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Full Endoscopic Anterior Cervical Discectomy vs Anterior Cervical Discectomy with Fusion. A Systematic Review

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ABSTRACT

AIM: To assess and compare the efficacy of anterior endoscopic cervical discectomy (AECD) and anterior cervical discectomy with fusion (ACDF).

MATERIAL and METHODS: Major databases, registries, and other relevant material were screened for prospective trials directly comparing AECD and ACDF. No restrictions were imposed. Meta-analysis was not conducted due to high heterogeneity.

RESULTS: After screening a total of 1339 articles, 2 studies enrolling 225 patients were included. One of these is a randomized-controlled-trial, including 120 patients, with a 14% lost to follow-up, showing no statistically significant differences in clinical outcomes according to the visual analogue scale (VAS) of the neck/arm and the North American Spine Society criteria regarding pain/neurological status. Radiological follow-up showed no adjacent-segment disease, with both groups presenting a statistically non-significant progression of a pre-existing adjacent-disc degeneration, and no difference in kyphosis. Recurrence was registered in 7.4% and 6.1% of patients who underwent AECD and ACDF, respectively. No statistically apparent differences in complications were observed. The second is a cohort study, including 135 patients with a 14.8% lost to follow-up. No statistically significant difference was found in clinical outcomes assessed using the VAS of the neck/arm and the neck disability index. No radiological data were provided. Recurrence was reported in 4% and 2% of patients in the AECD and ACDF group, respectively. No remarkable differences in complications were reported. Both studies reported that the surgical time was statistically shorter in AECD.

CONCLUSION: A definitive conclusion cannot be drawn. Single-level AECD seems to have results equivalent to ACDF, presenting even some benefits. Technical limitations combined with required surgical skills and experience should be considered. We recommend cautious employment in anticipation of future updates.

KEYWORDS: Endoscopic, Anterior, Cervical, Discectomy, Herniation, Minimally invasive

INTRODUCTION

Anterior cervical discectomy with fusion (ACDF) is a commonly performed procedure and is considered the treatment of choice for cervical radiculopathy and myelopathy associated with ventral compression of neural structures due to degeneration, trauma, or infection. It is described as a safe and effective technique presenting with good fusion rates even in multilevel cases without using an anterior plate (7,28). However, various potential fusion and access complications are described in 13.2%–19.3% of patients, some of which are associated with high mortality rates (e.g., esophageal perforation) (5,6,33). A previous study reported that ACDF is also associated with adjacent-segment diseases (19). Various surgical techniques have been employed to reduce the complication rates including anterior cervical discectomy without fusion (ACD) and anterior foraminotomy, among others. Endoscopic methods have evolved into a standard of care for the treatment of various spinal pathologies. Previous studies highlight that these techniques present similar or even better results when compared to conventional surgery (8,16) and are associated with minimal rates of perioperative and postoperative adverse events when compared to other minimally invasive techniques and open spinal surgery (24).

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Endoscopic lumbar discectomy has presented with superior results as opposed to the conventional microscopic procedure regarding the overall complication rates, outcomes, and surgical duration, showing noninferiority in all other parameters (3, 17). Another study also pointed toward an ever-growing international adoption of full endoscopic techniques for thoracic spine pathologies (9). Posterior endoscopic cervical decompression (PECD) has shown favorable results in patients with mediolateral disc herniations, comparable with that of ACDF in terms of efficacy, adverse events, and reoperation rates (13). The use of anterior endoscopic cervical discectomy (AECD) is less frequently reported in the literature. This technique employs the anatomical tissue plane between the esophagus and carotid artery to achieve adequate decompression of the cervical nerve structures, similar to the one used for ACDF/ACD. However, endoscopic spinal procedures require significantly lesser tissue manipulation and collateral traumatization, ensuring the reduction of local and systemic inflammation (23,25). Therefore, this study aimed to identify, assess, and compare the evidence regarding the efficacy and complication rates between AECD and conventional microsurgical ACDF.

MATERIAL and METHODS

Protocol and Registration

The study was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. The protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO - CRD 42022336749) (29).

Search Strategy and Study Selection

Three major databases were screened (MEDLINE, EMBASE, and CENTRAL), as well as clinical trial registries (ClinicalTrials.gov and clinicaltrialsregister.eu), and conference material of the European Association of Neurosurgical Societies, the World Association of Neurosurgical Societies, and the International Federation of Neuroendoscopy. Gray literature was assessed employing a hand search technique. No restrictions were imposed regarding the language, time, or type of publication; thus, all relevant studies until June 2022 were included. The same terms were applied in the form of Medical Subject Headings (MeSH) terms and free texts to avoid missing studies that were not yet indexed. The search strategy is provided. To minimize bias, all screening and analysis steps were independently performed by two researchers, whereas disagreements were resolved through discussion.

Inclusion Criteria and Outcomes

Manuscripts were eligible for inclusion if they presented a randomized controlled trial (RCT) or a prospective comparative study, assessing outcomes in adult patients (>18 years) treated with ACDF or AECD associated with symptomatic degenerative disc disease. Studies focusing on endoscopic techniques and not using the transdiscal approach (e.g., transcorporal) were not considered. Manuscripts were excluded if there was only an abstract and/or if they did not provide any primary data. The primary outcome of our study was the comparison of clinical results expressed in at least one of the following factors: a visual analogue scale (VAS), neck disability index (NDI), Odom criteria, North America Spine Society scale (NASS), Oswestry disability index, or Japanese Orthopedics Association Scale (JOA). Secondary outcomes included the mortality, complication rates, surgical time, blood loss, hospital stay, returning to work, and radiological outcomes.

Data Extraction and Analysis

The identified studies were imported into EndNote 20 for further handling. Deduplication was performed employing the software's integrated search. Studies were initially screened for the title and abstract before a full-text assessment of those to be potentially included. The following data were extracted: study information (authors, publication year, journal, and digital object identifier), study characteristics (design, number of participants, and drop-out rates), participants' baseline characteristics (age, gender, body mass index [BMI], pre- and postoperative outcome measures, intervention and comparator details (type of intervention, surgical time, and blood loss), and outcomes of interest per protocol. The risk of bias was assessed by employing the risk of bias tool (ROB-2) for RCTs (11) and the Newcastle-Ottawa Scale (NOS) for prospective comparative studies (30). The NASS criteria were employed to assign evidence levels (18). Publication bias was not evaluated due to the small number of included studies (<10). A meta-analysis was not conducted as it was not feasible due to a high heterogeneity.

RESULTS

Search Results

The literature search resulted in a total of 1339 records (778 from MEDLINE, 553 from EMBASE, and 8 from CENTRAL). Screening identified two studies meeting our inclusion criteria. A PRISMA flow diagram is provided including the reasons for exclusion (Figure 1). Ruetten et al. presented an RCT (22), whereas Ahn et al. conducted a cohort study (2) where participants were prospectively enrolled and data were retrospectively collected.

Baseline Characteristics

A total of 255 patients were enrolled. The RCT included 120 patients (43 male/ 77 female), with an age range of 30–61 and pain duration of 4–128 days. The lost to follow-up after 2 years was 14%, whereas based on their per-protocol analysis, three patients from the AECD groups were excluded as they were reoperated using ACDF; thus, data from a total of 99 patients were analyzed (48 ACDF and 51 AECD). The cohort included 135 patients with symptomatic soft cervical disc herniations. A total of 20 patients (14.8%) were lost to follow-up after 2 years. Data from the remaining 115 patients (64 male/ 51 female), with a mean age of 42.2 (AECD)/47.5(ACDF) years and mean BMI of 24.06 (AECD)/23.71 (ACDF) (kg/m^2) were analyzed.

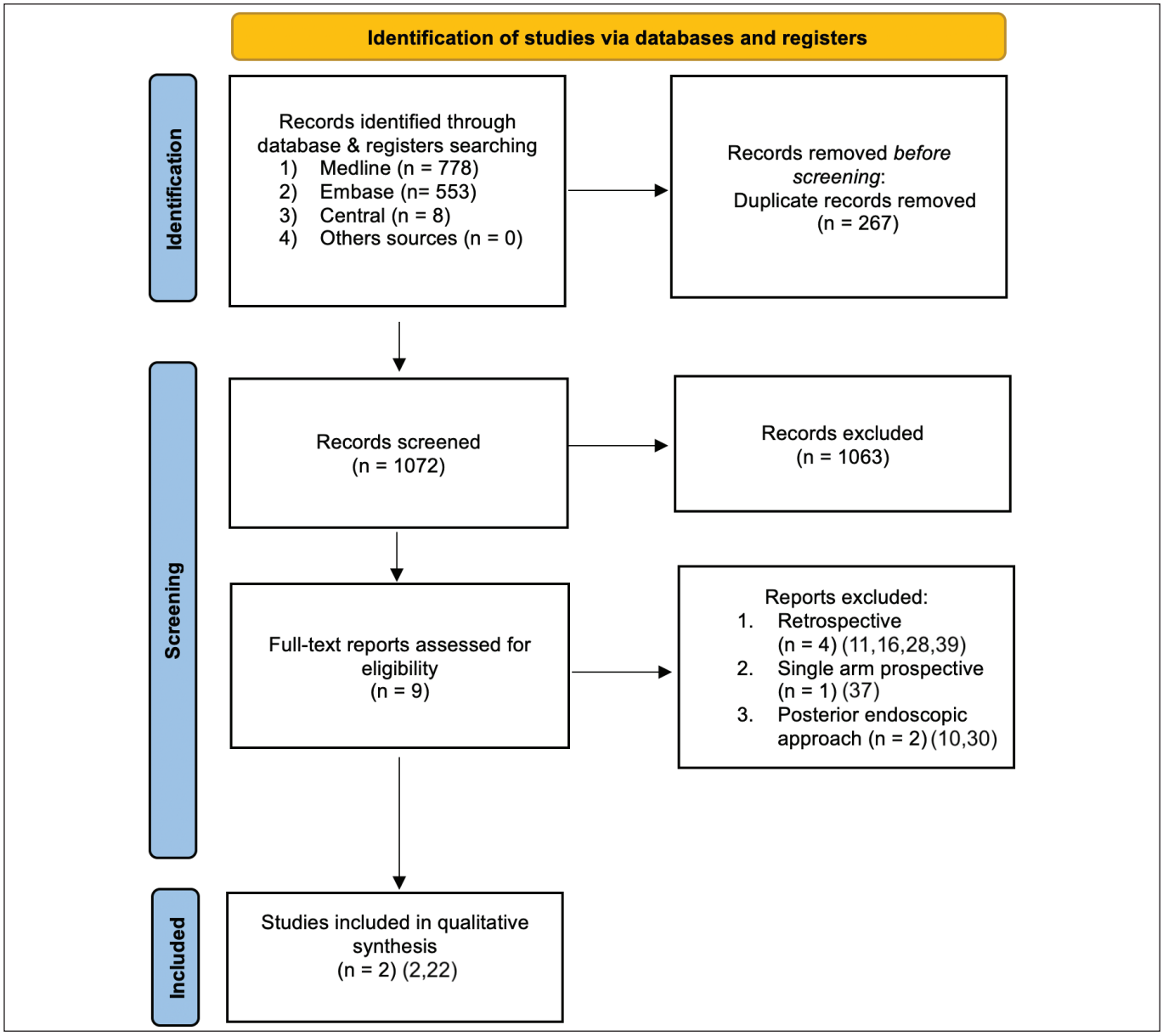

Figure 1: PRISMA flow chart diagram mapping out the number of records identified, included and excluded, highlighting the reasons for exclusion.

Outcomes

Both studies employed pre- and postoperative VAS scores during their evaluation process; however, due to their discrepancies, the 0–10 VAS in Ahn et al.'s study was modified to meet the 0–100 in Ruetten et al.'s study. Ruetten et al. employed the German NASS pain (21) and Ahn et al. employed the Korean NDI (26) for further evaluation. Outcomes are presented analytically in Table I. No significant differences were observed between the two groups in any of the studies.

Radiological Findings

Patients included in the RCT were assessed by magnetic resonance imaging and X-ray 2 years postoperatively. No adjacent segment disease was detected. A total of 12 patients presented a progression of a pre-existing adjacent disc degeneration (AECD: 3 [5.9%] and ACDF :9 [18.8%]); however, this was statistically not significant. An increase in the kyphosis angle was observed in 10 patients (AECD: 6 [11.8%]; ACDF: 4 [8.3%]), whereas the intervertebral height significantly decreased in both groups (AECD: 5.3–4.1 mm; ACDF: 6.1–5 mm). The absolute height was significantly higher in the ACDF group. However, no statistical significance regarding the kyphosis, height, and clinical outcome was reported. No spontaneous fusion was observed in the AECD group, whereas 21 (24%) patients presented with signs of advancing disc degeneration. The authors of the cohort did not assess any radiological data.

Reoperation Rates

Revision surgeries including the type of the second intervention are presented in Table I.

Complications

Both techniques present low complication rates without any significant differences between them. However, the AECD groups presented no surface hematomas in contrast to those treated with ACDF. All complications are presented in Table 1.

Additional Outcomes

Both studies confirmed a highly significant difference ($p<0.01$) in the operative time, required hospitalization time, and return to work in favor of the AECD. The mean operative time in

Table I: Summary of the Included Studies

Study ID	Ruetten, 2008 (22)		Ahn, 2020 (2)	
Study Design	Unblinded RCT		Prospective controlled	
Indication	Single level mediolateral soft disc herniation		Single level soft disc herniation	
Follow up	Postop (day 1), 3-6-12-24 months		6 weeks, 6-12-24-60 months	
Final analysis	51 AECD, 48 ACDF / 14% lost to follow up		51 AECD, 64 ACDF / 14.8% lost to follow up	
Endoscope sheath	Oval 3.8 x 6.2 mm, angle of vision 25°		Round 4mm in diameter	
Operated Levels	AECD	ACDF	AECD	ACDF
C3/4	2	1	3	5
C4/5	7	9	10	6
C5/6	29	26	22	37
C6/7	20	21	16	16
C7/T1	2	3	0	0
Mean operating time (min)	32 (18-51)	62 (41-102)	55.2± 18.03	124.53±35.68
Significance	**p<0.001**		**p<0.001**	
Complications				
Transient difficulty swallowing	2	5	1	3
Surface hematoma	0	2	0	2
Recurrence	4 (7.4%)	3 (6.1%)	2 (4%)	1 (2%)
Revision	1 via AECD, 3 via ACDF	1 via ACDF, 2 via Posterior Foraminotomy	Both via ACDF	via Posterior Foraminotomy
Significance	**p>0.05**		**p>0.05**	
Clinical outcome				
Mean (±SD) VAS neck pain - Preop	18	13	45.8 (±19.5)	39.1 (±17.8)
Mean (±SD) VAS neck pain – Last follow up	15	14	13.5 (±13.4)	11.4 (±8.5)
Mean (±SD) VAS arm pain - Preop	82	79	76.1 (±17.8)	71.6 (±1.27)
Mean (±SD) VAS arm pain – Last follow up	8	10	14.4 (±13.4)	16.1 (±10.8)
Mean (± SD) NASS pain – Preop	4.2	4.4	N/A	N/A
Mean (± SD) NASS pain– Last follow up	1.5	1.6	N/A	N/A
Mean (± SD) NASS neurology – Preop	3.1	3.2	N/A	N/A
Mean (± SD) NASS neurology– Last follow up	1.8	1.6	N/A	N/A
Mean (± SD) NDI – Preop	N/A	N/A	51.87 (±21.47)	58.27 (±17.73)
Mean (± SD) NDI – Last follow up	N/A	N/A	7.82 (±13.41)	6.59 (±10.14)
Global outcome				
Excellent	37 (72.54%)	36 (75%)	16 (31.37%)	11 (17.19%)
Good	11 (21.56%)	7 (14.58%)	29 (56.86%)	47 (73.44%)
Fair	2 (3.92%)	2 (4.16%)	5 (9.80%)	5 (7.81%)
Poor	1 (1.96%)	3 (6.25%)	1 (1.96%)	1 (1.56%)
Total	51	48	51	64
Significance	**p>0.05**		**p>0.05**	

Ruetten et al was 62 (41–102) min in the ACDF and 32 (18–51) min in the AECD groups, with Ahn et al. noting 55.20 ± 18.03 and 124.53 ± 35.68 in the in AECD and ACDF groups, respectively. Ahn et al. reported a hospital stay of 2.18 ± 1.16 and 5.23 ± 2.93 in the AECD and ACDF groups, respectively, whereas Ruetten et al. mentioned a maximum of 3 and 7 days for the AECD and ACDF groups, respectively. Return to work was 3.14 ± 1.08 and 10.84 ± 3.12 weeks in the AECD and ACDF groups, respectively, according to Ahn et al. (2) Ruetten et al. mentioned that 30 (62.6%) patients treated with ACDF and 43 (84.3%) patients treated with AECD had returned to work or were able to work after 3 months. Blood loss was only mentioned by Ruetten et al., registering a total of <10 ml in the ACDF group and no measurable volume in the AECD group (22).

Quality and Bias Assessment

Ruetten et al. presented some concerns according to the ROB-2 revised tool, whereas Ahn et al. was graded as a high-quality cohort study according to the NOS tool (Tables II and III). Based on the NASS scale, both included studies are classified as Evidence Level II, providing a fair quality of evidence (Grade B).

DISCUSSION

Summary of Findings and Comparison with Literature

To the best of our knowledge, this is the first systematic review of published clinical data directly comparing AECD and ACDF. The two techniques share the same indications and use the same anatomical plane, one utilizing the standard microscopic technique and the other an endoscopic alternative. Some authors used a Mayfield clamp, which in some cases (e.g., 8.3% in Ruetten et al.'s study) resulted in the presentation of pain (duration up to 2 days). Other authors circumvented such unwanted effects by avoiding the use of head fixation if possible (4).

Based on the pre- and postoperative functional and subjective scores, both techniques present favorable outcomes, without any significant differences between them, regardless of the evaluation tool employed either in the included studies or other studies. From the relevant studies that did not meet the inclusion criteria, Haijun et al. (10) retrospectively presented a direct comparison on AECD and ACDF in 115 patients employing VAS and JOA scores. A significant improvement was registered in both groups ($p<0.05$); however, no difference was found between the experimental and control groups. The authors did not divide the VAS in the arm and neck as in the rest of the literature; thus, the presentation of results may be considered confusing. Yadav et al. (31) presented a single-arm analysis in patients treated with AECD due to myelopathy and radiculopathy, confirming the results presented through improved VAS for the neck (mean preop, 3.2; postop, 1.1), arm pain (mean preop, 7.6; postop, 1.9), and Nurick grade (mean preop, 2.7; postop, 0.82). No statistical analysis was provided by the authors. Despite the lack of data supporting the superiority of either technique, the minimal tissue trauma inflicted during an endoscopic procedure may be potentially associated with a significantly shorter hospitalization and return to work times. The overall surgical time may be also minimized when the procedure is performed by an experienced endoscopic spinal surgeon. A group of authors (1) has analyzed the data from 1000 consecutive patients treated with a single-level ACDF and proposed its use in an outpatient setting, reporting a mean surgical time of 65 ± 16.6 min, blood loss of 39.8±24.8 ml, and hospitalization of shorter than a day in 629 cases. However, in their analysis, they refer a discrepancy with the inpatient group presenting a mean blood loss and operative time of 85.0 ± 97.5ml and 197.7 ± 42.3 min, respectively, with a mean hospitalization of 1.1 ± 1.7 days. The reason for this difference is unclearly stated. Considering that 629 patients were treated in an outpatient setting and 274 as inpatients, some could conclude a possibility that the length of hospitalization in patients treated with ACDF

Table II: Risk of Bias Assessment Employing the ROB-2 Tool

Study ID	Outcome	Randomization process	Deviation from intended intervention	Missing outcome data	Measurement of the outcome	Selection of the reported results	Overall bias
Ruetten et al. 2009 (22)	Primary	Low	Some concerns	Low	Low	Some concerns	Some concerns

Table III: Risk of Bias Assessment Employing the NOS Tool

	Selection					Outcomes			
Study ID	Representa-tiveness of the cohort	Selection of non-exposed cohort	Ascertment of exposure	Outcome not present at the start of the study	Comparability	Assessment of outcomes	Length of follow-up	Follow-up adequacy	Total
Ahn et al. 2020 (2)	*	*	*	*	*	*	*	*	8/8

Asteriscs are employed by the NOS tool to show that the section was covered accordingly. Otherwise this is depicted graphicaly as an absence of asterisc. The overall score regards the number of asteriscs (n out of a total of 8).

may be comparable to that of patients treated using the endoscopic approach; however, the previously referred studies have confirmed the superiority of AECD regarding the hospitalization, blood loss, and surgical times.

Both surgical techniques present low complication rates, the most common complications were being mild difficulty in swallowing and recurrence. The overall complication rate of ACDF ranges from 13.2%–19.3% (5); however, this was not confirmed by the included studies. The complications were dysphagia (1.7%–9.5%), postoperative hematoma (0.4%–5.6% required surgery in 2.4% of 5.6% patients), exacerbation of myelopathy (0.2%–3.3%), recurrent laryngeal nerve palsy (0.9%–1.6%), increased radiculopathy (1.3%), Horner's syndrome (0.06%–1.1%), respiratory insufficiency (1.1%), esophageal perforation (0.3%–0.9% with mortality of 0.1%) hardware failure (0.1%–0.9%), pseudoarthrosis (0%–4.3%), and scarce mentions of jugular vein occlusion and phrenic nerve injury. The reoperation rate was found to be 11.1%. A recent systematic review found the following most common complications of conventional anterior spine surgery: adjacent segment disease (8.1%), dysphagia (5.3%), C5 palsy (3%), pseudoarthrosis (2%), graft or hardware failure (2.1%), recurrent laryngeal palsy (1.3%), infection (1.2%), hematoma (1%), cerebrospinal fluid leak (0.5%), new or worsening neurological deficit (0.5%), Horner syndrome (0.4%), and vertebral artery injury (0.4%) (33). We should highlight that higher complication rates are certainly associated with studies including patients who underwent a multiple-level treatment. The AECD complication rates of the included studies are very low, with transient dysphagia being the most common, which is similar to that of ACDF. Yang et al. (32) referred the possibility of deep hematoma formation in the AECD group, something that is associated with colli muscle injury. They also registered a case with temporary postoperative headache, attributed to the prolonged high intraoperative irrigation pressure. Elevated epidural pressure has been reported to increase the intracranial pressure, leading to the manifestation of symptomatology (14); however, this may be prevented by ensuring the regulation of irrigation inflow and outflow using open systems, oval optics, and irrigation pumps programmed to modify function based on pressure. The included studies referred transient swallowing difficulty, predominantly in the ACDF group, followed by the formation of surface hematoma only in patients treated with ACDF in both studies. The complication rates of both techniques were very low, and no statistically significant difference was found. However, the minor incidence alongside the restricted number of included cases limits the capability of drawing a meaningful conclusion.

Radiological evaluation in Ruetten et al.'s study confirmed no adjacent segment disease (ASD), whereas both groups presented progression of a pre-existing adjacent disc degeneration, a condition that has been previously associated with postoperative changes (mainly due to fusion) (15), but that has been attributed lately to the natural history of an aging spine (20). An increased kyphosis angle was also reported in both groups. A greater disc height, that is, the foramen height, was achieved in the ACDF group using an interbody spacer. This is expected to benefit patients with significant reduction of the interbody and subsequently foramen spaces. The aforementioned underlines the importance of correct patient selection. However, the clinical outcomes were not associated, highlighting that radiologic findings will not always be associated with the clinical presentation. Haijun et al. also evaluated the range of motion (ROM), the cervical lordosis angle (CLA) expressed through the Cobb angle, and the Height of the adjacent vertebral body (HAVB). The CLA significantly increased in both groups, without any difference. The ROM did not significantly change in the AECD group but significantly decreased in the ACDF group, leading to the hypothesis that endoscopic technique may result in a better motion preservation. HAVB was significantly higher in the ACDF group. A previous also included scarce mentions of endoscopically assisted interbody spacer placement (27), pointing toward the possibility of conducting a full-endoscopic ACDF in the near future. The endoscopic approach primarily aimed at providing noninferior outcomes while eliminating complications and minimizing techniques associated factors, which according to the study results have been achieved. The endoscopic procedure itself is also significantly less time-consuming if performed by an experienced surgeon and ensures superior visualization of the anatomical structures and optimal cosmetic results. The lack of using any instrumentation equipment also minimizes the cost of this surgical procedure. Some physicians would highlight the possibility of conducting endoscopic interventions under local anesthesia; however, we believe that this could potentially cause significant increase of complication rates while also being uncomfortable for the patient.

Strengths and Limitations

Strengths include the conduction of a thorough literature search, the respect of the a priori published protocol, the adherence to both PRISMA guidelines and Cochrane handbook for systematic reviews of intervention guide, and the inclusion of studies providing a direct comparison between AECD and ACDF. Limitations were associated with the restricted quantity of available manuscripts, the number of included patients, the lack of robust evidence, and the presence of significant heterogeneity, something expected when synthesizing RCTs with cohorts. A meta-analysis was not feasible.

Standardized Nomenclature

A discrepancy can be detected regarding the characterization of the surgical technique with Ruetten et al. employing the term full-endoscopic anterior decompression and Ahn et al. employing the term percutaneous endoscopic cervical discectomy. However, both refer to a similar technique with minor modifications applied. The AO Spine has prompted all authors to employ the endoscopic spine surgery nomenclature (12) to achieve uniformity in reporting of their results; thus, we employed the proposed term AECD. The authors should also be cautious when using the term endoscopic, which according to the AO Spine should only be used to describe procedures performed with a working-channel endoscope, distinguishing these procedures from endoscopically assisted ones where tools are passed through trajectories separate from the endoscope.

Future Considerations

Based on the results of the included research, which presents a fair quality of evidence, physicians could consider the adaptation of a single-level AECD. However, a greater number of robust studies are required to establish a stronger confidence in the advantages of the technique. Despite the promising results, some technical limitations of AECD should be carefully considered. The approach is fluoroscopically assisted; thus, there is no possibility of direct visualization or tactile control of important anatomical structures. The neural structures are located behind the disc material and ligament; thus, the visual feedback is limited. Surgical handling errors may have a devastating result and associated with dura and spinal cord trauma. Endoscopic spine procedures are known to present long learning curves, and a skill-demanding approach as AECD is expected to require an even longer one. We strongly believe that the limited data and lack of updates from authors who have already published their results with this technique support the aforementioned considerations.

CONCLUSION

Based on the available data and their quality and strength, we cannot draw a definitive conclusion. A single-level AECD and ACDF seem to yield equivalent results regarding the outcomes and complication rates while presenting some benefits of minimally invasive techniques (less blood loss, shorter surgical, hospitalization, and return-to-work times). Technical limitations and required surgical skill and experiences should be considered before choosing this technique. We recommend cautious employment by experienced surgeons in expectation of future updates. Inexperienced surgeons should definitely avoid the use of this technique.

AUTHORSHIP CONTRIBUTION

Study conception and design: MT

Data collection: MT, PV

Analysis and interpretation of results: MT, PV

Draft manuscript preparation: MT

Critical revision of the article: MT, PV

Other (study supervision, fundings, materials, etc...): MT, PV

All authors (MT, PV) reviewed the results and approved the final version of the manuscript.

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