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Cervical Fusion Techniques Unmasked: Plating vs. Cage-Only

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ABSTRACT

AIM: To compare the effect of fusion with anterior plating and cage (PLATE) versus cage-only (CAGE-O) technique on postoperative cervical sagittal alignment parameters, clinical outcome, and complication profiles after two-level anterior cervical discectomy and fusion (ACDF).

MATERIAL and METHODS: Clinical and radiological data of 42 patients who underwent two-level ACDF with either cage-only or anterior plating were retrospectively analyzed. Sagittal alignment parameters, including cervical lordosis, C0-C2 angle, T1 slope, and cervical sagittal vertical axis (cSVA), were evaluated preoperatively and postoperatively. Clinical outcomes were analyzed using the visual analog scale (VAS) and Neck Disability Index (NDI) scores.

RESULTS: Both groups showed significant clinical improvement in VAS and NDI scores over a 2-year follow-up period. Postoperatively, the CAGE-O group exhibited a significant increase in T1 slope and C0-C2 angles, whereas the PLATE group did not. Cervical lordosis and cSVA values showed no significant change postoperatively in both groups. Complication rates were similar between both groups.

CONCLUSION: Both anterior plating and cage-only techniques in two-level ACDF demonstrated comparable outcomes in terms of sagittal alignment, clinical improvement, and complication rates. The decision to utilize anterior plating should be based on individual patient factors and surgeon preference rather than differences in outcomes.

KEYWORDS: Cervical discectomy, Plate, Cage, Alignment, Disc degeneration

INTRODUCTION

The anatomy and biomechanics of the cervical region are remarkably complex (4). It is more mobile than the other parts of the spine (17). The primary function of the cervical region is to support the head, allowing a wide range of movements. This feature makes the cervical region susceptible to degenerative diseases (3). One of the most commonly applied surgical treatment methods for cervical problems is anterior cervical discectomy and fusion (ACDF), which provides successful outcomes and has low complication rates (9). There are several studies on the effect of changes in sagittal alignment parameters after surgery on clinical results, among which some studies have reported a relationship between sagittal alignment parameters and clinical outcomes (1,12,14). Conversely, some studies also argue that the alignment exerts limited effect on clinical outcomes (10,11,15).

Although the inclusion of an anterior plate can provide the benefit of instant stability, it also presents potential limitations, including the possibility of plate or screw malfunction, loosening, incorrect placement, and an increased risk for degen-

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eration in the segments adjacent to it, especially in multilevel surgery (21).

Elucidating the changes in sagittal alignment parameters after ACDF with polyetheretherketone cages, which is one of the most common surgical interventions in neurosurgery, and the effect of plating on them will help determine the aspects to be considered in the surgical technique, contribute to the accumulated knowledge on the subject, and pave the way for future studies.

This retrospective study was conducted to investigate the effect of anterior plating compared with the cage-only technique on clinical outcomes and postoperative cervical sagittal alignment parameters after two-level ACDF.

MATERIAL and METHODS

This retrospective study was conducted in two tertiary healthcare and spine centers and was approved by the local ethics committee (Decision number: TUTF-BAEK 2023/67). Due to the retrospective and anonymous nature of the study, written informed consent was waived.

Study Design

Data of patients who underwent two-level ACDF with polyetheretherketone cages in the participating study centers between January 1, 2014, and December 31, 2021, were retrospectively examined. Clinical and radiological data of the patients were accessed through 1. Hospital Information Systems, 2. Patient files (Neurosurgery and Spine Center Clinical Archives), and 3. Picture Archiving and Communication Systems.

The predefined study inclusion criteria were as follows: 1) ACDF performed in the participating study centers between January 1, 2014, and December 31, 2021, 2) First time and two levels, 3) ACDF performed with polyetheretherketone cages with or without anterior cervical plate and screw fixation, and 4) Diagnosis of cervical degenerative disc disease or/and cervical spondylotic myelopathy.

The predefined exclusion criteria were as follows: 1) ACDF performed on dates other than between January 1, 2014, and December 31, 2021, or in nonparticipating study centers, 2) Except for the first time or other than two levels, 3) Operated with other techniques, and 4) Operation due to tumor, trauma, or infection.

Data Acquirement

Patients' data were extracted from all existing written and electronic medical records, which included age, gender, duration of pain in months, and level of the relevant spine. Demographic, clinical, and radiological data were extracted by scanning patients' electronic and written documents. The following variables were used in this study: age, gender, operated spine levels, duration of pain in months, preoperative and postoperative cervical sagittal vertical axis (cSVA) values, cervical lordosis angle, occipito-C2 angles, and T1 slopes. All patients were evaluated using the visual analog scale (VAS) and Neck Disability Index (NDI) scores in the preoperative period, early postoperative period, and at the 6-, 12-, and 24-month postoperative follow-up. Furthermore, all patients underwent anteroposterior and lateral cervical X-ray examinations during the preoperative period and throughout all postoperative follow-ups.

Statistical Analysis

Results were expressed as mean ± SD for normally distributed numerical variables and as median (interquartile range) or percentages where appropriate. Average or median values were calculated for continuous variables, and frequency numbers and percentages were calculated for categorical variables. Statistical analysis of categorical variables was performed using the chi-square test. For continuous variables, the ordinary one-way ANOVA was performed to compare multiple groups, and t-test was used for the comparison of two groups.

$p \leq 0.05$ was accepted as the threshold for statistical significance. Statistical analyses were conducted using the Jamovi Statistics version 2.4 package program (12). An *a priori* power analysis was conducted for a two-tailed Wilcoxon signed-rank test [$\alpha = 0.05$, power $(1 - \beta) = 0.80$, and effect size = 0.5], which yielded a required sample size of 35. Power analysis was performed using the G*Power software version 3.1.

RESULTS

Participant Demographics and Baseline Characteristics

This study enrolled 42 participants, of whom 21 (50%) were women. The mean age was 47.8 ± 10.3 years, with a range of 20–68 years. The median duration of pain before intervention was 6.5 (IQR = 7.5) months. A total of 23 (54.8%) patients were stabilized with only cages (CAGE-O), and 19 (45.2%) were stabilized with plates and screws in addition to cages (PLATE) (Table I). The distribution of surgical etiologies and the analysis results of patients' preoperative values are presented in Tables II and III, respectively. Regarding the preoperative characteristics of the patients, only the preoperative number of days with pain before admission (higher in the cage-only group) was different. Other parameters (radiological parameters, age, sex, etiology, and operated levels) showed no differences between the groups.

Radiological Outcomes

Sagittal alignment of the cervical spine was evaluated using preoperative and postoperative cervical lordosis, C0-C2 angle, T1 slope, and cSVA values. Both cSVA and cervical lordosis values remained significantly unchanged after the operation (p=0.5900 and p=0.2163, respectively). The T1 slope of patients in the CAGE-O group significantly increased (preoperative: 11.10 ± 2.98, postoperative: 14.52 ± 3.66, p=0.0035), whereas it remained significantly unchanged in the PLATE group (preoperative: 10.30 ± 4.09, postoperative: 12.38 ± 3.70, p=0.2976). Similarly, the C0-C2 angle significantly increased in only the CAGE-O group (preoperative: 33.47 ± 5.44, postoperative: 38.95 ± 7.16, p=0.0171), whereas the PLATE group showed almost no change (preoperative: 30.25 ± 5.87, postoperative: 30.22 ± 5.85, p>0.9999). Table V summarizes the radiological outcomes of the patients.

Table I: Patient Characteristics

		n (%)
Age, Mean ± SD		47.8 ± 10.3 (20-68)
Gender	Female	21 (50)
	Male	21 (50)
Operation	CAGE-O	23 (54.8)
	PLATE	19 (45.2)
Level of Operations	C3-C5	1 (2.4)
	C4-C6	14 (33.3)
	C5-C7	27 (64.3)

CAGE-O: *Fusion with only cage,* ***PLATE:*** *Fusion with cage and plates.*

Clinical Outcomes

Both the PLATE and CAGE-O groups showed significant improvement in VAS and NDI scores over the 2-year follow-up period ($p<0.001$) (Table IV). Significant improvements in the mean VAS and NDI scores were observed at all time points in both groups. All patients in the CAGE-O and PLATE groups showed fusion as evaluated by lateral cervical graphs and cervical CT scans. No instrument failure or pseudoarthrosis was observed in the follow-ups for both groups. All patients showed satisfactory neurological recovery levels and clinical improvements. The mean operating time was 92.23 ± 9.45 min in the CAGE-O group and 107.48 ± 12.38 min in the PLATE group. The estimated blood loss volume in the CAGE-O group was 105.43 ± 23.51 mL and 132.54 ± 19.62 mL in the PLATE group. Among the cases analyzed, 1 (5.26%) subcutaneous hematoma and 1 (5.26%) temporary hoarseness were detected in the PLATE group. Furthermore, 1 (4.34%) new-onset

Table II: Distribution of Etiologies

		n (%)
CAGE-O	Degenerative disc disease	8 (42.1)
	Cervical spondylotic myelopathy	7 (36.84)
	Mixed	4 (21.05)
PLATE	Degenerative disc disease	9 (39.13)
	Cervical spondylotic myelopathy	11 (47.83)
	Mixed	3 (13.04)

CAGE-O: *Fusion with only cage,* ***PLATE:*** *Fusion with cage and plates.*

Table III: Analysis of Preoperative Age, Pain Duration and Radiological Values

	Group	Mean	Median	SD	p-value*
Preop C0-2	CAGE-O	33.47	34.0	5.438	0.088
	PLATE	30.25	31.00	5.868	
Preop CL	CAGE-O	9.67	10.0	4.207	0.288
	PLATE	8.26	8.00	5.046	
Preop T1 Slope	CAGE-O	11.10	11.0	2.979	0.469
	PLATE	10.30	9.50	4.093	
Preop cSVA	CAGE-O	12.73	11.0	6.311	0.389
	PLATE	11.42	10.00	7.305	
Age	CAGE-O	49.04	49.0	9.979	0.418
	PLATE	46.37	46.00	10.673	
Pain Duration	CAGE-O	12.17	10.0	9.238	<.001
	PLATE	5.42	4.00	3.220	

*****Mann-Whitney U test was performed.* ***N:*** *Number,* ***SD:*** *Standard Deviation,* ***CAGE-O:*** *Fusion with only cage,* ***PLATE:*** *Fusion with cage and plates.*

Table IV: Clinical Parameters of the Patients

Clinical parameters	Preoperatively	3 months	6 months	12 months	2 year	p-value*
CAGE-O						
VAS	7.83 ± 2.39	4.77 ± 1.38	4.06 ± 1.29	3.12±1.21	2.67 ± 0.91	<0.001
NDI	35.41 ± 8.71	24.12 ± 6.04	20.43 ± 5.72	20.05 ± 4.19	17.25 ± 3.92	<0.001
PLATE						
VAS	8.02 ± 2.15	3.94 ± 1.25	3.22 ± 1.08	2.90 ±1.02	2.82 ± 1.05	<0.001
NDI	33.25 ± 7.38	22.15 ± 6.11	20.71 ± 5.53	19.37 ± 4.66	18.41 ± 4.18	<0.001

Repeated measures ANOVA (Friedman) test was applied.* ***CAGE-O:* *Fusion with only cage,* ***PLATE:*** *Fusion with cage and plates,* ***VAS:*** *Visual Analog Scale,* ***NDI:*** *Neck Disability Index.*

Table V: Radiological Parameters of the Patients

Radiological Parameters	Preoperative		p-value*	Postoperative		p-value*
	CAGE-O	PLATE		CAGE-O	PLATE	
cSVA(mm)	12.73 ± 6.31	11.42 ± 7.31	0.389	13.91 ± 4.91	12.53 ± 4.43	0.509
C0-C2(°)	33.47 ± 5.44	30.25 ± 5.87	0.088	38.95 ± 7.16	30.22 ± 5.85	<0.001
T1 Slope(°)	11.10 ± 2.98	10.30 ± 4.09	0.469	14.52 ± 3.66	12.38 ± 3.70	0.072
Cervical Lordosis(°)	9.67 ± 4.21	8.26 ± 5.05	0.288	11.25 ± 4.77	11.63 ± 7.98	0.595

Mann Whitney U test was applied.* ***CAGE-O:* *Fusion with only cage,* ***PLATE:*** *Fusion with cage and plates*

disc in the adjacent segment in the CAGE group and 1 (5.26%) adjacent segment degeneration and consequent new-onset disc formation in the PLATE group were observed in the follow-ups. The new-onset disc in both patients was radiological only, and both patients did not require intervention. Moreover, 4 (21.19%) patients in the PLATE group and 2 (8.69%) patients in the CAGE group reported dysphagia. However, no statistically significant differences were observed in early dysphagia occurrences (p=0.255). Patients did not require treatment for dysphagia, and the symptoms resolved after 1 month in both groups. There were no cases of subsidence in this cohort. Figure 1-2 represents selected cases from this cohort.

DISCUSSION

ACDF, initially described by Smith and Robinson in 1958 (18), is a commonly performed surgical intervention for degenerative cervical spine conditions and radiculopathies, providing successful outcomes with low complication rates (7). This procedure involves removing a damaged disc or bone spurs from the cervical spine and fusing the adjacent vertebrae to stabilize the spine. However, there is still a lack of consensus on the utilization of anterior plating on two-level ACDF. In this study, we investigated the effect of fusion with cage and anterior plating (PLATE) compared with the cage-only (CAGE-O) technique on postoperative cervical sagittal alignment parameters, clinical outcomes, and complication profiles after two-level ACDF. Our findings contribute to the ongoing debate concerning the need and implications of adding anterior plates in two-level ACDF procedures.

Both the CAGE-O and PLATE groups exhibited comparable radiological outcomes regarding spinal alignment. For two-level ACDF, both techniques caused no significant changes in cSVA values and cervical lordosis, although the mean values improved in both groups, which may be due to either the low sample size or the preoperative characteristics of the patients. Furthermore, most patients had accompanying cervical degenerative changes in addition to the disc herniation, and hence pain-related loss of lumbar lordosis might explain the lower postoperative cervical lordosis values than those reported in the literature (5,19). Zavras et al. observed no significant change in sagittal alignment followed by T1 slope, cSVA value, and cervical lordosis between the cage-only and anterior plating techniques in ACDF (21). Similarly, Akgun et al. observed no significant change in sagittal alignment followed by laminoplasty or laminectomy with fusion (2). Interestingly, in our cohort, only the CAGE-O group showed a significant increase in T1 slope and CO-C2 angles, whereas these values remained stable in the PLATE group. This difference may be related to better stability of the fused segment by anterior plating and consequent changes in adjacent vertebrae. Conversely, Lau et al. reported that cSVA values, cervical lordosis, and T1 slope showed no correlation with pain outcomes in patients who underwent ACDF (13). Similarly, in our cohort, both the CAGE and PLATE groups showed significant improvement in pain outcomes irrespective of differences in radiological differences between the groups.

When we compared the clinical outcomes of patients who underwent ACDF with either anterior plating or cage-only tech-

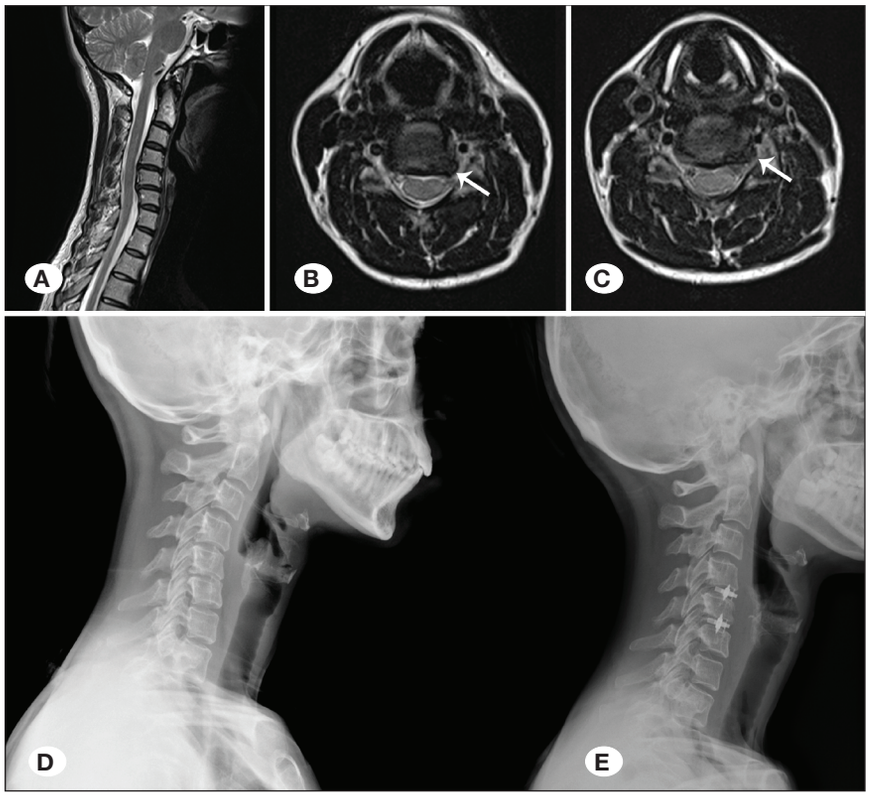

Figure 1: Radiographic images of the patient treated with anterior cervical discectomy and fusion with cage-only technique. **A)** Preoperative T2W sagittal MRI. **B, C)** Preoperative T2W axial MRI showing C4-C5 and C5-C6 disc herniations respectively. **D)** preoprative and **E)** postoperative lateral cervical X-Rays. Arrows indicate disc herniations.

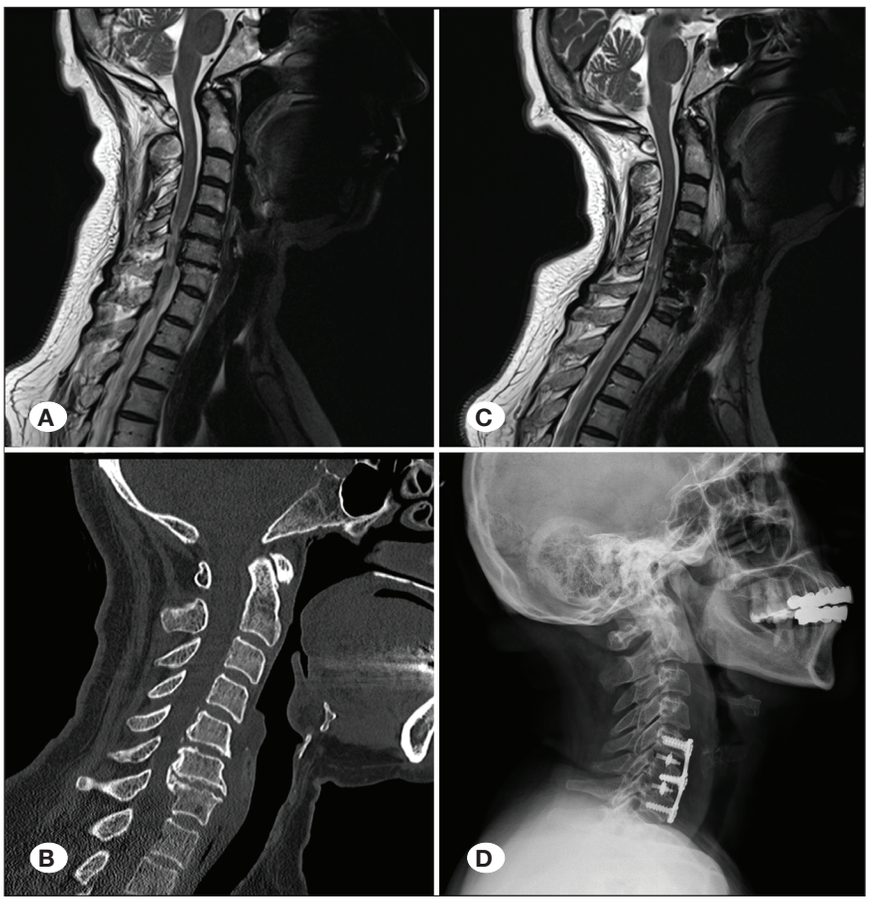

Figure 2: Radiographic images of the patient treated with anterior cervical discectomy and fusion with cage and anterior plating technique. Preoperative sagittal **(A)** T2W MRI and **(B)** CT showing osteophyte formation and myelomalacia. Postoperative **(C)** sagittal T2W MRI and **(D)** lateral X-Ray showing anterior cervical plate at C5-C7 levels.

niques, we observed similar and significant improvements in both groups over the 2-year follow-up period. The VAS and NDI scores exhibited substantial improvements with no significant differences between the CAGE-O and PLATE groups. These results suggest that both techniques effectively alleviate symptoms and improve functional status in patients with two-level cervical radiculopathy. Oh et.al. observed that both anterior plating and cage-only techniques provide comparable clinical outcomes in patients who underwent two-level ACDF (16). Similarly, Cheung et al. conducted a meta-analysis and reported no significant difference in VAS, JOA, or NDI scores between anterior plating and cage-only techniques in ACDF (6). Our clinical findings comparing these two techniques also support the interchangeable characteristics of these anterior plating and cage-only techniques, in terms of alleviation of pain, in two-level ACDF.

Regarding complication profiles, both the PLATE and CAGE-O groups exhibited similar rates of adverse events, with no significant difference in hardware-related complications or postoperative morbidity. Dysphagia is one of the most common complications of ACDF surgery (8). In our cohort, a higher number of patients reported early postoperative dysphagia in the PLATE group than in the CAGE-O group; however, this difference did not reach statistical significance. Moreover, no patients' symptoms persisted for more than 1 month. New-onset adjacent segment pathology was rare and occurred at similar rates in both groups. Nevertheless, Ji et al. reported a higher incidence of adjacent segment disease (ASD) with anterior plating and construction than with the cage-only technique in two-level ACDF (20). Similarly, Cheung et al., in their meta-analysis, observed a higher rate of ASD (6). Our findings of low incidence and similar rate of ASD among the groups may be related to our preoperative planning. Regarding possible disc bulging and apparent degenerative changes in adjacent segments, we opted for a longer three-level ACDF. This emphasizes the importance of careful consideration of factors such as the extent of disc pathology and the presence of adjacent segment degeneration, which can mitigate the risk of developing postoperative complications. Regarding perioperative findings, assuming that additional hardware such as plates and screws are not used in the cage-only technique, it reduces the risk of hardware-related complications, including implant failure, loosening, and malpositioning. This simplification of the surgical procedure may result in shorter operative times and reduced intraoperative blood loss, thereby contributing to improved surgical outcomes and patient recovery. Moreover, the cage-only technique may provide cost savings compared with anterior plating, as it eliminates the costs associated with implanting additional hardware.

The limitations of our study include its retrospective design and the relatively small sample size. Furthermore, the 2-year follow-up duration may not capture the long-term outcomes and complications associated with ACDF. In addition, the decision to utilize anterior plating or cage-only technique was based on surgeon preference and patient characteristics. This variability in the selection of the surgical approach could limit the generalizability of our findings. Prospective studies with larger cohorts with broader patient characteristics and longer follow-up periods are required to further clarify the comparative effectiveness and long-term outcomes of cage-only versus plating techniques in two-level ACDF procedures.

CONCLUSION

This retrospective study comparing anterior plating versus cage-only techniques in two-level ACDF demonstrated comparable outcomes in terms of sagittal alignment, clinical improvement, and complication rates over a 2-year follow-up period. Both the anterior plating and cage-only groups showed significant postoperative clinical improvement in VAS and NDI scores. Complication rates were also similar between the two groups, except for short-term dysphagia that was detected more in the anterior plating group. Our findings contribute to the increasing evidence that ACDF without anterior plating is a feasible technique for maintaining the desired cervical sagittal alignment. The decision to utilize anterior plating should be based on individual patient factors and surgeon preference rather than differences in clinical outcomes.

Declarations

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Availability of data and materials: The datasets generated and/or analyzed during the current study are available from the corresponding author by reasonable request.

Disclosure: The authors declare no competing interests.

AUTHORSHIP CONTRIBUTION

Study conception and design: ATA, MYA, TO, OA, AFO

Data collection: CG, BC, ATA

Analysis and interpretation of results: MYA, EAU, SOG, BC, ATA, OT

Draft manuscript preparation: MYA, CG, ATA

Critical revision of the article: MYA, ATA, TO, OA, AFO

All authors (CG, MYA, EAU, BC, ATA, SOG, TO, OA, AFO) reviewed the results and approved the final version of the manuscript.

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