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Clinical Case Studies

# Full-endoscopy with intraoperative O-arm navigation for cervicothoracic gas-containing hemorrhagic synovial cyst: A case report

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ABSTRACT

*Background:* Synovial cysts are benign fluid-filled sacs commonly found in the degenerative lumbar spine. Few studies have reported the detailed epidemiology and standardized therapy for this disease. Conservative treatment is recommended if synovial cysts are asymptomatic or show mild clinical symptoms. If percutaneous facet joint steroid injections are ineffective or neurologic symptoms are aggravated, the open decompression with additional fusion is the reasonable surgical strategy to remove the pain generator. Furthermore, the synovial cysts that occur at the cervicothoracic spine are infrequently, especially accompanied by hemorrhagic radiographic evidence. Therefore, we describe the efficacy and safety of the full-endoscopy surgical procedure assisted by intraoperative O-arm navigation guidance to manage C7/T1 spinal synovial cysts.

*Case description:* We describe a 71-year-old male patient diagnosed with cervicothoracic hemorrhagic synovial cysts. The pathologic site is located at the posterior side of the C7 vertebral body to the medial side of the C7-T1 left facet joint. Herein is described a step-by-step protocol for the full-endoscopic procedure via the posterior approach to remove the lesions under intraoperative O-arm navigation guidance.

*Outcome:* The patient was successfully treated via full-endoscopic removal of the synovial cysts guided by intraoperative O-arm navigation. Intraoperative bleeding of 30 mL occurred, and the operative time was 150 minutes. The patient's sensory strength improved, and no opioid medicine was required with no complications postoperatively. One-year follow-up magnetic resonance imaging (MRI) and computed tomography (CT) scans showed no synovial cyst recurrence.

*Conclusions:* Full-endoscopy assisted with intraoperative O-arm navigation guidance improves precision and safety in treating patients with synovial cysts of the cervicothoracic spine. The O-arm navigation system improves the efficiency and safety of intraoperative positioning at the cervicothoracic lesion and reduces radiation exposure to the surgeons. Meanwhile, this technique preserves the range of cervicothoracic motion and facilitates the patient return to normal life.

## Background

Since 1974, Kao et al. reported the first case report of cervical juxtafacet cysts that consisted of a ganglion or synovial cyst [1], and researchers have started to investigate the detailed epidemiology and standardized therapy for synovial cysts that have been attributed to degenerative arthritis and hypermobility of the spinal segment [2]. Generally, synovial cysts occur mainly in the lumbar area due to high levels of segmental activity and spinal loads compared to the cervical area [3]. Complaints from patients often relate to myelopathy, radiculopathy, or radiculomyelopathy caused by extradural spinal cord compression [4].

In general, conservative treatments, such as bracing and steroid injection, are recommended as first-line therapy to treat the mild or moderate symptomatic synovial cysts [5,6]. If symptoms are aggravated, surgical treatment is usually considered the universal treatment standard. Currently, open decompression and fusion are considered recommended surgical options for spinal synovial cysts; however, it has the potential to cause a series of undesirable iatrogenic complications for patients, such as surgical site infection paraspinal muscle atrophy, or spinal destabilization. It particularly may occur at the cervicothoracic level, which is weight-bearing and surrounded by complex anatomical structures.

Endoscopic surgery as a minimally invasive procedure is an alternative surgical option to resect synovial cysts. To our knowledge, previous studies have yet to report the endoscopic removal of acute hemorrhagic synovial cysts in the cervicothoracic spine. We describe the full-endoscopy technique assisted by intraoperative O-arm navigation guidance to manage an acute gas-containing hemorrhagic spinal synovial cysts at the C7/T1 level.

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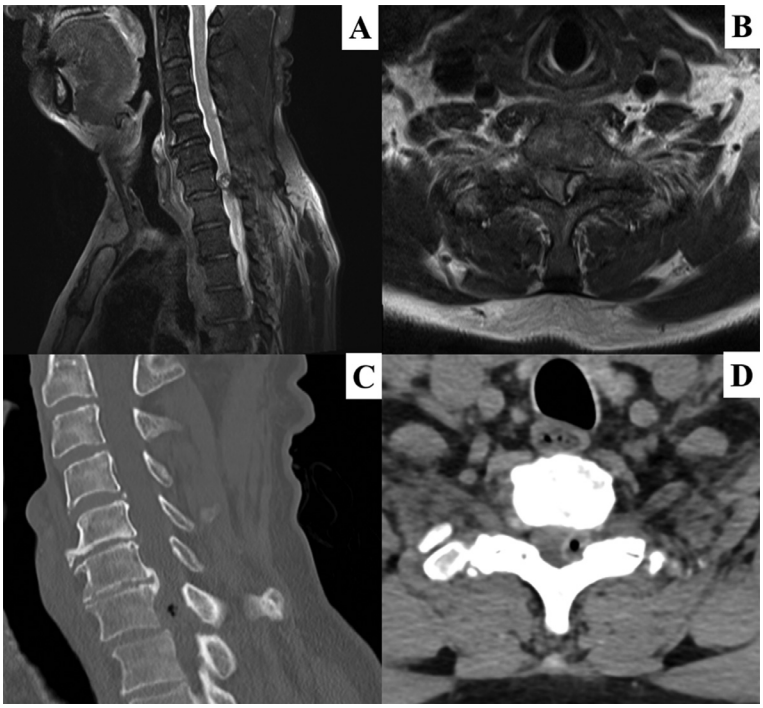


**Fig. 1.** Magnetic resonance imaging. (A and B) Synovial cysts located at the posterolateral dural sac with a low signal intensity surrounded by a high signal intensity in T1W1. Computed tomographic scans. (C and D) Anterior C5 and C6 vertebral body osteophytes and posterior C6 and C7 vertebral body osteophytes.

## Case and Surgical Description

### *Case illustration*

A 71-year-old male patient visited the emergency center complaining of weakness involving both lower extremities and tingling sensation in both upper extremities along with pain in the C8 and T1 dermatomes. Subsequently, the patient's symptoms worsened until he was unable to walk due to bilateral leg weakness. The pathologic reflex showed a positive Lhermitte's sign.

There was no radiological evidence of scoliosis or dynamic instability, and there was disc height reduction with mild spondylolisthesis of C7 on T1. MRI revealed a low signal intensity surrounded by a high signal intensity on the dorsal side of the dural sac in T1W1 (Fig. 1A and B). A CT scan showed the anterior C5 and C6 vertebral body osteophytes and the posterior C6 and C7 vertebral body osteophytes with no calcification or ligamentum flavum hypertrophy (Fig. 1C and D). After a comprehensive analysis of the clinical performance and radiographic data, we diagnosed the patient with synovial cysts accompanied by acute hemorrhage, which requires urgent surgical intervention to avoid irreversible neurological damage by spinal compression. The surgical video clip depicting this can be found in the supplemental material (Video).

### *Patient positioning and setup*

The operation was performed under general anesthesia while the patient was in a prone position on a radiolucent table. Mayfield clamps were used to stabilize the head and secure the upper extremities to the sides of the trunk. Intraoperative neuromonitoring was conducted during the entire surgery (motor and somatosensory evoked potentials). A third-generation endoscope system (Vertebris Stenosis, RIWOspine GmbH, Knittlingen, Germany) was used in this protocol: 9.3 × 7.4 mm in outer diameter, with a 20° optical angle, a 5.6 mm diameter working channel, and a 117 mm working length. An articulating radiofrequency probe (Elliquence, Baldwin, New York, USA) was used for coagulation and tissue ablation. Full-endoscopy was performed under intraoperative O-arm navigation guidance (O-arm surgical imaging system, Medtronic Sofamor Danek, Memphis, Tennessee, USA) (Fig. 2).

### *Incision planning*

The location of the pathological lesion was identified, and the appropriate surgical approach was selected according to the preoperative imaging data. Confirm the target level under the intraoperative O-arm navigation system with skin marks. Drape the patient before aseptically preparing the skin with isopropyl alcohol and povidone-iodine. A posterior interlaminar approach with full-endoscopy was selected for this patient. Then, a 1-cm skin incision was made over the correct segment before navigation registration. The sequential dilators and working cannula were inserted step by step into the facet joint under intraoperative navigation guidance until they reached the lower margin of the C7 lamina.

### *Synovial cysts resection and spinal decompression*

Under continuous irrigation with antibiotic saline, the full-endoscope was introduced into the working cannula. Attention should be given to flexible rotation of the angle lens of the full-endoscopic camera to ensure that all instrument operations are under visualization. Under O-arm navigation guidance, bipolar diathermy or monopolar was reconfirmed to be at the target level, and the soft tissues were removed from the medial cranial facet joint to the base of the C7 spinous process (Fig. 3A). To prevent iatrogenic injury to the nerve structure, a high-speed diamond burr was recommended to thin the outer layer of the cortex and cancellous bone. Kerrison punches were then inserted into the crevice in the middle of the laminae and the ligamentum flavum to perform the bone resection. The surgeon must pay attention to accidental instrument plunge when performing the bone work with the instruments. Meanwhile, the surgeon should not resect all the ligamentum flavum until the bone work is finished, which will help to avoid incidental dural tears. It is also worth noting that continuously controlling bleeding with radiofrequency modulation is effective in preventing postoperative epidural hematoma.

The operator moves the diamond drill cranially until detecting the proximal edge of the ligamentum flavum, and the extent of bone resection depends on the size of the cysts. After resecting partial of the ligamentum flavum, a yellow hard half-shell hemorrhagic synovial cysts

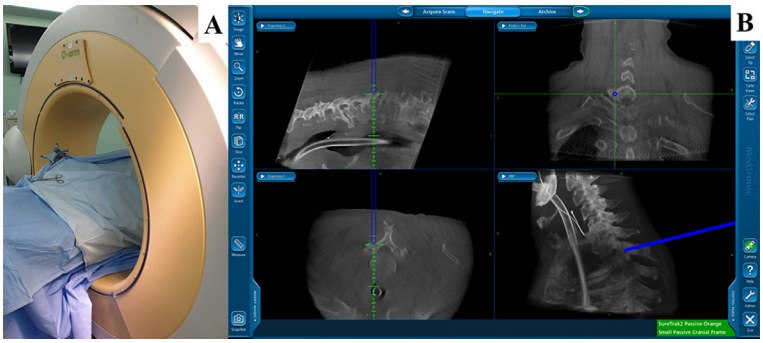


**Fig. 2.** (A) Intraoperative O-arm surgical imaging system. (B) The user-interaction interface system.

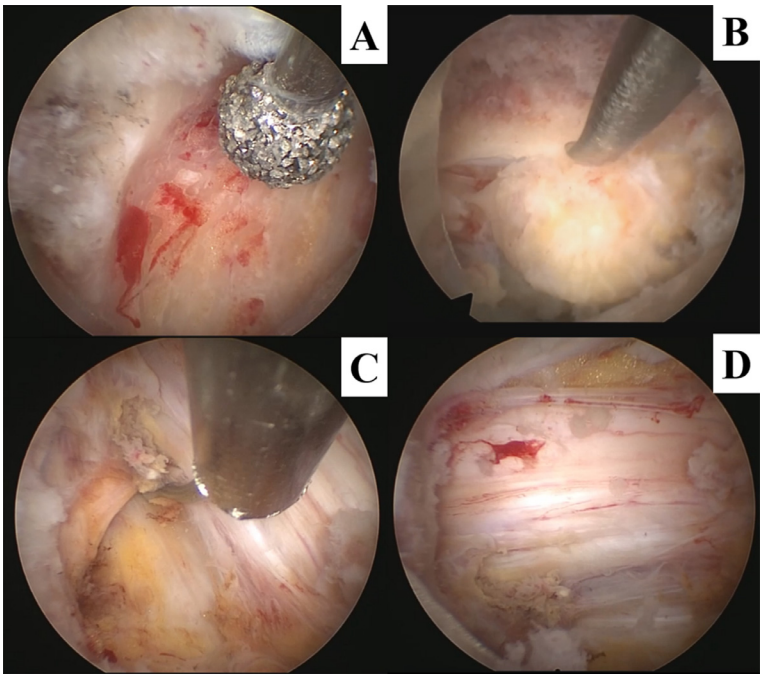


**Fig. 3.** Full-endoscopic visualization. (A) Removal of the base of the C7 spinous process with a diamond burr. (B) The synovial cysts were detected. (C) The tip of the nerve hook was used to check the activity of the axilla of the nerve root. (D) Final visualization after synovial cysts removal and nerve root decompression.

were then discovered (Fig. 3B). Kerrison punches cleaned the redundant tissue around the cysts, and the ventral adherent synovial cysts were meticulously dissection from the dura before resection with grasping forceps. The nerve root was then decompressed and confirmed with a nerve hook. The excrescent tissue was checked and removed with forceps and Kerrison punches to achieve adequate epidural decompression.

A working channel was then used to mildly retract the nerve root and decompress the ventral side of the nerve root (Fig. 3C). After careful hemostasis under bipolar coagulation. Free-floating of the dorsal dural sac was identified under the irrigation fluid which indicated sufficient decompression (Fig. 3D). The instrument was removed slowly to check hemostasis before the wound was sutured (Fig. 4A). No drainage is placed. Preoperative and intraoperatively right tibial SEP (Somatosensory evoked potentials) was not evoked and showed delayed latencies of left tibial SEP. There were no significant changes in SEP during the operation. Furthermore, the MEP (motor evoked potentials) was recorded in both upper extremities, but there was not recorded in both lower extremities. Also, there were no significant changes in MEP intraoperatively. Histological pathology suggested degeneration of synovial tissue with fibrosis and calcification.

### *Outcome*

The operation lasted 150 minutes, and the intraoperative blood loss was lower that could not be measured under continuous irrigation. No serious advent events such as wound healing disorders, infections, and cerebrospinal fluid fistulas were detected postoperatively. The synovial cysts were sufficiently removed, as confirmed by postoperative MRI. The integrity of the facet joints was reported to have been preserved in the postoperative CT scan three-dimensional reconstruction (Fig. 4B). The pain in the upper extremities decreased from VAS 8 to 2, and the muscle strength of the right lower extremities recovered from grade 2 to 4, with the left lower extremities recovered from grade 4 to 4+.

Two weeks after surgery, the patient had no neurologic symptoms with low-intensity physical activities. At the 3-month follow-up, the intervertebral height and spinal curvature were maintained, and motor power was adequately restored with minimal neck pain during daily activities. At the 1-year follow-up, the patient ambulated well with no complaints of arm pain and only occasional neck discomfort. Lateral X-ray revealed no signs of instability, and an MRI scan detected no sign of synovial cyst recurrence (Fig. 5).

## Discussion

Our report described the technology convergence of full-endoscopy with intraoperative O-arm navigation guidance for treating cervicothoracic acute hemorrhagic spinal synovial cysts. Previous literature reported that the most common diagnosis in subaxial cervical synovial cysts patients was C7/T1 [7–10]; however, the exact mechanism at the cervicothoracic junction of the synovial cysts remain debated in

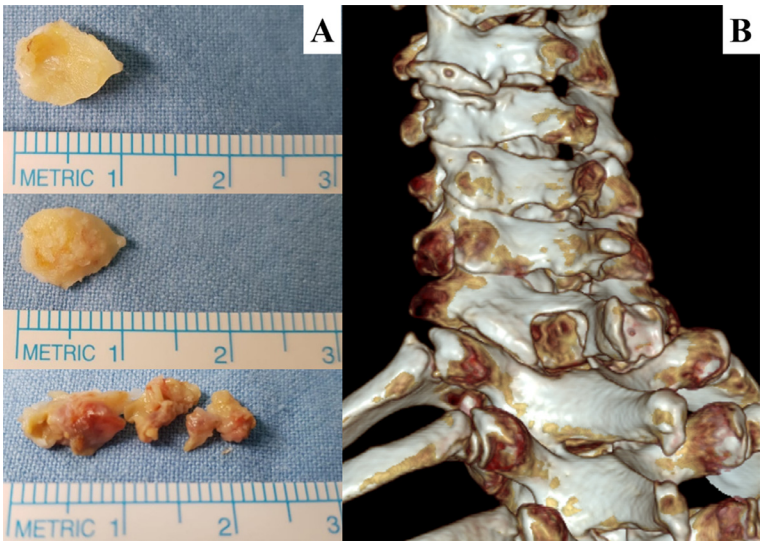


**Fig. 4.** Gross specimens. (A) Synovial cysts with a yellow hemispherical hollow hard shell, irregular tissue with hemorrhage. (B) Postoperative three-dimensional reconstruction.

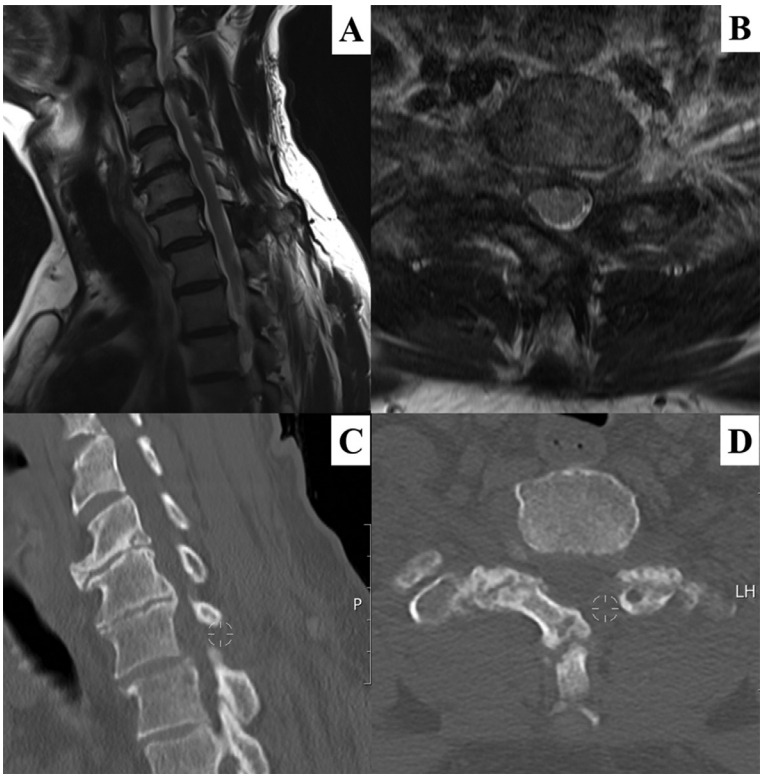


**Fig. 5.** Postoperative one-year follow-up MRI (A, B) and CT (C, D) scans. CT and MRI scans showed no evidence of instability and synovial cysts recurrence.

the literature. One of the speculations on the formation of the cysts were degenerative defect on the facet joints capsule due to severe stress loading on the transitional zones between the mobile and fixed segments. Moreover, the cause of acute clinical symptoms accompanied by hemorrhage change in synovial cysts may reason from the traumatic rupture or the venular vasculature of the degenerative synovium [7,10–15].

Our study also considers imaging differential diagnosis of ligamentum flavum cysts and synovial cysts. Synovial cysts show low signal intensity areas with smoothly circumscribed layers on T1- and T2-weighted MRI with calcification on CT [16–18]. To further ensure the diagnosis, intra-articular injection of contrast media for the histopathologic examination can be performed [14,19,20]. Furthermore, we found a gas-containing area between the spinal canal and the intervertebral disc beside the synovial cysts. The gas-containing area in the inner layer will push the posterior longitudinal ligament posteriorly. In our case, there was no evidence of an extruded ligament. Thus, we suspected that the gas was located posterior to the longitudinal ligament, and we also confirmed this in surgery.

In general, resection of the synovial cyst was using open or microsurgical surgery of hemilaminectomy or laminectomy with or without additional fusion. The majority of synovial cysts removal reported in the literature focused on the lumbar or cervicothoracic spine level [21–25]. As previous literature reports about the lumbar synovial cysts removal, the posterior endoscopic approach reduces the muscle denervation and decreases the risk of postoperative hematoma. It preserves the range of segmental motion and shortens the patient's recovery time [26,27]. We hope to transfer the above technical superiority to cervical spine

surgery. Our study conducted strict patient selection and meticulous surgical design. During surgery, only laminotomy was performed, and there was no aggressive facet joint resection. Furthermore, spinal instability was not detected with X-ray films. Clinical outcomes show no evidence of incomplete decompression postoperatively and no recurrence at the last follow-up.

As usual, overlapping anatomical structures are difficult to differentiate from the lateral view of image for less experienced physicians, especially at the cervicothoracic level, which provides shielding laterally by the shoulder joint [28,29]. Therefore, our team used the O-arm navigation system to provide real-time multiplane images so that surgeons could manipulate the instruments meticulously around the bony structures. Furthermore, the instrument-tip navigation was also used to control the instrument manipulation meticulously. It is worth noting that if the synovial cysts are located anterior to the facet joint, partial foraminotomy should be considered to enlarge the operation corridor. In our case, synovial cysts were closer to the adjacent joint space, making resection difficult without invasion of the facet joint. Because our patient also has mild spondylolisthesis, the integrity of facet joints was preserved to the greatest extent. Furthermore, the O-arm navigation systems reduced radiation exposure to the surgeons. Generally, surgeons positioning outside when performing O-arm system scan reduce radiation exposure compared to intraoperative C-arm fluoroscopy [30,31]. Even though the O-arm system will cause higher radiation exposure to the patient, it produces a high-quality intraoperative image compared to C-arm, especially at the cervicothoracic level, and decreases the risk of neurological deficits due to accidental misidentification by surgeons [32,33].

A clear enlarged surgical field provided by the characteristics of full-endoscopic illumination and visualization systems gives assurance to surgeons. The full-endoscopic system is designed to have the perfect flow control of saline irrigation; theologically, the chance of pressure-related complications on the spinal cord is extremely low except in the case of accumulation of blood or saline after the procedure. From a surgeon's perspective, the inner layer of ligamentum flavum is always kept until the bony decompression is finished. This minimizes the time that the spinal cord is exposed to continuous saline irrigation during the endoscopic procedure. By this kind of surgical tip, same in the lumbar endoscopic laminotomy, pressure change does not influence the safety issue. Moreover, we monitored the patient with the neuro-monitoring system. Even with that, the endoscopic procedure should not be too long to prevent pain induced by decreased compliance of the dural sac. Therefore, the irrigation pump should intermittently turn off to calm the epidural fluid pressure down during imaging scanning or extended surgical operations.

If you have never used an endoscopy system before, you might be in for a steep learning curve with anatomical localization and instrumental manipulation. It is remarkable that O-arm navigation is an effective tool to flatten the learning curve and decrease the severe conditions operated by novices. Also, inexperienced surgeons are recommended to attend seminars and select the appropriate patients as they gain experience. In our case, the operation was operated by senior endoscopic surgeon and lasted only approximately 150 minutes to remove this complicated case, including the time of the O- arm navigation system setting. We believe that the surgical time will be further decreased with the increasing number of cases.

The main limitation of this study is that it is a single case report. Second, the cost of the O-arm is relatively high, but with the reformation of the policies regarding commodity pricing and health insurance, the navigation system will gradually spread. Furthermore, a comparative analysis study with large sample size is necessary to further verify the feasibility of this technology compared with conventional surgery. Despite the limitations mentioned above, the primary purpose of our study is to illustrate the feasibility of full-endoscopic surgery for the removal of cervicothoracic complex synovial cysts, and the surgical technique is worth being promoted in select groups of patients.

## Conclusions

Full-endoscopy with intraoperative O-arm navigation guidance improves precision and safety in treating patients with synovial cysts of the cervicothoracic spine. The O-arm navigation system improves the efficiency and safety of intraoperative positioning at the cervicothoracic lesion and reduces radiation exposure to the surgeons. Meanwhile, our technique preserves the range of cervicothoracic motion and facilitates the patient return to normal life. It should be noted that less experienced surgeons are recommended to be supervised by attending surgeons to operate with the full-endoscopy technique.

## Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

## Funding

None.

## Declaration of Competing Interests

The corresponding author, Jin-Sung Kim, is a consultant of Richard Wolf, GmbH, and Elliquence, LLC. The other authors have no conflicts of interest to declare.

## Patient Informed Consent Statement

Complete written informed consent was obtained from the patient for the publication of this study and accompanying images.

## Acknowledgments

None.

## Supplementary materials

Description of supplementary video: The video describes the step-by-step workflow to remove the cervicothoracic gas-containing synovial cysts under full-endoscopy guided by O-arm navigation in a 71-year-old male patient. Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.xnsj.2022.100133.

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