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Cervical spinal stenosis: outcome after anterior corpectomy, allograft reconstruction, and instrumentation

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Object. The authors undertook a retrospective single-institution review of 261 patients who underwent anterior cervical corpectomy, reconstruction with allograft fibula, and placement of an anterior plating system for the treatment of cervical spinal stenosis to assess fusion rates and procedure-related complications.

Methods. Between October 1989 and June 1995, 261 patients with cervical stenosis underwent cervical corpectomy, allograft fibular bone fusion, and placement of instrumentation for spondylosis (197 patients), postlaminectomy kyphosis (27 patients), acute fracture (25 patients), or ossification of the posterior longitudinal ligament (12 patients). All patients suffered neck pain and cervical myelopathy or radiculopathy refractory to medical management. Of the procedures, 133 involved a single vertebral level (two disc levels and one vertebral body), 96 involved two levels, 31 involved three levels, and a single patient underwent a four-level procedure. Clinical and radiographic outcomes were assessed postoperatively and at 6-month intervals. The mean follow-up period was 25.7 months (range 24–47 months).

Successful fusion was documented in 226 patients (86.6%). A stable, fibrous union developed in 33 asymptomatic patients (12.6%), whereas an unstable pseudarthrosis in two patients (0.8%) required reoperation. There were no cases of infection, spinal fluid leakage, or postoperative hematoma. Complications included transient unilateral upper-extremity weakness (two patients), dysphagia (35 transient and seven permanent), and hoarseness (35 transient and two permanent). In 14 patients (5.4%) radiological studies demonstrated evidence of hardware failure.

Conclusions. Cervical corpectomy with fibular allograft reconstruction and anterior plating is an effective means of achieving spinal decompression and stabilization in cases of anterior cervical disease. Symptomatic improvement was achieved in 99.2% of patients. In their series the authors found a fusion rate of 86.6% and rates of permanent hoarseness of 3.4%, dysphagia of 0.7%, and an instrumentation failure rate of 5.4%.

KEY WORDS • cervical spondylosis • corpectomy • allograft • cervical spine • spinal fusion

ANTERIOR approaches to the cervical spine, first described in the 1950s, have become widely accepted in the treatment of cervical spinal disease.[1,10,35,40,41] These approaches provide a direct route to anteriorly located lesions for decompression and restoration of sagittal alignment. In cases in which lesions involve multiple levels or extend posteriorly to the VB, a corpectomy or vertebrectomy that encompasses adjacent discs may be indicated. The structural integrity of the column may be restored with autograft (fibula or iliac crest) or allograft fibula, typically combined with the placement of instrumentation. The use of an anterior cervical plate offers the advantage of conferring immediate stability, increased fusion rates, and a decreased incidence of graft extrusion.[9,11,13,14,20,22,28] Additionally, internal fixation may decrease the need for postoperative rigid brace immobilization and its attendant morbidity.[2,18,19,21,30,33,34,44]

Abbreviations used in this paper: PLL = posterior longitudinal ligament; VB = vertebral body.

Allograft bone had been used rarely in the cervical spine until recently, mainly because of concerns of lower fusion rates and the risk of disease transmission.[7,23,32,49] The use of allograft eliminates autograft donor site–related complications, which have been reported to reach as high as 20% in some series. Typical complications of autograft harvesting include prolonged donor-site pain, nerve injury, infection, and hematoma.[4,12,45,46]

To assess clinical and radiographic outcomes, we retrospectively reviewed a series of 261 patients, treated over a 6-year period, in whom a single surgeon (R.W.H.) performed anterior cervical corpectomy, placement of allograft fibular strut, and anterior plate fixation.

Clinical Material and Methods

Patient Population

Between October 1989 and June 1995, 261 patients (113 females and 148 males) with cervical stenosis underwent cervical corpectomy and fusion for spondylosis (197 patients), postlaminectomy kyphosis (27 patients), acute fracture (25 patients), or ossification of the PLL (12 patients) (Table 1). The mean patient age was 47.4 years (range 15–72 years). All patients suffered neck pain and cervical myelopathy or radiculopathy refractory to medical management. Indications for surgery included anterior VB-induced spinal cord compression causing spinal canal stenosis and resulting in myelopathy, radiculopathy, or myeloradiculopathy. Forty-nine patients had previously undergone anterior-approach surgery. Of the procedures, 133 involved a single vertebral level, which was defined as the removal of one VB and the two adjacent discs. Ninety-six patients underwent a two level corpectomy; 31, a three-level corpectomy; and one patient, a four-level procedure. No patients were included in this series who had undergone an anterior cervical discectomy and adjacent-level fusion or a supplemental posterior procedure. All patients were placed in rigid cervical collars for a mean period of 10.7 weeks (range 6–14 weeks).

Follow-Up Course

The cumulative mean follow-up period was 25.7 months (range 24–47 months). All patients were examined by the treating neurosurgeon and underwent static cervical spine radiography within 3 months of surgery. Clinical and radiographic outcomes were assessed at 6-month intervals thereafter. After 3 months, all patients underwent plain cervical flexion–extension radiography at each office visit. In cases in which fusion could not be determined definitively on radiographs, patients underwent computerized tomography scanning with 1- to 3-mm cuts and coronal/sagittal reconstructions to minimize hardware artifact and better define the graft–native bone interface.

Radiographic assessment of the fusion was based on the presence or absence of motion on dynamic radiographs and the extent of bone growth across the graft–native bone interface. Fusion may be defined as the absence of motion on dynamic radiographs with osseous trabeculae bridging both the rostral and caudal ends of the graft. A fibrous union is defined as the absence of motion on flexion/extension views without the presence of osseous trabeculae crossing either of the graft interfaces. Pseudarthrosis is defined as evidence of both motion on dynamic radiographs and lack of trabeculae bridging the graft margins.

Surgical Implants

All implants consisted of structural allograft fibula and fixation with a plating system. The allograft fibula was freeze-dried, sterilized bone bank graft. The morselized cancellous bone obtained during the corpectomy was used to pack the hollow portion of the fibula.

Our use of anterior plating systems changed over the course of the study period. In chronological order, we used the Caspar Anterior Trapezoidal Plates ([35 patients] Aesculap, San Francisco, CA), Synthes Cervical Spine Locking Plates ([78 patients] Synthes, Paoli, PA), Orion Anterior Cervical Plates ([101 patients] Medtronic Sofamor-Danek Group, Memphis, TN), and Codman Anterior Cervical Plates ([47 patients] Codman, Johnson & Johnson Professional, Inc., Raynham, MA). The number of levels of fixation for each plate is shown in Table 2.

Screws were placed only into the caudal and rostral VBs. No intermediate points of fixation into the allograft fibula were used.

TABLE 1
Indications for surgery

Diagnosis	No. of Patients (%)
spondylosis	197 (75)
postlaminectomy kyphosis	27 (10)
traumatic fracture	25 (9.6)
OPLL	12 (4.6)
total	261

Operative Procedure

Patients are placed in the supine position after induction of general anesthesia. The cervical spine is placed in mild extension by using a single, transverse shoulder roll. The head is rotated 5 to 10° to the left and is stabilized on a foam donut. We avoid external cervical traction but will apply gentle shoulder traction with tape to improve radiographic exposure. Similarly we do not use esophageal stethoscopes and nasogastric tubes so as to avoid causing esophageal injury due to retraction against a rigid object. A right-sided approach is performed via a transverse incision for exposure of up to two vertebral segments and a longitudinal incision for longer exposures. The exception to this is when the plating system is applied to T-1, in which case a left-sided approach is undertaken (six cases).

To provide tissue relaxation and prevent retraction-induced injury, extensive undermining of the platysma is performed. The spine is approached medial to the sternocleidomastoid muscle. The omohyoid muscle may be safely divided to enhance exposure. The prevertebral fascia may be divided in the midline and electrocautery used to reflect the longus colli musculature in a subperiosteal manner to visualize the uncovertebral joints. Single radiographs may be obtained or fluoroscopic imaging may be performed to confirm operative levels. We avoid performing electrocautery below C-6 so as not to cause thermal injury to the recurrent laryngeal nerve.

Both transverse and longitudinal self-retaining retractors are placed to maintain visualization. We attempt to release retraction hourly to enhance local tissue perfusion. Anterior osteophytes are removed at this point, and the anterior VBs are prepared for the plating system. Complete discectomies are performed at the involved segments by applying gentle internal distraction. The allograft fibula is packed using the cancellous autograft harvested during the corpectomy. The VB is resected and undercut lat-

TABLE 2
Summary of affected levels and fixation systems

	Fusion System				
No. of Levels	Caspar	Synthes	Orion	Codman	Total
1	24	37	45	27	133
2	11	29	38	18	96
3	0	12	17	2	31
4	0	0	1	0	1
total	35	78	101	47	261

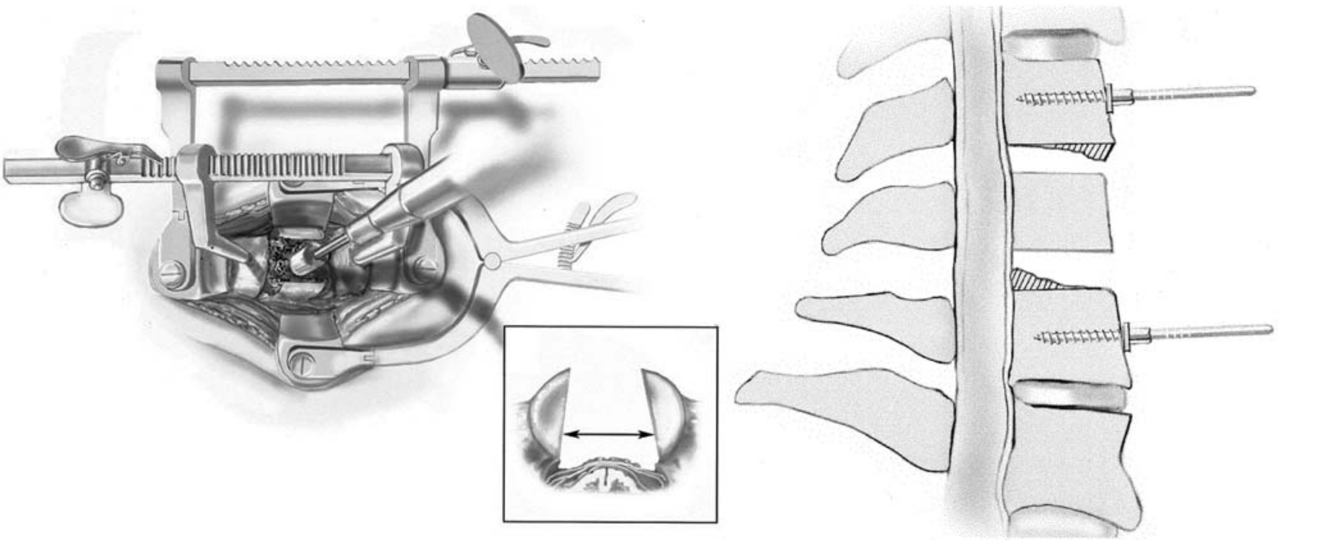

FIG. 1. *Left:* Illustration showing the width of decompression. The corpectomy is undercut so that the exiting nerve roots can be seen. *Right:* Illustration showing the anterior lip of the rostral VB and the posterior osteophyte of the caudal VB are removed in preparation for the graft placement.

erally (Fig. 1 *left*) to visualize the exiting nerve roots and the PLL. The width of the decompression varies from 15 to 22 mm. The preoperative imaging studies are assessed to help determine the adequate width of the decompression. The PLL is routinely resected, and the rostral and caudal VBs are carefully undercut using Kerrison rongeurs. The operating microscope may be used to improve visualization of osteophytes, the PLL, and the posterior cortices, and it is usually used in cases of ossification of the PLL or tight stenosis. The superior and inferior endplates are then gently decorticated and contoured into a parallel position by using a high-speed drill. Removal of the anterior lip of the rostral VB, and the posterior osteophyte of the caudal VB is necessary to allow for adequate graft placement (Fig. 1 *right*).

A wood-handled cotton-tipped applicator is cut to the size of the defect, which is then used as a template to measure the length of the fibular allograft. The hollow portion of the fibula is packed with morselized cancellous bone harvested from the corpectomy site. The allograft is then placed under gentle distraction. Distraction is then released, providing static graft compression. The shortest possible plate is selected, contoured into gentle lordosis, and positioned using a standard procedure. Closed suction drainage is used in all patients for the first 24 hours.

Results

Clinical Outcome

Two hundred fifty-nine (99.2%) of 261 patients reported improvement in their most significant preoperative complaint of radicular pain, level of functioning, muscle strength, or neck discomfort. Two patients (0.8%) noted no improvement in their myelopathy over the follow-up period.

Fusion Rates

Fusion was documented in 226 patients (86.6%). A stable, fibrous union developed in 33 asymptomatic patients (12.6%), whereas an unstable pseudarthrosis revealed in two patients (0.8%) required reoperation and revision of the construct.

The fusion rates, based on the type of plate implanted, were quite similar (Table 3). Of the 35 patients with Caspar plates, fusion developed in 29, and fibrous union in six. Of the 78 patients with Synthes plates, fusion developed in 67 and fibrous union in 11. Of the 101 patients with Orion plates, fusion developed in 89 and fibrous union in 12. Of the 47 patients with Codman plates, fusion developed in 41, fibrous union in four, and in two patients unstable fusion was demonstrated.

Procedure-Related Complications

There were no infections, cerebrospinal fluid leaks, or postoperative hematomas. There were no tracheal, vascular, or esophageal injuries. Perioperative mortality rate was 0%. There was a significant immediate postoperative complication rate of 36%, of which most were transient, and 9% were long term. Complications included transient unilateral upper-extremity weakness (two patients), dysphagia (35 transient and seven permanent), and hoarseness (35 transient and two permanent). In 14 asymptomatic patients hardware failure was present (12 screw fractures and two screw pullouts). The transient weakness was likely due to a C-5 radiculitis, as described by Saunders,[36] and others.[17,31,37]

Dysphagia was subjectively assessed by questioning the patient and, in severe cases, studied by gastrograffin swallow to discount possible occult esophageal injury. Such symptoms were transient in 35 patients (13.4%), but persisted in seven patients (2.7%). The degree of dysphagia did not correlate with the number of levels fused (Table 4).

Hoarseness was subjectively assessed by questioning the patient and, in severe cases, studied by flexible laryngoscopy to discount possible laryngeal nerve injury.

TABLE 3
Summary of fusion rates

Fixation System	No. Used	Success of Fusion (%) Osseous	Fibrous	Unstable
Caspar	35	29 (83)	6 (17)	0
Synthes	78	67 (86)	11 (14)	0
Orion	101	89 (88)	12 (12)	0
Codman	47	41 (88)	4 (8)	2 (4)
total		226 (87)	33 (13)	2 (0.8)

TABLE 4
Incidence of dysphagia and hoarseness stratified by number of fixation levels

	No. of Levels (no. of cases) 1 (133)	2 (96)	3 (31)	4 (1)	Total (%)
dysphagia					
transient	14	9	1	1	35 (13)
permanent	2	3	2	0	7 (3)
hoarseness					
transient	9	8	17	1	35 (13)
permanent	0	1	1	0	2 (0.7)

Thirty-five patients (13.4%) noted transient hoarseness, whereas in two patients (0.7%) the hoarseness failed to resolve over the follow-up period. One patient required an injection of Teflon for a recurrent laryngeal nerve palsy. The second patient suffered a superior laryngeal nerve palsy. The number of vertebral levels involved appeared to correlate with the incidence of neuropraxic injury to the laryngeal nerves (Table 4).

A total of 1048 screws were placed. Of these, 12 broken screws (1.1%) were identified (Table 5). Of the broken screws seven were Caspar, three were Synthes, and two were Codman. None of the screws required removal nor was fusion inhibited. There were no cases of plate fracture. Screw pullout (in the range of 2–4 mm) occurred in two cases. Both patients were elderly women with osteoporosis who underwent two-level corpectomies and stabilization in which Synthes plates were used. In both cases, the upper screws pulled away from the bone, but solid fusion eventually developed in both patients. Neither patient experienced dysphagia.

Discussion

There are many methods available for surgical decompression and stabilization of the cervical spine, with obvious merits to both anterior and posterior approaches. In performing an anterior cervical corpectomy, one must carefully select a structural graft, plating system, and means of postoperative immobilization. Table 6 summarizes the literature covering anterior corpectomy with or without plates.[3,5,6,8,13–17,25–27,29,31,37,39,42,43,45,47,48] The majority of these authors used autologous bone without a plate to reconstruct the spine. Variations in operative techniques, graft materials, and fixation devices make comparisons among the series difficult.

Autograft Compared With Allograft

The use of autograft bone, both cortical and cancellous components, has been associated with the highest fusion rates and represents the standard by which other graft materials may be judged. The obvious disadvantages associated with the use of autologous bone are related to the harvesting of the graft. These drawbacks include postoperative pain (often exceeding that of the primary incision), infection, nerve injury, hematoma, and increased operative time.[4,12,45,46] Several authors have combined the use of an autologous graft with placement of an internal plate to reconstruct the spine after corpectomy.[6,8,14,26,28,39] In the largest series in the literature, reported by Eleraky, et al.,[14] the fusion rate was 98.8% in the 179 patients in whom a plate was placed. Overall fusion rates are highest in series in which both autograft bone and instrumentation are used. The additional risks inherent in placing spinal instrumentation, including nerve root injury, hardware failure or malposition, and increased operative time, are not trivial considerations.

Allograft bone, either iliac crest or fibula, has been used with increasing frequency as a substitute for autograft bone. Although the complications associated with autograft harvesting are eliminated, the use of allograft bone may decrease fusion rates, prolong the time for graft incorporation, and introduce the risk of disease transmission.[7,23,32,49] MacDonald, et al.,[31] found no difference in fusion rates between patients in whom allograft or autograft bone was used for spinal reconstruction. The incidence of pseudarthrosis when using allograft bone was slightly higher, especially when longer-length constructs were required. Eleraky, et al.,[14] also found no difference in the fusion or complication rates between the 141 patients who received autografts and the 44 patients who received allografts.

Addition of Anterior Instrumentation

In this series, instrumentation was used in all cases after placement of a fibular allograft. A rigid plate allows for immediate stabilization of the spine and, when placed correctly, may decrease the incidence of graft migration.[9,11,13,20,22,28] When a plate is added to an anterior fusion construct, the morbidity typically associated with spinal instrumentation is also present, including plate malpositioning and failure, increased operative time, and possible nerve root or spinal cord injury. The increased fusion rates associated with an allograft plate system approximate those in cases in which autograft bone is placed without instrumentation; however, the additional risk of harvesting the graft is absent. In the current series of 261 patients

TABLE 5
Incidence of hardware failures stratified by fixation system

Complication	Fixation System Caspar (35)	Synthes (78)	Orion (101)	Codman (47)
broken plates	0	0	0	0
broken screws	7 (20%)	3 (3.8%)	0	2 (4.2%)
screw pullout	0	2 (2.6%)	0	0

TABLE 6
Summary of published series of patients who underwent corpectomy

Author & Year	No. of Cases	Graft Used*	Plates	Graft Displace-ment	Orthosis Used	Fusion Rates: Os-seous	Fusion Rates: Fi-brous	Fusion Rates: Pseud-arthro-sis	Complication (%)
Whitecloud, 1976	9	auto fib	no	1	collar	9	0	0	35
Boni, et al., 1984	39	AIBG	no	1	Minerva	39	0	0	20
Yonenobu, et al., 1985	21	AIBG	no	3	collar	16	0	5	14
Hanai, et al., 1986	30	AIBG	no	3	collar	30	0	0	3
Bernard & Whitecloud, 1987	21	auto fib	no	1	collar	21	0	0	5
Brown, et al., 1988	13	3 auto fib, 10 AIBG	yes	1 Fx	Minerva	13	0	0	57
Tippets & Apfelbaum, 1988	18	fibula or tibia	yes	0	NA	18	0	0	20
Caspar, et al., 1989	41	AIBG	yes	0	soft	41	0	0	19
Kojima, et al., 1989	45	AIBG	no	4	halo	45	0	0	24
Zdeblick & Bohlman, 1989	14	AIBG or fibula	no	3	2 post or halo	14	0	0	27
Fernyhough, et al., 1991	59	allo fib	no	3	collar	35	3	21	3
	67	allo fib	no	0	collar	49	1	17	
Saunders, et al., 1991	40	AIBG	no	1	collar	39	0	1	48
Seifert & Stolke, 1991	22	AIBG	yes	0	collar	22	0	0	18
Hu & Wilber, 1993	31	27 AIBG,	no	0	collar	27	0	0	19
		4 auto fib	no	0	(4 halo)	3	0	1	
Herman & Sonntag, 1994	20	19 AIBG	yes	0	collar	20	0	0	38
		1 allo	yes		(2 halo)				
Tominaga, et al., 1994	8	AIBG	yes	0	collar	8	0	0	0
Ebraheim, et al., 1995	25	22 AIBG	yes	1 Fx	cervicothoracic	25	0	0	40
		3 auto fib	yes						
MacDonald, et al., 1997	26	allo fib	15 yes, 11 no	5	halo	25	1	0	22
Emery, et al., 1998	57	19 AIBG	no	2	44 collar	17	0	2	NA
		38 fib	no	4	13 halo	37	0	1	
Fessler, et al., 1998	93	7 AIBG, 86 fib	27 yes, 66 no	1	collar or halo	82	0	11	18
Eleraky, et al., 1999	185	141 AIBG, 44 allo	179 yes, 6 no	0	167 collar, 18 halo	183	0	2	23
Mayr, et al., present series	261	allo fib	yes	2	collar	226	33	2	36 temporary, 9 permanent

* AIBG = autologous iliac bone graft; allo fib = allograft fibula; auto fib = autograft fibula; collar = rigid cervical collar; fib = fibula; NA = not applicable; soft = soft cervical collar.

the fusion rate was 86.6%, the fibrous union rate was 12.6%, and the pseudarthrosis rate was 0.8%. Overall, radiographical stability and documented improvement in neck pain were demonstrated in 99.2% of the patients. In patients with a stable fibrous union, however, a pseudarthrosis may develop over a longer follow-up period.

Type of Orthosis

Various external immobilization systems have been used postoperatively to provide comfort and enhanced fusion rates. In the majority of published series the authors have used a rigid collar, although several have used other devices (Table 6). Apart from issues of comfort, halo brace immobilization has several potential complications including infection and pin loosening, as well as other more serious complications such as brain abscess or sinus thrombosis.[2,18,19,21,30,33,34,44] The Minerva brace is also uncomfortable. There have been reports on the difficulty in maintaining oral and facial hygiene and, occasionally, pain from the temporomandibular joint.[6]

In the current series, a rigid cervical collar was used in all patients for a minimum of 6 weeks. We believe that in cases in which the cervical spine has been fitted with instrumentation the need for more aggressive bracing is obviated in most cases.

Special Considerations

Longer-length constructs tend to be associated with a higher failure rate than their shorter counterparts, with failure rates approaching 20% in three- and four-level fusions.[16,26,28,31] If the planned construct is to span more than two vertebral segments, we often undertake a combined anterior–posterior approach, which creates an intrinsically stronger construct and precludes the need for more aggressive external stabilization. Schultz, et al.,[38] have reported 72 patients who underwent combined anterior–posterior decompression and fusion in a single stage. They reported a 100% fusion rate. The combined approach may be particularly valuable in individuals with ostopenia, traumatic injury causing anterior and posterior instability, or those with predisposing risk factors such as diabetes, tobacco use, or dialysis dependence.[38]

The records documenting the smoking patterns of patients early in the series were incomplete and therefore could not be analyzed. Chronic cigarette smoking may adversely affect fusion rates, as has been shown in the excellent review by Hadley and Reddy.[24] In patients who smoke, the bone has less potential for vascular ingrowth and capillary budding, both of which are essential for fusion to occur. It has been our practice to offer chronic tobacco users autologous bone, usually iliac crest, to increase the chance for a successful fusion. The majority of patients in this series were nonsmokers. We acknowledge the limitations of this study, including the lack of data on tobacco use and the retrospective nature of the study's design. A prospective study, in which possible graft choices and instrumentation use are compared, may yield more definitive results regarding cervical corpectomy.

Conclusions

This work represents the largest clinical series in the literature to date of patients treated with cervical corpectomy followed by fibular allograft and plate reconstruction. In selected cases, we believe such instrumentation/allograft fusions represent a safe and effective alternative to autograft bone for osteosynthesis following cervical corpectomy, while avoiding autograft donor-site complications. Acceptable fusion rates may be obtained with postoperative rigid collar immobilization, while avoiding the problems associated with more extensive brace therapies.

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