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Is anterior cervical plating necessary for cage constructs in anterior cervical discectomy and fusion surgery for cervical degenerative disorders? Evidence-based on the systematic overview of meta-analyses

Vibhu Krishnan Viswanathan[a,b], Sathish Muthu[b,c,*]

[a] Department of Musculoskeletal Oncology, University of Calgary, Alberta, Canada
[b] Orthopaedic Research Group, Coimbatore, Tamil Nadu, India
[c] Department of Orthopaedics, Government Medical College, Dindigul, India

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ABSTRACT

Study design: Systematic review of meta-analyses.
Objective: To perform a systematic review of meta-analyses to compare the clinical and radiological outcomes following anterior cervical discectomy and fusion with stand-alone cage (SAC) and anterior cervical cage-plate constructs (ACCPC).
Methods: The systematic overview was conducted in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and reported as per Cochrane Handbook for Systematic Reviews of Interventions following the methodology described in reporting Overview of reviews.
Results: Based on the available level-1 evidence, SAC offers significantly better benefits over ACCPC, in terms of shorter operative time ($p < 0.00001$; $I^2 = 0\%$), lower blood loss ($p = 0.01$; $I^2 = 0\%$), lesser rates of post-operative dysphagia ($p = 0.02$; $I^2 = 0\%$), reduced overall expenditure ($p = 0.001$) and long-term adjacent segment degeneration (ASD)/anterior longitudinal ligament ossification (ALO; $p = 0.0003$; $I^2 = 0\%$). There is no significant difference between the two constructs with regard to fusion rates, functional outcome scores, follow-up radiological sagittal alignment parameters or cage subsidence.
Conclusion: Based on the available evidence, SAC constructs in ACDF reduce blood loss, decreases operative time, mitigates post-operative dysphagia, lessens hospital-related expenditure and minimises long-term ASD rates.

1. Introduction

Since the initial description by Smith and Robinson in 1958, anterior cervical discectomy and fusion (ACDF) has remained an effective procedure performed for degenerative conditions of the cervical spine.[1] Traditionally, this has been achieved with an anterior cervical cage-plate construct (ACCPC), where augmentation of the anterior column with a plate device provides greater spinal stability, enhances intervertebral fusion and mitigates cage displacement.[2–4] Nevertheless, these plate-augmented constructs were associated with complications including plate failure, dysphagia, neurovascular adversities, soft tissue damage and adjacent segment degeneration (ASD).[5–7]

In order to overcome these complications, a newer surgical technique was introduced around two decades earlier, which involved the utilization of a stand-alone-cage (SAC) system using zero-profile anchoring cages.[8,9] This construct consists of a cage anchored directly to the adjoining vertebral bodies by a pair of locking screws, which precludes the need for an additional plate.[8,9] This has been reported to potentially

Abbreviations: ACCPC, Anterior cervical cage-plate constructs; ACDF, Anterior Cervical Discectomy and Fusion; ACP, Anterior cage plating; ALO, Anterior longitudinal ligament ossification; AMSTAR, Assessment of Systematic Reviews; ASD, Adjacent Segment Degeneration; CCT, Cochrane Collaboration's tool; CHSRI, Cochrane Handbook for Systematic Reviews of Intervention; CLH, Cochrane Library Handbook; CRBT, Cochrane Risk of Bias Tool; CRGC, Cochrane Review Group criteria; DBS, Downs and Black score; JBISS, Joanna Briggs Institute Scoring System; JOA, Japanese Orthopaedic Association; MOOSE, Meta-analyses Of Observational Studies in Epidemiology; NDI, Neck Disability Index; NOS, Newcastle–Ottawa Scale; NR, Not reported; OCEBMLECS, Oxford Centre for Evidence-Based Medicine Level of Evidence 2 classification system; PRESS, Peer Review of Electronic Search Strategy; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; PROSPERO, Prospective Register of Systematic Reviews; RCT, Randomised controlled trial; SAC, Stand-Alone Cage; VAS, Visual Analog Scale score.

* Corresponding author. Research Head, Orthopaedic Research Group, Coimbatore, Tamil Nadu, India.
E-mail addresses: drvibu007@gmail.com (V.K. Viswanathan), drsathishmuthu@gmail.com, sathishmuthu@orthopaedicresearchgroup.com (S. Muthu).

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offer less soft tissue violation and lower implant profile, resulting in mitigated implant-related adversities. On the other hand, certain studies have also reported compromised early stability, higher rates of subsidence and poorer sagittal alignment restoration following the use of SAC.

Diverse randomised trials and systematic reviews have been published on this subject hitherto.[10–14] Nevertheless, there has been no definitive evidence on whether one of these surgical options is clinically, radiologically or functionally superior to the other. The current study was thus planned to perform a systematic review of the existing meta-analyses, so as to explore these controversies, compare the high-quality evidence regarding the clinical and radiological outcome; and provide recommendations on this issue.

2. Methods

The systematic overview was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and reported as per Cochrane Handbook for Systematic Reviews of Interventions following the methodology described in reporting Overview of reviews.[15]

2.1. Search strategy

We searched for the systematic reviews with meta-analysis published in the English literature analysing the cage constructs utilised in ACDF surgery using search terms such as "ACDF", "anterior cervical decompression fusion", "cage", "standalone cage", "cage with plate", "systematic review", "meta-analysis" in PubMed, EMBASE, Web of Science, Scopus and the Cochrane Database of Systematic Reviews. We made our search strategy in accordance with the Peer Review of Electronic Search Strategy (PRESS) guidelines.[16] We also searched the reference list of the included studies for any relevant additional studies not identified in primary search. Moreover, we also looked into the International Prospective Register of Systematic Reviews (PROSPERO) registry for any potential ongoing reviews nearing completion on the subject analysed. The literature search was done on April 15th 2022 without any restriction of publication period. Two reviewers made an independent and duplicate search of literature with above search strategy and any discrepancy were resolved with discussion. Fig. 1 shows the PRISMA flow diagram of selection of reviews for inclusion into the analysis.

2.2. Inclusion & exclusion criteria

We included only systematic reviews with meta-analysis that compared the utilisation of standalone cage versus cage with plate fixation for ACDF surgeries. We included studies published in English language with a clear reporting of strategies for study selection, appraisal methods and result synthesis. The study must have included at least one of the outcomes of interest such as fusion, functional outcome parameters, complications in their research question of systematic review. We excluded narrative reviews, correspondence articles, topical reviews, reviews without a comparator group, systematic review without meta-analysis and reviews with mixed intervention groups analysed together. Two reviewers made an independent and duplicate search of literature and any discrepancy in inclusion of reviews were resolved with discussion.

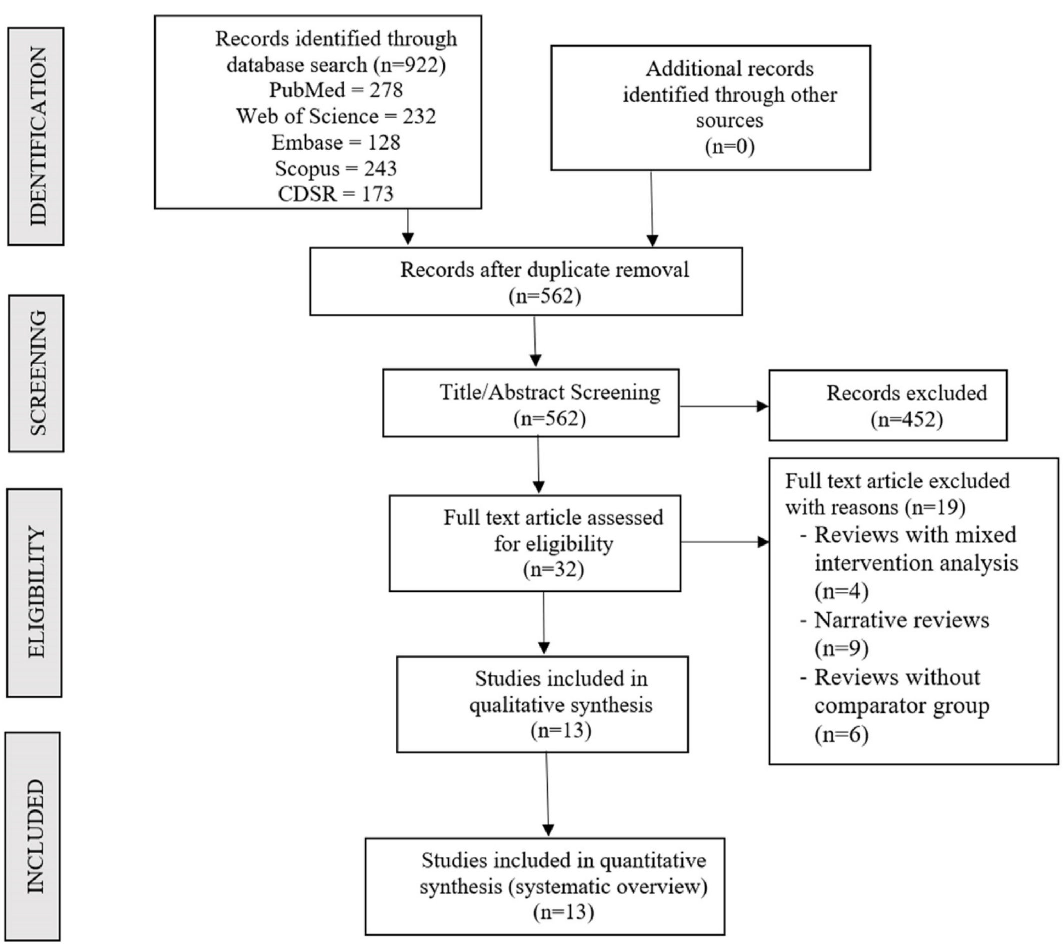

Fig. 1. PRISMA flow diagram of the included studies in the analysis.

2.3. Data extraction

Two reviewers did an independent and duplicate data extraction from the included studies. We extracted data such as name of the author, year and journal of publication, date of literature search, total number of included studies, nature of the included studies, language restrictions if any, their inclusion and exclusion criteria, databases searched, heterogeneity of the reported results and subgroups analysed. Any disagreement in the data extraction was resolved by discussion until a consensus was attained.

2.4. Quality assessment

We ascertained the methodological quality of the included systematic review based on the level of evidence of the included primary studies in them based on the Oxford Levels of Evidence. We used the Assessment of Systematic Reviews (AMSTAR) score and its upgraded tool AMSTAR 2 grading to evaluate the methodological quality of the included reviews.[17,18] Two reviewers made independent and duplicate assessment of methodological quality and any disagreement was resolved by discussion until a consensus was attained.

2.5. Heterogeneity assessment

I^2 values reported in the included reviews were used to analyse the heterogeneity in the reported results. If $I^2 > 50\%$ and $p < 0.1$, heterogeneity was deemed to exist in the reported results and the reviews were further explored for sensitivity or subgroup analysis if done to explore into the heterogeneity noted in their reported results. Final recommendations were derived from the results analysed from the individual reviews with due appraisal of the heterogeneity of the result concerned and overall level of evidence of the review performed.

3. Results

The comprehensive systematic search in the electronic databases generated 922 articles, which were subjected to an initial screening for the removal of duplicate articles. This yielded 562 articles. Further screening of title and abstract resulted in the exclusion of 452 articles. Following this, a total of 32 articles qualified for reviewing the full-text. After full-text review by both reviewers, 19 studies were excluded. Finally, 13 meta-analyses[10–14,19–26] were included in this systematic review. These overlapping meta-analyses were published in different journals between 2015 and 2021. The number of studies included in these studies ranged between 6 and 19 as shown in Table 1. The publication years of the included studies in these meta-analyses ranged between 2004 and 2019 as shown in Table 2. The characteristics of the patients included in these reviews were presented in Table 3.

Table 1
Studies included in the analysis.

Sl. No	Study	Publication year	Journal	Country	Number of included Primary Studies
1	Shao et al.	2015	Journal of Orthopaedic Surgery and Research	China	7
2	Xiao et al.	2016	European Spine Journal	China	16
3	Oliver et al.	2017	Spine	USA	15
4	Nambiar et al.	2017	European Spine Journal	Australia	6
5	Tong et al.	2017	World Neurosurgery	China	7
6	Lu et al.	2018	European Spine Journal	Germany	9
7	Zhang et al.	2018	World Neurosurgery	China	15
8	Yang et al.	2018	Medicine	China	10
9	Cheung et al.	2019	Global Spine Journal	USA	19
10	Gabr et al.	2020	Global Spine Journal	USA	14
11	Zhao et al.	2020	European Spine Journal	China	7
12	Boer et al.	2021	Global Spine Journal	Brazil	6
13	Savio et al.	2021	Asian Spine Journal	Indonesia	14

SAC – Stand-Alone Cage; ACP – Anterior cage plating.

3.1. Quality assessment

Based on the AMSTAR criteria the scores of the included reviews ranged from 6 to 10 with a mean score of 9 showing good methodological quality of the included articles. However, on further analysis based on the AMSTAR 2 grading, most of the included studies failed at critical domains of AMSTAR 2 grading such as non-availability of the complete list of excluded articles from the full-text screening with their reasons for exclusion and analysis of publication bias. Hence almost all of them were allotted to low or critically low grades as shown in Table 4.

3.2. Heterogeneity assessment

All the included studies[10–14,19–26] used I^2 values to assess the heterogeneity of the results from their analysis. But only four of the included studies[11,12,14,24] explored into the causes for heterogeneity by sensitivity or subgroup analysis. Of all the included studies only one study[12] performed GRADE assessment of their outcomes. All the results from the included systematic reviews were appraised based on the heterogeneity of the results and the overall level of evidence of the review performed and presented below.

3.3. Clinical outcomes

Table 5 shows the compilation of evidence regarding the clinical outcomes such as improvement on Visual Analog Scale score (VAS), Odom's criteria, Robinson's criteria, Japanese Orthopaedic Association (JOA) criteria and Neck Disability Index (NDI); and overall fusion rates from the included studies. With regard to fusion rate, a majority of the included studies (excepting three) reported no significant difference in the fusion rate between the two constructs.[12,23,26] Three studies (Oliver et al,[12] Savio et al[26] and Gabr et al[23]) demonstrated statistically better fusion rates with cage-plate constructs. However, on further evaluation, it was noted that the quality of these 3 studies was relatively less acceptable (the former 2 studies were observational in nature; while the latter study did not follow a standard meta-analytic methodology resulting in the generation of heterogenous inferences).

Similarly, with regard to the improvements in pain (VAS score) and functional outcome (based on Odom's criteria, Robinson's criteria, JOA score, and NDI score), a majority of included studies did not demonstrate any statistically significant difference between the two constructs. The only study which demonstrated significantly better outcome with ACCPC was published by Oliver et el.[12] However, in view of the afore-mentioned reasons regarding its methodology, the quality of evidence in this study was relatively less reliable.

3.4. Perioperative parameters and early complications

Table 6 shows the compilation of evidence on perioperative parameters such as operative time, blood loss, length of hospitalisation and immediate postoperative complications such as dysphagia and dysphasia

Table 2
Characteristics of the included systematic reviews and meta-analyses.

Sl. No	Study	SAC [*n* (%)]	Years of publication (Individual studies)	Studies included	Primary Study Design	Level of Evidence	Number of patients included	Study Appraisal
1	Shao et al.	262 (46.8%)	2013 to 2015	7	Prospective – 2 RCT – 1 Retrospective – 4	Level III	560	CLH
2	Xiao et al.	545 (51.1%)	2013 to 2016	16	Prospective – 3 RCT – 2 Retrospective – 11	Level III	1066	NOS
3	Oliver et al.	486 (54.4%)	2004 to 2016	15	RCT – 3 Prospective – 1 Retrospective – 11	Level III	893	NOS, CRGC
4	Nambiar et al.	167 (51.38%)	2014 to 2016	6	RCT – 1 Retrospective – 5	Level III	325	MOOSE
5	Tong et al.	195 (47.7%)	2012 to 2016	7	RCT – 1 Retrospective – 6	Level III	409	MINORS
6	Lu et al.	302 (44%)	2012 to 2017	9	Retrospective – 9	Level III	687	MOOSE
7	Zhang et al.	496 (48.7%)	2012 to 2018	15	Prospective – 3 Retrospective – 12	Level III	1018	NOS
8	Yang et al.	277 (48.8%)	2012 to 2018	10	Retrospective – 10	Level III	NR	NOS
9	Cheung et al.	603 (51.5%)	2009 to 2016	19	Prospective – 4 Retrospective – 15	Level III	1170	DBS
10	Gabr et al.	583 (50%)	NR	14	RCT – 14	Level I	1173	CHSRI
11	Zhao et al.	268 (49.6%)	2015 to 2018	7	RCT – 7	Level I	540	CCT
12	Boer et al.	154 (49.8%)	2007 to 2017	6	RCT – 6	Level I	309	CCT, CRBT
13	Savio et al.	522 (54.38%)	2010 to 2019	14	Prospective – 2 Retrospective – 12	Level III	960	JBISS

CCT - Cochrane Collaboration's tool; CHSRI - Cochrane Handbook for Systematic Reviews of Intervention; CLH - Cochrane Library Handbook.
CRBT - Cochrane Risk of Bias Tool; CRGC - Cochrane Review Group criteria; DBS - Downs and Black score; JBISS - Joanna Briggs Institute Scoring System; Methodological index for non-randomized studies; MOOSE - Meta-analyses Of Observational Studies in Epidemiology; NOS–Newcastle–Ottawa Scale; NR – Not reported; OCEBMLECS - Oxford Centre for Evidence-Based Medicine Level of Evidence 2 classification system; RCT – Randomised controlled trial.

Table 3
Characteristics of patients included in the systematic review analysed.

Sl. No	Study	Age (years)		Levels of surgery	Follow-up (months)	
		Standalone Cage group	Anterior Cage Plate group		Standalone Cage group	Anterior Cage Plate group
1	Shao et al.	43.6–56.8	44.9–54	1–3	6–33.6	6–33.2
2	Xiao et al.	40.9 ± 7.2–58.2 ± 1.45	41.6 ± 7.0–57.5 ± 9.5	1–4	6–36	6–36
3	Oliver et al.	53.2	53.4	1–4	21.6	21.95
4	Nambiar et al.	40.9 ± 7.2–57.3 ± 13.3	41.6 ± 7–54.0 ± 8.5	1	6–35.2	6–35.5
5	Tong et al.	49.3–56.9	48.8–57.5	≥2	12.8–36	13.6–36
6	Lu et al.	48–59	48–61	2	6–36	6–36
7	Zhang et al.	43.4–56.9 ± 5.9	43.5–59.5 ± 12.6	≥2	12.77 ± 7.85–40.6 ± 9.2	14.6–43.5 ± 10.4
8	Yang et al.	48.9 ± 4.0–56.9 ± 5.9	48.8 ± 3.9–58.6 ± 7.2	NR	23.3 ± 6.9–40.6 ± 9.2	24.2 ± 6.4–43.5 ± 10.4
9	Cheung et al.	44.1 ± 5.8–63.55 ± 7.12	42.8 ± 6.1–64.28 ± 8.76	NR	6–36	6–36
10	Gabr et al.	50.84 ± 4.91	50.87 ± 4.79	1–4	NR	NR
11	Zhao et al.	40.9 ± 7.2–56.9 ± 5.9	41.6 ± 7.0–59.5 ± 12.6	1–4	6–36	6–36
12	Boer et al.	NR	NR	NR	NR	NR
13	Savio et al.	49 ± 11–62.3 ± 6.7	44.3 ± 9.7–64.4 ± 3.2	1–3	12–50	12–50

NR – not reported.

from the included studies. Heterogeneity was noted in the results of the included studies with regard to operative time and blood loss between the two procedures, owing to the fact that these parameters vary depending upon the expertise and experience of the surgeons. Nevertheless, level-1 evidence revealed a significantly shorter operative time and lower blood loss for ACDF using SAC constructs.[23,24]Although the study by Boer et al[25] did not concur with this inference, the heterogeneity of the generated result downgraded the value of the evidence generated from their analysis. There was no statistically significant difference in the length of hospital stay between the two constructs.[23,24] However, based on level-1 evidence, utilisation of cage-plate (CP) construct for ACDF increased the overall cost of the procedure and hospitalisation [$6478.20 ± 836.6 (SAC) vs $7510.80 ± 899.9 (ACP); $p = 0.001$].[23] With regard to the immediate or late post-operative complications such as dysphasia and dysphagia, we noted more homogenous results from the included studies.[23–25] Although the choice of the construct did not alter the incidence of dysphasia,[23–25] the use of SAC construct significantly reduced the dysphagia rates in ACDF surgeries.[23,24]

3.5. Late radiological outcomes

Table 7 shows the compilation of evidence on the late radiological outcome parameters such as maintenance of cervical lordosis, segmental lordosis, disc height along with the incidence of cage subsidence and adjacent segment disease. Heterogeneity was noted among the included studies with regard to the radiological outcomes analysed. Overall, level-1 evidence showed no significant difference between the two ACDF constructs with regard to a majority of cervical spinal radiological alignment parameters. With regard to the development of adjacent segment degeneration, level-1 evidence seems to suggest a substantially higher rate of anterior longitudinal ligament ossification (ALO) and adjacent segment degeneration following ACPC. In the other level-1 study (Gabr et al[23]), although higher rates of ALO were reported following SAC, the differences were not statistically significant.

Table 4
Methodological quality assessment of the included systematic reviews.

Sl. No	Author	Year	Priori design	Literature search	List of included and excluded studies	Publication bias assessment	Appropriate meta-analysis methods	Conclusion based on study quality	Duplicate study selection & extraction	Grey literature search	Included study data	Quality appraisal	Conflicts of interest	AMSTAR Score	AMSTAR 2 Grade
1	Shao et al.	2015	1	1	0	0	1	1	1	0	1	0	1	7	Critically Low
2	Xiao et al.	2016	1	1	0	0	1	1	1	0	1	0	0	6	Critically Low
3	Oliver et al.	2017	1	1	0	0	1	0	1	0	1	1	1	7	Critically Low
4	Nambiar et al.	2017	1	1	0	0	1	1	1	0	1	1	0	7	Critically Low
5	Tong et al.	2017	1	1	0	0	1	1	1	0	1	1	1	8	Critically Low
6	Lu et al.	2018	1	1	0	1	1	1	1	0	1	1	1	9	Low
7	Zhang et al.	2018	1	1	0	0	1	1	1	0	1	1	1	8	Critically Low
8	Yang et al.	2018	1	1	0	0	1	1	1	0	1	1	0	7	Critically Low
9	Cheung et al.	2019	1	1	0	0	1	1	1	0	1	1	1	8	Critically Low
10	Gabr et al.	2020	1	1	0	0	1	0	1	0	1	1	1	7	Critically Low
11	Zhao et al.	2020	1	1	0	0	1	1	1	0	1	1	1	8	Critically Low
12	Boer et al.	2021	1	1	0	0	1	1	1	0	1	1	1	8	Critically Low
13	Savio et al.	2021	1	1	0	0	1	0	1	0	1	1	0	6	Critically Low

AMSTAR - Assessment of Systematic Reviews.

Table 5
Fusion rates and clinical outcome among the included studies.

Sl. No	Study	Fusion	VAS improvement	Odom's criteria	Robinson's criteria	JOA	NDI
Level I Evidence							
1	Gabr et al.	p=0.019; I^2=NR	NR	NR	NR	NR	p=0.37; I^2=NR
2	Zhao et al.	p=0.63; I^2=0%	p=0.23; I^2=0%	NR	NR	p=0.05; I^2=95%	p=0.08; I^2=92%
3	Boer et al.	p=0.66; I^2=13%	VAS neck: p=0.814; I^2=83% VAS arm: p=0.766; I^2=97%	NR	NR	NR	p=0.04; I^2=98%
Level III Evidence							
1	Shao et al.	NR	NR	NR	NR	NR	NR
2	Xiao et al.	NR	NR	NR	NR	NR	NR
3	Oliver et al.	P<0.05; I^2=0%	VAS neck: p<0.05; I^2=0% VAS arm: p<0.05; I^2=0%	NR	NR	NR	p>0.05; I^2=0%
4	Nambiar et al.	p=0.31; I^2=5%	p = 0.15; I^2=NR	NR	NR	p=0.63; I^2=NR	p=0.54; I^2=NR
5	Tong et al.	p=0.78; I^2=0%	NR	NR	NR	p=0.53; I^2=0%	p=0.87; I^2=0%
6	Lu et al.	p=0.45; I^2=NR	p=0.14; I^2=NR	NR	NR	p=0.77; I^2=NR	
7	Zhang et al.	p=0.86; I^2=0%	NR	NR	NR	p=0.39; I^2=0%	p=0.73; I^2=0%
8	Yang et al.	p=0.5; I^2=0%	NR	NR	NR	p=0.51; I^2=0%	p=0.93; I^2=0%
9	Cheung et al.	p=0.09; I^2=2%	p=0.28; I^2=81% p=0.64; I^2=94%	NR	NR	p=0.1; I^2=0%	p=0.62; I^2=0%
10	Savio et al.	p=0.02; I^2=0%	p=0.85; I^2=89%	p=0.93; I^2=0%	p=0.47; I^2=11%	p=0.39; I^2=0%	p=0.26; I^2=42%

(blue)	No difference among groups
(orange)	Favour standalone cage group
(pink)	Favour anterior cage with plate group

JOA – Japanese Orthopaedic Association Score; NDI – Neck Disability Index; NR – Not reported; VAS – Visual Analog Scale score.

4. Discussion

Although multiple meta-analyses have been published heretofore comparing SAC and APCC for patients undergoing ACDF, the evidence regarding the superiority of one of these constructs over the other is still ambiguous.[10–14,19–26] This can be attributed to the scarcity of high-quality studies performing a thorough comparison of clinical and radiological outcome parameters between these two modalities.[26] Realising the need for a thorough analysis comparing these surgical procedures in terms of perioperative factors, complications, clinical and radiological outcomes; and to provide high-quality evidence regarding the same, the current systematic review of the existing meta-analyses was

Table 6
Perioperative parameters and early complications among the included studies.

Sl. No	Study	Operative time	Blood loss	Dysphasia	Dysphagia	Hospitalisation
Level I Evidence						
1	Gabr et al.	p=0.0001; I^2=NR	p=0.0001; I^2=NR	p=0.5; I^2=NR	p=0.001; I^2=NR	p=0.48; I^2=NR
2	Zhao et al.	P<0.00001; I^2=0%	p=0.01; I^2=0%	NR	p=0.02; I^2=0%	p=0.27; I^2=36%
3	Boer et al.	P<0.001; I^2=99%	NR	NR	NR	NR
Level III Evidence						
1	Shao et al.	p=0.38; I^2=92%	P=0.0001; I^2=23%	NR	p=0.001; I^2=0%	NR
2	Xiao et al.	NR	NR	NR	p=0.006; I^2=0%	NR
3	Oliver et al.	NR	NR	NR	p>0.05; I^2=0%	NR
4	Nambiar et al.	p=0.04; I^2=43%	p = 0.08; I^2=87%	NR	p=0.05; I^2=0%	NR
5	Tong et al.	p=0.10; I^2=89%	p=0.07; I^2=73%	NR	p=0.01; I^2=0%	NR
6	Lu et al.	p=0.21; I^2=NR	p=0.90; I^2=NR	NR	p=0.09; I^2=0%	p=0.39; I^2=NR
7	Zhang et al.	p=0.01; I^2=80%	p=0.002; I^2=86%	NR	p=0.002; I^2=0%	p=0.03; I^2=0%
8	Yang et al.	NR	NR	NR	p=0.012; I^2=0%	NR
9	Cheung et al.	p=0.65; I^2=92%	p=0.001; I^2=82%	p=0.96; I^2=0%	p=0.00001; I^2=22%	p=0.52; I^2=47%
10	Savio et al.	p<0.00001; I^2=74%	P<0.00001; I^2=96%	P=0.67; I^2=0%	p=0.0001; I^2=0%	p=0.40; I^2=0%

(blue)	No difference among groups
(orange)	Favour standalone cage group
(pink)	Favour anterior cage with plate group

NR – Not reported

performed. The recommendations were provided on the basis of the consensus statements issued on the relevant and crucial questions on this subject among the studies with highly reliable study methodology (level-1 evidence).

Between 2015 and 2021, 13 meta-analyses comparing the relative efficacies of SAC and ACCPC have been published.[10–14,19–26] A majority of these contributions emanated from China (46.2%) and the United States of America (23.1%) between 2004 and 2019.[10–14,19–26] Despite such large volume of data, we could observe that only 3 meta-analyses included level-1 evidence.[23–25] The reminder of the literature included both retrospective and prospective trials; and therefore, offered less reliable evidence on this subject. Among these 3 studies providing level-1 evidence, Gabr et al[23] (2020) performed a systematic review of 14 RCTs (involving 1173 patients) to compare the rates of pseudoarthrosis and dysphagia following these procedures. The other two RCT-based reviews, published by Zhao et al[24] (2020) and Boer et al[25] (2021), included 7 (540 patients) and 6 (309 patients) individual studies, respectively. A majority of the strongest evidence, available hitherto on this subject, is based upon these 3 studies only.

It is well-acknowledged that the clinical and radiological outcome parameters following ACDF (including pseudo-arthrosis and other complication rates) vary depending upon the levels and extent of surgery.[23–26] However, there is a significant heterogeneity in the published literature regarding the reporting of outcome measures in comparison with the extent of surgery.[10–14,19–26] Only the reviews by Nambiar et al[13] (2017 – single-level ACDF only) and Lu et al[19] (2018 - two-level ACDF only) focused specifically on evaluating the outcome for specified levels of fusion. However, both these reviews primarily included retrospective studies (excepting one RCT on single-level ACDF). On the other hand, studies with level-1 evidence on this subject have been very inclusive with regard to the surgical levels (1 to 4-level ACDF).[23–25] Therefore, based on our systematic review, we do emphasize upon the need for high-quality prospective and RCTs evaluating the comparative efficacies of these constructs, separately focusing on single- and multi-level ACDFs. Based on the AMSTAR grading too, the methodological quality of published meta-analyses has varied between critically low to low. Despite these limitations, based on a critical analysis of the available level-1 and level-3 studies, we were able to put forth lucid recommendations on this subject.

The primary outcome measure in a majority of the published meta-analyses was the ***rate of fusion***.[10–14,19–26] The follow-up period in these meta-analyses extended between 6 and 50 months. A majority of the meta-analyses (8 out of 11 studies) have reported no significant differences between the two constructs in terms of final fusion rates.[13,14,19–22,24,25] On the other hand, three (1 level-1[23] and 2 level-2[12,26] evidence) studies reported better fusion rates with ACCPC. It is well-recognised that the healing rates following ACDF depend on a number of clinical and radiological parameters, namely levels of fusion, associated comorbidities (like diabetes mellitus, renal osteodystrophy etc.), underlying osteoporosis, revision procedures and the use of biological agents (allografts, allografts or other osteo-biologics).[10–14,19–26] The available literature does not provide any evidence on whether one of

Table 7
Late radiological outcomes among the included studies.

Sl. No	Study	Cervical Lordosis	Segmental Lordosis	Disc Height	Cage Subsidence	Adjacent Segment Disease
Level I Evidence						
1	Gabr et al.	NR	NR	NR	NR	p=0.24; I^2=NR
2	Zhao et al.	p=0.48; I^2=0%	p=0.26; I^2=27%	p=0.06; I^2=0%	p=0.78; I^2=NR	p=0.0003; I^2=0%
3	Boer et al.	p=0.04; I^2=87%	NR	NR	NR	NR
Level III Evidence						
1	Shao et al.	NR	NR	NR	NR	NR
2	Xiao et al.	NR	NR	NR	NR	NR
3	Oliver et al.	NR	NR	NR	P<0.05; I^2 = 28%	NR
4	Nambiar et al.	p=0.12; I^2=0%	p = 0.07; I^2=0%	NR	p=0.42; I^2 =0%	NR
5	Tong et al.	p=0.21; I^2=52%	p=0.09; I^2 =91%	p=0.71; I^2 =70%	p=0.15; I^2 =48%	p=0.51; I^2=0%
6	Lu et al.	p=0.04; I^2=56%	p=0.12; I^2=NR	p=0.04; I^2=45%	p=0.0001; I^2=15%	NR
7	Zhang et al.	p=0.03; I^2=56%	p=0.15; I^2=92%	p=0.41; I^2=81%	p=0.22; I^2=69%	p=0.05; I^2=0%
8	Yang et al.	p=0.04; I^2=26%	NR	NR	NR	p=0.04; I^2=0%
9	Cheung et al.	p=0.04; I^2=59%	p=0.09; I^2=0%	p=0.003; I^2=0%	p=0.0001; I^2=20%	p=0.003; I^2=0%
10	Savio et al.	p=0.002; I^2=72%	p=0.01; I^2=65%	p=0.02; I^2=71%	p=0.00001; I^2=32%	p=0.002; I^2=0%

(blue)	No difference among groups
(orange)	Favour standalone cage group
(pink)	Favour anterior cage with plate group

NR – Not reported

these constructs offers additional benefits over the other in any of these aforementioned, complex situations. Following a critical analysis of the current evidence, ***we did not observe any substantial difference in the fusion rates between the two techniques.***[10–14,19–26] Additionally, none of the available reviews has critically evaluated whether there is any significant difference in time required for fusion between the two constructs, which is also an opportunity for future research.

Six meta-analyses reviewed the ***prevalence of neck pain*** (one review also analysed residual radicular pain) during the follow-up.[13,19,22,24–26] Apart from one level-3[12] evidence study, ***all others failed to demonstrate any significant difference in follow-up VAS scores between the two procedures.*** Four different ***functional outcome parameters*** (NDI – 10 studies, JOA – 8 studies, Odom's and Robinson's criteria in one study each) were evaluated in the included meta-analyses.[10–14,19–26] All the studies were consistent in demonstrating ***no significant difference in the functional outcome parameters between the two surgical procedures.***[10–14,19–26]

A majority of the included reviews compared the ***intra-operative blood loss and operative times*** between these two constructs.[10,13,14,19,20,22,26] There is substantial level-1 evidence in favour of SAC constructs, in terms of both these variables.[23,24] Although both these parameters depend upon a number of variables like surgeons' experience, expertise and familiarity with the procedure, levels and extent of procedure, and the underlying diagnosis; the ***literature evidence demonstrates a significant advantage of SAC constructs*** in this context.[23,24] Six reviews evaluated the difference in the ***length of hospitalisation*** between the two constructs.[19,20,22–24,26] Other than one level-3 evidence study by Zhang et al[20] which demonstrated a significantly shorter hospitalisation time in SAC constructs in multi-level ACDFs, ***none of the included studies demonstrated any substantial superiority of one construct*** over the other in this regard.[19,22–24,26] One of the included reviews (with level-1 evidence), which evaluated the ***cost difference*** during hospitalisation between the two constructs, showed a ***statistically significant advantage of SAC over ACCP construct.***[23]

Among the early complications following ACDF, the two most commonly reported adversities included dysphasia (reported in 1 level-1,[23] and 2 level-2[22,26] studies) and dysphagia.[10–14,19–24,26] There is a ***substantially good level-1 evidence*** to support ***better outcome following SACconstructs***, with respect to ***post-operative dysphagia.***[10,11,14,20–24,26] The various factors which may result in mitigated dysphagia rates in SAC constructs include reduced profile of the cervical implant, shorter duration of procedure, reduced need for retraction of esophagus and subsequently less irritation of the trachea–esophageal complex. There is ***no difference in the dysphasia rates.***[22,23,26] With regard to the comparison of other early complications including surgical site infections (SSI), wound dehiscence, febrile episodes, breathing difficulty etc., there is still insufficient evidence in the published literature.

Various studies have also compared the long-term radiological outcome following these two surgical procedures.[12–14,19–26] One of the most crucial benefits of additional plate stabilisation initially put forth by the proponents of this construct was the meliorated maintenance of sagittal alignment.[25] The past reviews have evaluated radiological parameters, namely cervical lordosis, segmental lordosis and disc height to study the sagittal cervical alignment.[12–14,19–26] In terms of ***segmental lordosis and disc height, the evidence seems to suggest a similar outcome following both the procedures.***[14,20,24] Nine studies compared the change of cervical lordosis during the follow-up following the two surgical procedures.[13,14,19–22,24–26] Among them, 5 level-3 evidence studies observed better ***restoration or maintenance of cervical lordosis*** following ACCPC.[19–22,26] Nevertheless, ***the evidence on this issue among the level -1 studies is still not clear***.[24,25] Additionally, other relevant factors like levels of surgery, underlying diagnosis or cervical pathology, size of cage, cervical segment involved (eg. upper, middle or lower-segment disease) and associated osteoporosis which could potentially influence the final lordotic alignment, were not critically analysed in these studies.[10–14,19–26] Therefore, there is still insufficient evidence to definitively conclude upon the influence of the surgical construct on the final sagittal alignment after ACDF.[10–14,19–26] Another long-term radiological parameter, which was compared in relation to these two surgical constructs, was cage subsidence.[12–20,22,24,26] Even though 4 level-3 studies[11,19,22,26] observed mitigated rates of cage subsidence following plate stabilisation, there is no strong level-1 evidence to substantiate this finding.[24]

Another important concern regarding the use of CP construct includes the development of adjacent segment degeneration.[24] The current level-1 evidence also seems to favour better outcome with SAC on this issue.[24] The study by Zhao et al[24] demonstrated a significantly lower incidence of both ASD and ALO. On the other hand, while the level-1 evidence by Gabr et al[23] also showed better outcome with SAC in this regard, the difference did not reach a statistically significant threshold. The higher rates of ALO and ASD with ACCPC can be well-explained by the fact that application of an anterior plate necessitates greater violation and irritation of soft tissues in relation to the adjacent-level disc.[24] In addition, plate also adds substantial rigidity to the construct, which in turn enhances the stress at the adjacent level, leading to higher degeneration.[24]

Our Study has few limitations. As previously mentioned, only 3 of the published 13 meta-analyses provide level-1 evidence.[23–25] The available meta-analyses also have not specifically compared the role of these two constructs, with respect to specific, relevant scenarios like single-level or multi-level procedures, cervical deformity surgeries, and patients with serious comorbidities or underlying osteoporosis. The number of high-quality, prospective and randomised-controlled studies on this subject is also fairly limited.

5. Conclusion

Based on a systematic overview of the existing meta-analyses, we have been able to conclude that SAC offers significantly better benefits over ACCPC, in terms of shorter operative time, lower blood loss, lesser rates of post-operative dysphagia, reduced overall expenditure related to hospital stay and long-term ASD or ALO. There is no definitive evidence to show any substantial difference between the two constructs with regard to fusion rates, function outcome scores, follow-up radiological parameters like sagittal alignment or cage subsidence and other adverse events.

Declaration of competing interest

Authors declare no conflicts of interst.

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