

Adjacent Segment Disease Occurred in Cervical Spine Due to Trauma Rather Than Degeneration: Observation from Skeletal Scintigraphy in a Case of Tetraplegia

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Abstract

Cervical adjacent segment disease (ASD) is a symptomatic condition that may occur after cervical spine surgery, accounting for approximately 6% of cases requiring a second surgery. However, some cases may lack abnormal radiographic findings, complicating both the diagnosis and treatment planning. We present the case of a 66-year-old male who developed cervical ASD following anterior cervical discectomy and fusion performed due to a traffic accident. The diagnosis was made using single-photon emission computed tomography/computed tomography (SPECT/CT), which disclosed increased uptake in the C3 to C7 vertebral bodies. We suggest that SPECT/CT should be considered for patients presenting with pain following cervical spine surgery to achieve a more accurate diagnosis of ASD.

Keywords: Adjacent Segment Disease, SPECT/CT, Spinal Cord Injury, Cervical Spine, Anterior Cervical Discectomy and Fusion, Scintigraphic Rehabilitation, Adjacent Segment Degeneration

Introduction

Adjacent segment disease (ASD), accountable for almost half of all revision spine surgeries, arises from the degeneration of segments adjacent to a previously operated site [1]. With a global prevalence of 13.34% and an annual increase of 1.43%, ASD following cervical spine surgery causes considerable distress for both patients and surgeons, with 5.78–6.57% of cases requiring a second surgery [2,3]. Unlike ASD, adjacent segment degeneration is solely a radiographic diagnosis, characterized by imaging findings without accompanying symptoms [1]. Consequently, the standard approach to diagnosing ASD prioritizes the identification of clinical symptoms, followed by radiographic imaging to confirm potential structural abnormalities. Most ASD cases are initially managed conservatively unless magnetic resonance imaging (MRI), computed tomography (CT), or flexion-extension radiographs indicate myelopathy or neurological deficits, which may then prompt surgical intervention [4]. In certain cases, stimulation of cervical cord is also considered a viable treatment option [5].

The total number of spine surgery has been calculated around four to five hundred thousand per year in America [6]. As the incidence of spinal disorder continues to increase in an aging population, the amount of elective inpatient lumbar fusions has increased by 62% from 2004 to 2015 [7].

Compared to lumbar ASD, cervical ASD remains less extensively studied, and guidelines for follow-up care are less established. Key differences exist between cervical and lumbar ASD. For example, the incidence of lumbar ASD requiring a secondary surgery is reported at 22.2% over a ten-year period [8]. Additionally, biomechanical differences between cervical and lumbar regions present distinct risk factors for ASD at each site [1,9]. Panjabi and White [10] have demonstrated that lumbar spine vertebrae can sustain physiological compression loads up to four times greater than those in the cervical spine, while the cervical spine—particularly at the C1–C2 level—can tolerate up to ten times more axial rotation than the lumbar spine. These findings underscore the need for further research to refine diagnostic and evaluative approaches for cervical ASD.

Single-photon emission computed tomography/computed tomography (SPECT/CT), which merges the sensitivity of SPECT with the anatomical precision of CT, shows promise as a central tool in clinical practice [11-13]. Despite its potential, reports on the use of SPECT/CT specifically for evaluating cervical ASD are limited. Currently, MRI and CT remain the standard imaging modalities for cervical ASD [4]. Recent studies by Mesregah et al. [14] have identified several key radiographic risk factors in patients post-anterior cervical discectomy and fusion (ACDF). Nevertheless, some ASD cases lack adequate radiographic evidence for a definitive diagnosis [15]. In this report, we present a case of a male patient with cervical spine trauma who, following ACDF, was diagnosed with ASD using SPECT/CT rather than conventional CT or MRI.

Case Presentation

A 66-year-old male with robust in the past was involved in a vehicle accident on May 3, 2024, in which he was struck by a car while riding a motorcycle, leading to an immediate loss of consciousness. He was transported to the hospital, where cervical spine CT revealed a flexion teardrop fracture at C3 with retrolisthesis, spinal stenosis, and myelopathy at C3/4. On May 4, 2024, he underwent an anterior C3/4 discectomy with cage and plate fusion. Following inpatient rehabilitation and post-operative care, he was referred to our outpatient department for continued rehabilitation and was admitted on August 27, 2024, for further evaluation and therapy.

Upon admission, he was alert with stable vital signs, presenting with complete tetraplegia, cervical pain and left shoulder pain. He reported frequent lower limb spasms, resulting in swelling and discomfort. The patient was maximally dependent on bed mobility and required a wheelchair for mobility.

Laboratory tests and imaging studies were arranged, and consultations were made with physical therapy, occupational therapy, and traditional Chinese medicine specialists. Laboratory results indicated a normal hemogram, controlled lipid and glucose levels, and no rheumatologic abnormalities. Cervical spine X-ray confirmed C3-C4 fixation with a cage from C3 to C6 (Figure 1). SPECT/CT demonstrated increased uptake in the cervical and lumbar spine, notably from C3 to C7 (Figure 2), as well as in the appendicular joints, likely due to arthritis. During hospitalization, the patient reported sensations of cold without fever, suggestive of poikilothermia. He also experienced dysphagia, prompting initiation of swallowing rehabilitation. Left shoulder pain was noted; however, shoulder X-ray showed no fractures, dislocations, or internal humeral rotation limitations.

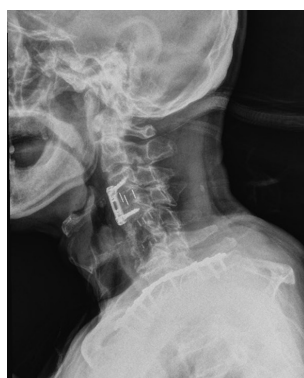


Figure 1. X-ray films of cervical spine with C3-C4 fixation and cage fusion.

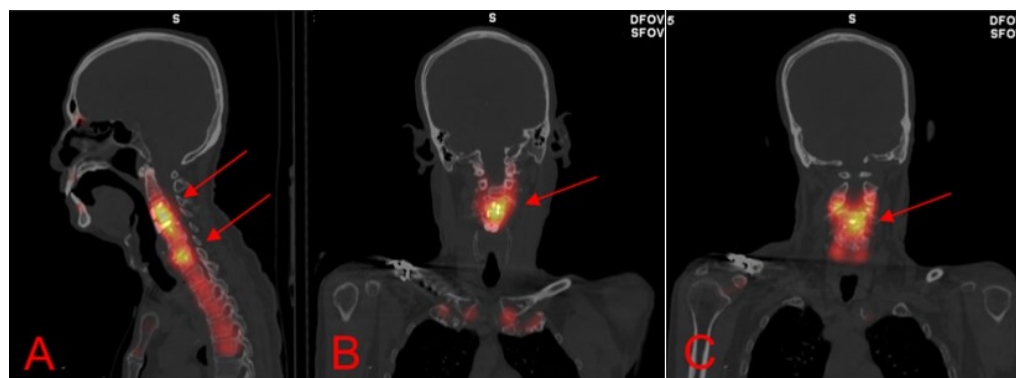


Figure 2. The SPECT/CT imaging of the cervical spine. The film reveals distinct scintigraphic activity marked by areas of increased uptake, highlighted as red focal loci specifically at levels C3 to C7 (arrow), in sagittal view (A) and coronal view (B, C).

On October 22, 2024, he was readmitted for a second evaluation. Sensory testing revealed intact pinprick and light touch sensation at the C2 dermatome bilaterally. Sensory impairment began at the right C3 and left C4 dermatomes, establishing the sensory level at C2 on the right and C3 on the left. Manual muscle testing demonstrated grade 3 strength in elbow flexors, with no muscle strength exceeding grade 2 below the C6 myotome bilaterally. The muscle tone was increased in all four limbs. Digital rectal examination confirmed positive deep anal pressure and voluntary anal contraction. He was diagnosed with a flexion teardrop fracture at C3 resulting in spinal cord injury, with motor-incomplete C2 tetraplegia classified as ASIA Impairment Scale C. Bowel function remained continent; however, a Foley catheter was necessary due to neurogenic bladder. The patient could eat and drink with assistance, though he reported persistent cervical spine pain, particularly when lying flat, which corresponded to increased uptake in the C3 to C7 vertebral bodies on SPECT/CT.

Discussion

This case involves a patient who developed cervical ASD following ACDF performed due to a motor vehicle accident, rather than degeneration, with persistent cervical spine pain as his primary complaint. Initial cervical X-ray findings were unremarkable. However, further evaluation with SPECT/CT revealed increased uptake in the C3 to C7 vertebral bodies, suggesting ongoing inflammation within the cervical spine.

Cervical spine ASD post-surgery is relatively uncommon, with a global prevalence of 13.34% and an annual increase of 1.43% [2]. MRI or CT are typically used to identify definitive signs of myelopathy or neurological deficits in suspected cases of ASD. Koppula et al. [16] highlighted the role of SPECT/CT in evaluating skeletal pathology, particularly in oncology, extremity assessment, spinal pain due to degenerative disorder, and failed back surgery syndrome; sadly, its use in cervical ASD was not specifically addressed. Recently, Mesregah et al. [14] reported several radiographic factors contributing significant risk for ASD after ACDF, including reduced post-operative cervical lordosis, increased changes in cervical sagittal alignment pre- and post-operation, and congenital cervical canal stenosis. Furthermore, a latest study utilized SPECT/CT in patients undergoing ACDF by comparing pre- and post-operative visual analog scores in patients with positive versus negative preoperative SPECT/CT findings, and demonstrated that SPECT/CT is a tough predictor of pain and may aid in guiding fusion decisions [17].

SPECT/CT is a powerful hybrid imaging modality with combination of the diagnostic sensitivity of SPECT and the anatomical precision of CT, allowing for more accurate diagnostic clarity in complex cases such as this one [18-25]. Ahn et al. [15] demonstrated that there is no significant differences in neck and arm pain between patients with radiographically confirmed adjacent segment degeneration and those without, supporting the notion that some ASD cases may lack abnormal radiographic findings. Additionally, SPECT/CT's vivid imaging provides a more intuitive and detailed depiction compared to standard radiographic findings in the field of scintigraphic rehabilitation.

Numerous risk factors for cervical ASD have been identified. The relative risk of ASD development has been confirmed lowest at the C2/C3 and cervicothoracic interspace levels; by comparison, the risk is 4.9 times higher at the C5/C6 and C6/C7 levels and 3.2 times higher at the C3/C4 and C4/C5 levels [26]. A study enrolled 672 patients with ACDF disclosed a 7.1% reoperation rate due to ASD, which results confirmed that factors such as age, sex, body mass index, cigarette exposure, symptoms, number of segments fused, distance of plate-to-disc, and type of graft did not significantly affect reoperation rates [27]. In a study of 60,292 patients undergoing cervical decompression, Shahzad et al. reported a 6.57% rate of ASD requiring reoperation, with the incidence peaking at 8.12% among those aged 30 to 39, followed by a decline with advancing age. Independent risk factors included cervical disc disorder, cervical spondylosis, and multilevel surgery, especially for those in their 40s to 60s [3]. Baram et al. [28] examined 507 cases receiving ACDF for degenerative cervical myelopathy and noted that ASD developed in 14 cases, particularly among patients with preexisting degenerative changes (Pfirrmann grade ≥ 2). However, many recent studies—such as those by Mesregah et al., Garcia et al., and Baram et al.—exclude traumatic cases, complicating the evaluation of cervical ASD diagnosis and prognosis.

The mechanisms underlying cervical ASD are multifactorial. Two previous studies documented elevated internal stress at adjacent segments following spinal fusion [29], and a 20% elevation in shear strain at adjacent segments one year after ACDF [30]. A following study demonstrated a considerable increase in segmental motion and intradiscal pressure at adjacent levels after fusion, even though the range of motion remained normal, which may accelerate the degenerative process [31].

A recent investigation comparing fusion with two levels and single levels showed a 13.68% decrease in range of motion (ROM), along with increases in stiffness during extension and flexion by 37% and 31%, respectively, suggesting patients with multi-level fusion requiring more effort to achieve the same ROM as those with single-level fusion [32]. In contrast, however, a prior study showed a significantly inferior risk of developing ASD in multi-level arthrodesis (12%) compared to single-level fusion (18%) [26]. Furthermore, a study reported no significant difference in the incidence of ASD between cases who received ACDF and those who accepted cervical disc arthroplasty, a procedure that preserves the native ROM [33].

Additionally, the health of adjacent levels may influence the risk of cervical ASD. Lee et al. found a higher proportion of adjacent segment degeneration in cases who underwent fusional operation for degenerative conditions compared to those with congenital fusion [34]. Based on these evidence, we propose that the health of the adjacent segment plays a crucial role in the development of ASD. Regardless of whether the fusion is single-level or multi-level, the surgical procedure itself may accelerate the aging process. Furthermore, post-surgical ROM might play a more important role than internal stress in the development of ASD, because the restriction of ROM in adjacent segments following multi-level fusion might serve as a protective factor against ASD, as it reduces the risk of unintentional overexertion to achieve angles achievable in a healthy cervical spine. This passive restriction effectively reduces multidirectional forces on adjacent segments compared to single-level fusion, potentially limiting abnormal loading that could alter cytokine levels and trigger inflammatory cascades leading to matrix remodeling and osteoarthritis [35]. However, this hypothesis requires further investigation to be validated.

Limitation

This case report has two limitations. First, the lack of similar cases for comparison means that the sensitivity and specificity of SPECT/CT in diagnosing cervical ASD remain unclear. Second, we did not have CT or MRI results for direct comparison with the SPECT/CT findings, and the correlation between CT/MRI and SPECT/CT results warrants further investigation.

Conclusion

Cervical ASD, which may lack radiographic findings, can be highly frustrating for both patients and physicians. In this case, SPECT/CT enabled us to diagnose cervical ASD following trauma-related ACDF, demonstrating a straightforward approach to identifying a complex condition. We recommend SPECT/CT for patients experiencing pain after cervical spine surgery when standard radiographic findings are inconclusive, as it may provide a more accurate diagnosis.

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