials was performed using the Cochrane Risk of Bias Tool¹⁵ as shown in Figure 1.

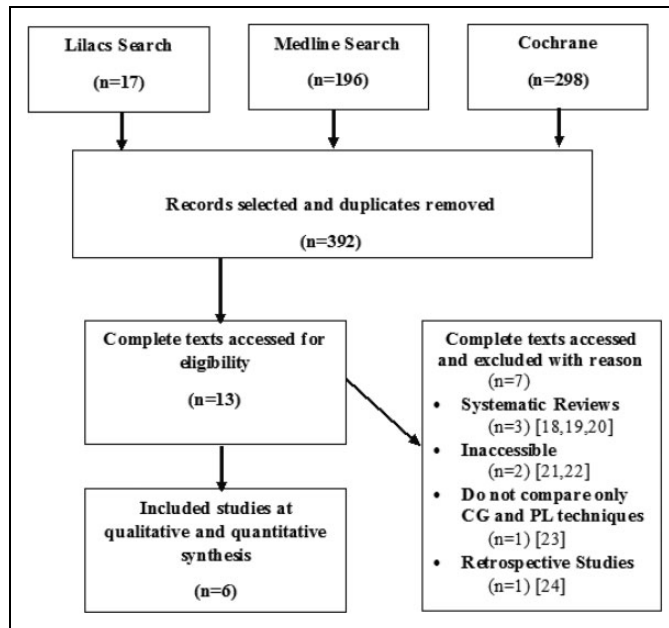


Figure 2. Flowchart of systematic review and PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) meta-analysis. The studies analyzed are represented by numbers, as shown in Table 1.

Statistical Analysis

Initially, a descriptive analysis was performed on the results of these studies in order to characterize the variables and the experiments. The results were presented in the form of a table, with the means, standard deviations and proportions, in accordance with the nature of the variable. To measure and test heterogeneity, in order to choose the best model, Cochran's Q test was used, whose distribution under a null hypothesis of heterogeneity is approximately chi-square.¹⁴ In addition, the I^2 measurement, which uses a scale from 0% to 100% to measure the magnitude of heterogeneity, was also considered. In order to apply the methodology of the meta-analysis, we considered the measurement of the effect as the difference between the variables measured in the pre- and postintervention periods (pre – post) and for the calculation of the variance of this difference, the basic property of variance of the difference of 2 random variables was used. For the analysis, the meta and Metafor packages for the statistical environment R (Vienna, Austria, 2015) were used and the levels of significance were set at 5% for all cases.

Results

A total of 511 studies were found using the search strategy. After the exclusion of duplicate entries, 392 were analyzed by title and abstract, and 13 were selected for comprehensive reading, of which 6 were included in this review, as shown in the flowchart presented in Figure 2 (see also Table 1).

Pain Scales

VAS scores for cervical and arm pain were present in the 6 studies analyzed.¹⁶⁻²¹ There is heterogeneity in the studies ($I^2 = 83.39\%$; $Q = 48.15$, $P < .001$) and the results show a slight improvement in cervical pain on the VAS scale in the PLATE group, although there was no significant difference between the procedures (mean difference = -0.09 ; 95% CI = $[-0.46, 0.27]$; $P = .8144$) as shown in Figure 3. On the VAS for arm pain the opposite was found, a slight improvement in pain for the CAGE group, without a significant difference between the techniques (mean difference = 0.30 ; 95% CI = $[-0.29, 0.88]$; $P = .7666$) as shown in Figure 4. Again, heterogeneity was found ($I^2 = 97.47\%$; $Q = 315.18$, $P < .001$).

Figure 5 shows that there was no significant difference between the 2 procedures compared using the NDI scale (mean difference = -0.70 ; 95% CI = $[-1.88, 0.47]$; $P = .04$), present in 4 clinical trials¹⁷⁻²⁰ with evident heterogeneity between the studies ($I^2 = 98.45\%$; $Q = 258.34$; $P < .001$).

Radiological Results

Bone consolidation was reported in 5 of the studies analyzed, with percentages ranging from 88.9% to 100%.^{16,18-21} These results indicate that there is no significant difference between the surgical techniques, which is apparent in the similar estimates of the odds ratio (OR) (fixed: OR = 1.36 and 95% CI = $[0.53, 3.53]$; random: OR = 1.38 and = $[0.51, 3.74]$; $P = .66$) represented in Figure 6. In the evaluation of heterogeneity, I^2 and Q estimates of 63.12% and 12.69, respectively, culminate in a P value of .0055. The angle of cervical lordosis was described in 3 of the analyzed works.^{18,20,21} Figure 7 clearly shows a significant increase in the angle for the PLATE group (mean difference = 1.94 ; 95% CI = $[0.15, 3.74]$) and heterogeneity ($I^2 = 87.15\%$; $Q = 15.56$, $P = .0004$).

Fusion was evaluated by x-ray in all included studies¹⁶⁻²¹; however, 3 studies also used computed tomography (CT) scans^{17,18,21} and 1 study included MRI in the fusion evaluation.¹⁸

Operative Time

Operative time was present in 3 clinical trials for both groups.^{18,20,21} Figure 8 shows shorter operative time for the CAGE group both in the analysis of random effects models (mean difference = -18.40 ; 95% CI = $[-24.89, -11.92]$; $P < .66$) and fixed effects models (mean difference = -17.87 ; 95% CI = $-28.53; -7.21]$; $P < .001$). The values found show heterogeneity ($I^2 = 99.66\%$; $Q = 583.80$; $P < .001$).

Discussion

The present systematic review analyzed six randomized clinical trials with regard to the surgical intervention of 309 patients with CDD submitted to the anterior surgical approach to the spine with stand-alone cages or cages with plates.

Table 1. Data on Studies Analyzed.

First Author	Country	Year	Study Type	No. Patients in Cage Group	No. Patients in Plate Group	Cage Material	Clinical Outcomes	Radiological Outcomes	Outcomes
Panchal, PR	USA	2017	Randomized clinical trial	26	28	PEEK	VAS and NDI	Bone consolidation, cervical lordosis	Operative time
Dai, LY	China	2008	Randomized clinical trial	29	33	PEEK + Beta-TCP	VAS	Bone consolidation, cervical lordosis	Operative time
Kim, CH	South Korea	2013	Randomized clinical trial	29	23	PEEK ^a	VAS and NDI	Bone consolidation	
Lee, SE	South Korea	2016	Randomized clinical trial	27	31	PEEK ^a	VAS and NDI	Bone consolidation	
Nabhan, A	Germany	2011	Randomized clinical trial	19	18	PEEK	VAS		
Nemoto, O	Japan	2007	Randomized clinical trial	24	22	PEEK	VAS	Bone consolidation, cervical lordosis	Operative time

Abbreviations: PEEK, polyetheretherketone; beta-TCP, β -tricalcium phosphate; VAS, visual analogue scale; NDI, neck disability index.

^aCage + Autograft.

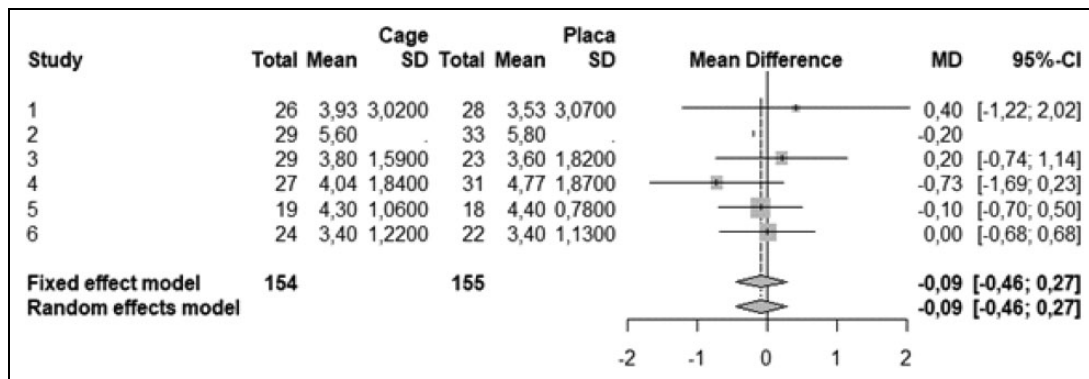


Figure 3. Results of the meta-analysis of mean difference (before – after) of the visual analogue scale (VAS) scores for the neck according to group.

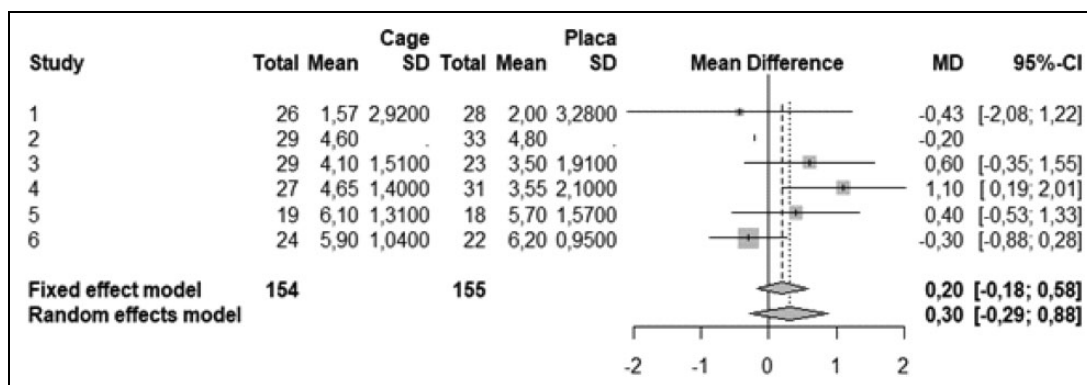


Figure 4. Results of the meta-analysis of mean difference (before – after) of the visual analogue scale (VAS) scores for the arm according to group.

The results showed that, in relation to the VAS cervical pain scale, there was a difference in the standard deviation with the other groups, with patients treated with CAGE presenting a lower value, with the exception of group 6, which did not

follow this pattern. Despite this difference there was no significance in relation to the group with PLATES. On the same scale, with regard to improvement in arm pain, the pattern repeated itself very similarly to that cited above.

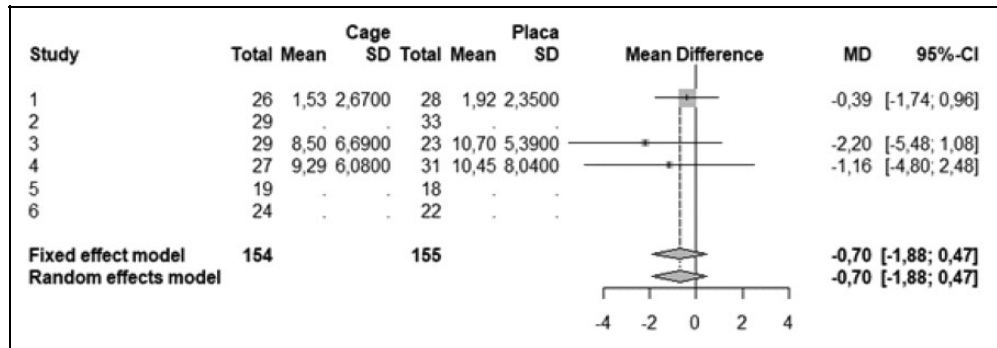


Figure 5. Results of the meta-analysis of mean difference (before – after) of the neck disability index (NDI) scores according to group.

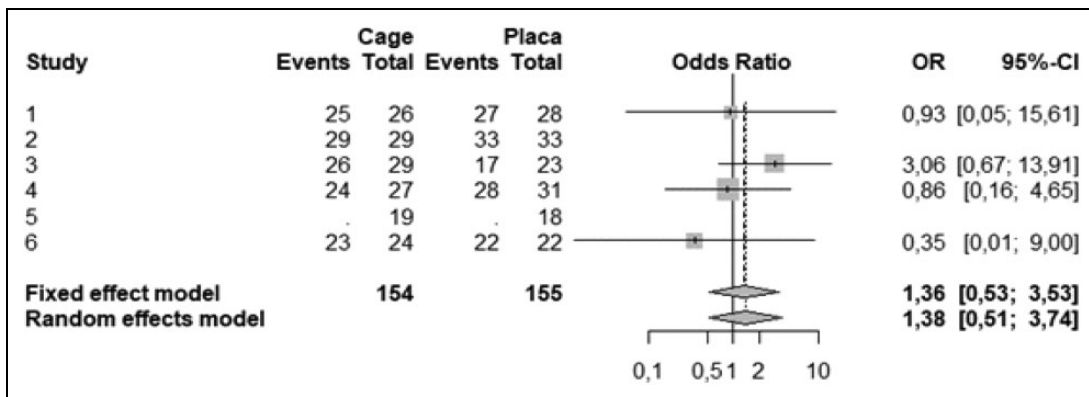


Figure 6. Results of the meta-analysis of the proportion of bone consolidation according to group.

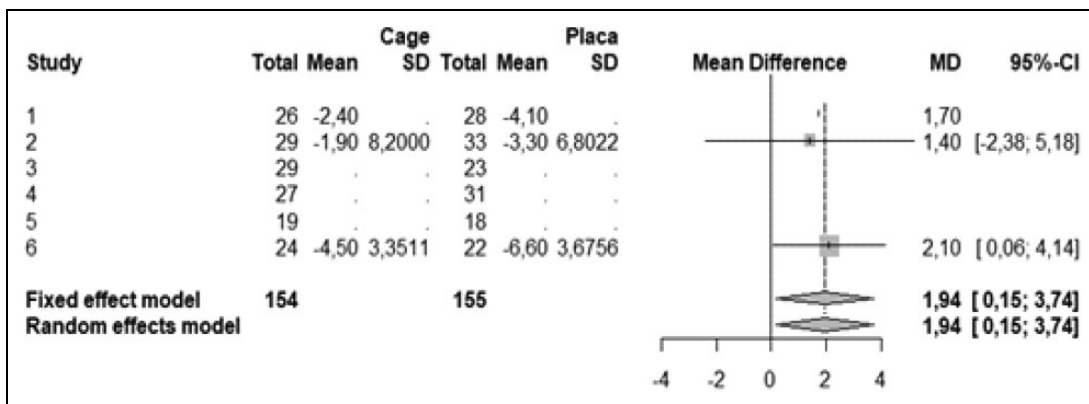


Figure 7. Results of the meta-analysis of the reduction of cervical lordotic angles according to group.

For the assessment of neurological improvement, the NDI scale data in studies 1, 3, and 4 showed a greater difference in standard deviation for the groups treated with CAGE than the group with PLATES. In the other groups, no information was presented for this scale. Even considering this difference, no relevance was found between the techniques.

With regard to bone consolidation, the highest proportion found for the CAGE group was in study 2 (100%) and the lowest proportion was found in study 4 (88.90%). On the other hand, there was 100% bone consolidation in studies 2 and 6 for

the PLATE group, while the lowest proportion found for this group was found in study 3 (75.8%). For study 1, the difference was 0.1%, and this was the highest for the PLATE group. The difference between the 2 groups was therefore not relevant, even considering the higher values presented by the PLATE group.

All works used PEEK (polyetheretherketone) cages, except Dai and Jiang,²¹ who used carbon fiber cage (27 patients) and PEEK (35 patients). Autologous bone from iliac crest was used for fusion augmentation in all studies. In 2 cases, hydroxyapatite

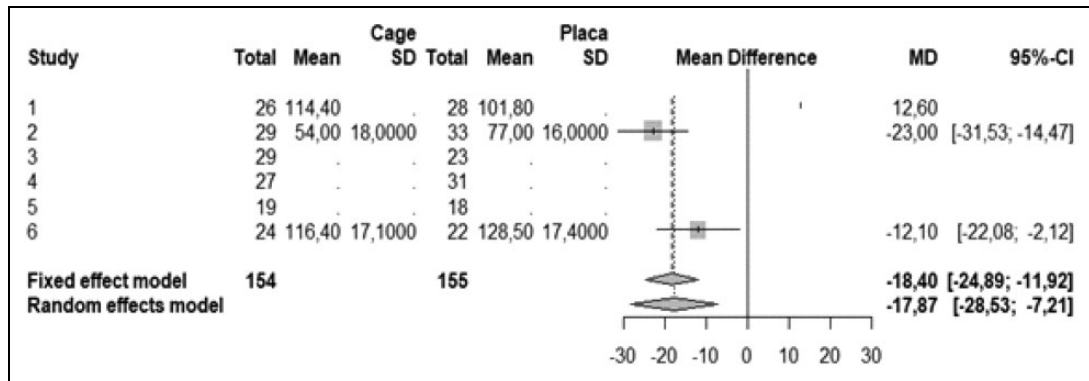


Figure 8. Results of the meta-analysis of average operative time according to group.

with collagen¹⁸ and beta-TCP (β -tricalcium phosphate)²¹ were also used.

With regard to operative time, only studies 1, 2, and 6 contain this information, and the mean operative time for the PLATE group was shorter only in study 1. In addition, a large difference is seen in the operative time values in study 2 as compared with the others, which are shorter, despite the similar standard deviations. This difference is also found in group 6, although to a lesser extent. With regard to operative time, we conclude that the CAGE group presents a slight advantage over the PLATE group. We believe that the mean difference of 18.4 minutes less time for the CAGE group, although statistically significant, is small, considering that surgeons tend to create the surgical opening and prepare the surgical field with the placement of the plate in mind. The learning curve for inserting the locking screws can also increase operative time but does not interfere in a significant manner in reducing the time for this technique. There is perhaps a difference with regard to the size of the incision, but this was not reported in the studies evaluated. Another point to be considered is that the self-locking screws limit the surgery to the compromised disk space, reducing the risk of osteophytosis to the level adjacent due to poor positioning of the plate.

Similar to that presented for operative time, only groups 1, 2, and 6 provided information regarding cervical lordosis. The results showed that the first one did not present information pertinent to the deviation, so it cannot be considered in the subsequent analysis. It was noted that study 2 differs from the others, with higher initial and final means for both groups, despite there being a smaller mean difference (in magnitude) between the studies for both the CAGE group (average = -1.90 ; SD = 8.20) and the PLATE group (average = -3.30 ; SD = 6.80), similar to what occurred for group 6, again to a lesser extent. One possible factor for the plate presenting a better correction for lordosis may be related to the molding performed for the attachment which already sets the spine in a position of lordosis.

One postoperative complication is dysphagia, although none of the studies offered information on the subject. Other reviews showed that despite the higher number of plate technique cases, no significant effect was found regarding the techniques.^{22,23}

However, in patients in the work by Forgel and McDonnell,²⁴ who were submitted to surgery to remove plates, high adhesion of the esophagus to the prevertebral and anterior cervical fascias that envelop the plate was observed.²⁴ All the cases were successful and improved dysphagia of solids and liquids after removal of the plates.²⁴

Conclusion

The use of stand-alone CAGE is equivalent to the use of PLATE in ACDF. The results do not show significant differences in the clinical outcomes (VAS and NDI scores) or radiological results (fusion and cervical lordosis) between the 2 groups. Even with a significantly shorter operative time for the CAGE group, these 2 approaches remain comparable, with no clear overall superiority of one approach over the other. Other randomized clinical trials are needed to establish conclusive evidence in favor of one of the surgical techniques.

Declaration of Conflicting Interests

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ORCID iD

Luis Fernando Ricci Boer  <https://orcid.org/0000-0002-2192-0936>

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