Human Pathology (2020) **103**, 14–24

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Human PATHOLOGY

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Original contribution

# Paraspinal pseudoneoplasms: a series of 58 consultation cases emphasizing the importance of pathology-radiology correlation ☆

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Received 28 May 2020; revised 6 July 2020; accepted 7 July 2020

Available online 15 July 2020

**Keywords:**
Herniated disc;
Intervertebral disc histology;
Paraspinal pseudoneoplasm;
Synovial cyst;
Compression fracture;
Pathology–radiology correlation

**Summary** A variety of non-neoplastic diseases of the spine, including herniated/sequestered intervertebral discs, synovial cysts, and degenerative or post-traumatic changes, may present as mass lesions. Over the past several years, we have seen a large number of such paraspinal pseudoneoplasms in consultation, referred out of concern for malignancy on the part of the clinician, pathologist, or both. Herein, we report our experience with these specimens, emphasizing the clinical, radiologic, and histopathological features that allow their confident distinction from various mesenchymal tumors. Fifty-eight cases were identified within our consultation archives, referred in consultation to exclude malignancy and diagnosed as non-neoplastic disease involving the intervertebral disc, ligamentum flavum, or paraspinal soft tissues (2006–2019). Available radiologic studies were reviewed by 2 musculoskeletal radiologists. The histologic features of all cases were re-evaluated. Available clinical records were reviewed. The masses occurred in adults (median age 62 years, range 20–86 years) with a male predominance (35 males and 23 females). Sites included lumbar spine ($N = 33$), thoracic spine ($N = 15$), cervical spine ($N = 6$), paraspinal region ($N = 3$), and sacral spine ($N = 1$). In 44 cases (76%), the referring pathologist regarded the specimen as representing a benign or malignant neoplasm, either primary or metastatic. Fifteen cases (26%) were sent for second opinion at the request of the treating clinician, following an initial malignant diagnosis. Advanced imaging studies were available for review in 37 cases (64%) and showed herniated/extruded disc ($N = 17$), compression fracture ($N = 9$), synovial cyst ($N = 8$), and degenerative joint disease ($N = 7$). Multiple radiologic findings were seen in 9 patients. Histologically, the specimens showed a spectrum of often florid reactive changes involving degenerating disc material, ligamentum flavum, and bone. Awareness that non-neoplastic spinal processes may form pseudoneoplastic mass lesions, and careful clinical-radiologic-pathologic correlation should allow their confident distinction from potential morphologic mimics.
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☆ Disclosures: None.

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https://doi.org/10.1016/j.humpath.2020.07.012
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## 1. Introduction

Non-neoplastic disorders of the spine and paraspinal soft tissues are common, especially in older adults, and include changes related to degenerative arthritis, intervertebral disc-related problems such as herniated or sequestered discs, post-traumatic lesions including fracture, and facet joint-associated conditions such as synovial cyst. In most instances, these various spinal and paraspinal conditions are readily recognized by the astute clinician and radiologist and thus do not come to the attention of surgical pathologists. However, on occasion, these disorders may present as mass lesions mimicking neoplasms and undergo biopsy or excision with pathological evaluation.

Over the past several years, we have seen in consultation a considerable number of such paraspinal pseudoneoplasms, referred out of concern for malignancy on the part of the clinician, pathologist, or both. Anecdotally, our impression has been that a significant percentage of these cases were sent in consultation either because of a lack of clinical-radiologic-pathologic correlation at the referring institution, lack of familiarity by pathologists with the normal histology of the intervertebral discs and paraspinal ligaments, or both (Fig. 1). Although most pathologists are well aware of the importance of pathologic-radiologic correlation in the diagnosis of bone tumors, this seems to be less emphasized for paraspinal lesions. Furthermore, although the orthopedic and radiology literature is replete

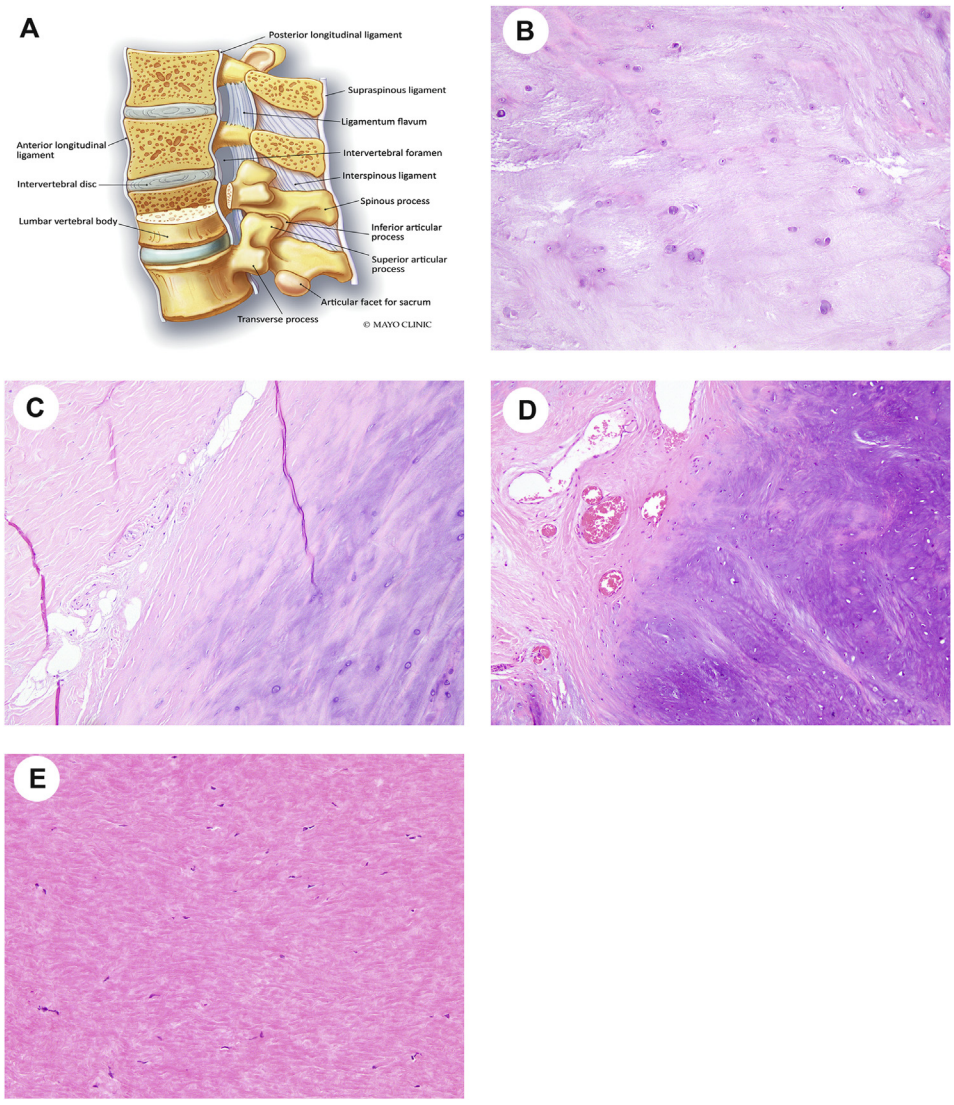


**Fig. 1** The anatomy of the vertebral column is complex. Tissues from this region that may come to the attention of the surgical pathologist include the intervertebral disk, the facet joint, bone, and various ligaments, including the ligamentum flavum (A). Normal components of the intervertebral disc include the nucleus pulposus (B), the annulus fibrosum (C), and the cartilaginous end-plate (D). The ligamentum flavum is notably hypocellular and has a distinctive, somewhat lamellar architecture (E).

**Table** Studied cases, with referral and final diagnoses.

| Case number | Age/ Sex | Site | Contributors' suggested diagnosis | Final diagnosis after radiology-pathology correlation |
|---|---|---|---|---|
| 1 | 72 F | Lumbar | "Atypical cartilaginous proliferation" | Disc with reactive changes |
| 2 | 53 M | Thoracic | "Epidural tumor" | Spinal ligament and disc with reactive changes |
| 3 | 83 F | Lumbar | Not given | Compression fracture |
| 4 | 86 M | Thoracic | "Spindle cell neoplasm" | Disc with reactive changes |
| 5 | 57 M | Lumbar | "Spindle cell neoplasm" | Synovial cyst, spinal ligament, and disc with reactive changes |
| 6 | 56 M | Lumbar | Chondrosarcoma | Herniated disc |
| 7 | 44 M | Thoracic | "Chondro-osseous lesion" | Non-neoplastic bone and spinal ligament with reactive changes |
| 8 | 47 M | Lumbar | Chondrosarcoma | Compression fracture |
| 9 | 73 F | Lumbar | "Chondroid neoplasm" | Herniated disc with florid reactive changes |
| 10 | 51 M | Cervical | "Chondroid neoplasm" | Spinal ligament and disc with reactive changes |
| 11 | 51 M | Thoracic | "Chondroid neoplasm" | Herniated disc |
| 12 | 41 F | Cervical | Metastatic carcinoma | Spinal ligament and disc with reactive changes |
| 13 | 55 F | Lumbar | "Chondroid neoplasm" | Herniated disc into compression fracture |
| 14 | 62 F | Thoracic | "Chondroid neoplasm" | Herniated disc into compression fracture |
| 15 | 59 F | Lumbar | Chondrosarcoma *vs* chondroma *vs* chordoma | Herniated disc with florid reactive changes |
| 16 | 20 M | Lumbar | Osteoblastoma *vs* metastasis | Facet joint tumoral calcinosis |
| 17 | 59 F | Lumbar | "Sarcoma" | Herniated disc with florid reactive changes |
| 18 | 58 M | Sacrum | "Chondro-osseous lesion; rule out malignancy" | Non-neoplastic bone and disc |
| 19 | 74 F | Lumbar | Discitis *vs* osteomyelitis | Disc with reactive and degenerative changes |
| 20 | 36 M | Lumbar | "Reactive disc and fracture; rule out malignancy" | Herniated disc into compression fracture |
| 21 | 73 F | Lumbar | Chondrosarcoma | Synovial cyst, spinal ligament, and disc with reactive changes |
| 22 | 67 M | Thoracic | Pigmented villonodular synovitis *vs* meningioma *vs* vascular tumor | Synovial cyst, spinal ligament, and disc with reactive changes |
| 23 | 86 M | Thoracic | Not given | Compression fracture |
| 24 | 69 F | Cervical | "Spindle cell neoplasm" | Spinal ligament and disc with reactive changes |
| 25 | 84 M | Thoracic | Chondrosarcoma | Compression fracture |
| 26 | 69 F | Lumbar | "Chondroid neoplasm" | Compression fracture |
| 27 | 47 M | Thoracic | Osteoid osteoma *vs* osteoblastoma | Bone, spinal ligament, and disc with reactive changes |
| 28 | 70 M | Lumbar | "Epidural mass" | Disc with reactive changes |
| 29 | 69 F | Paraspinal | "Chondroid neoplasm" | Herniated disc |
| 30 | 85 M | Paraspinal | Chordoma | Herniated disc |
| 31 | 69 F | Paraspinal | Myxoma *vs* myxoid chondroma | Herniated disc |
| 32 | 62 M | Lumbar | Chordoma *vs* chondroma | Herniated disc |
| 33 | 83 M | Thoracic | "Spindle cell neoplasm" | Compression fracture |
| 34 | 31 M | Cervical | Phosphaturic mesenchymal tumor | Compression fracture |
| 35 | 46 M | Thoracic | Fibrosarcoma *vs* fibromatosis | Spinal ligament and disc with reactive changes |
| 36 | 46 F | Lumbar | "Benign degenerative fibrocartilage" | Disc with reactive changes |
| 37 | 60 F | Lumbar | "Extradural mass" | Herniated disc |
| 38 | 47 M | Lumbar | "Giant cell rich neoplasm within synovial cyst" | Pseudocyst involving spinal ligament and disc with reactive changes |
| 39 | 51 M | Thoracic | Not given | Herniated disc and synovial cyst |

**Table** (*continued*)

| Case number | Age/ Sex | Site | Contributors' suggested diagnosis | Final diagnosis after radiology-pathology correlation |
|---|---|---|---|---|
| 40 | 64 M | Lumbar | Chordoma | Herniated disc with florid reactive changes |
| 41 | 72 F | Lumbar | Osteomyelitis *vs* fracture | Discitis |
| 42 | 75 M | Cervical | Hemangioma *vs* aneurysmal bone cyst | Discitis |
| 43 | 63 F | Thoracic | "Epidural mass" | Herniated disc |
| 44 | 44 M | Lumbar | Chordoma *vs* extraskeletal myxoid chondrosarcoma *vs* chondrosarcoma | Herniated disc with reactive changes including cyst formation |
| 45 | 54 M | Lumbar | "Atypical cartilaginous proliferation" | Herniated disc |
| 46 | 52 F | Lumbar | Not given | Synovial cyst |
| 47 | 72 M | Thoracic | Chondrosarcoma | Disc with reactive changes |
| 48 | 53 F | Cervical | "Cannot exclude neoplasm" | Disc with reactive changes |
| 49 | 60 M | Lumbar | "Nerve sheath tumor" | Herniated and sequestered disc with florid reactive changes |
| 50 | 38 F | Lumbar | Giant cell tumor of bone | Disc with reactive changes |
| 51 | 78 F | Thoracic | Metastatic carcinoma | Compression fracture |
| 52 | 51 F | Lumbar | "Intraspinal extradural mass" | Herniated disc and synovial cyst |
| 53 | 65 M | Lumbar | "Benign cystic lesion" | Herniated disc and synovial cyst with florid reactive changes |
| 54 | 76 M | Lumbar | "Atypical myxoid lesion with giant cells" | Herniated disc and synovial cyst with florid reactive changes |
| 55 | 80 M | Lumbar | "Cannot exclude neoplasm" | Herniated disc |
| 56 | 73 M | Lumbar | Chondrosarcoma | Herniated disc into compression fracture |
| 57 | 70 M | Lumbar | Chondrosarcoma | Herniated disc into compression fracture |
| 58 | 75 M | Lumbar | Not given | Herniated disc |

Abbreviations: M, male; F, female.

with reports of non-neoplastic paraspinal lesions mimicking tumors, information on this subject in the pathology literature is quite sparse.

Herein, we review our experience with paraspinal pseudoneoplasms sent in consultation, emphasizing the critical importance of careful clinical-radiologic-pathologic correlation, and familiarity with the morphology of this region, in their distinction from potentially more ominous mesenchymal neoplasms.

## 2. Materials and methods

The approval for this study was granted by the Mayo Clinic Institutional Review Board. The consultation archives of the senior author (A.L.F.) were searched for non-neoplastic cases coded as "herniated intervertebral disc", "spinal", or "paraspinal" for the period 2006–2019, yielding 83 cases. These cases comprised approximately 17% of the roughly 500 vertebral or paraspinal consultation cases seen during this time period. On re-review, 25 cases were excluded either for insufficient material or because pathologic-radiologic correlation strongly suggested a nondiagnostic biopsy or sampling error, leaving a final study population of 58 cases. Demographic and clinical information was obtained from the contributing pathologist or clinician. All available slides were re-reviewed (J.M.G, A.L.F) and relevant radiologic imaging studies were re-reviewed by two experienced musculoskeletal radiologists (B.M.H, S.M.B). Contributors' suggested diagnoses were recorded, when available.

## 3. Results

Table summarizes the clinicopathologic and radiologic findings and submitting diagnoses for the 58 studied cases.

### 3.1. Clinical features and suggested diagnoses

The masses occurred in 35 males and 23 females (M:F = 3:2), ranging from 20 to 86 years of age (median: 62 years of age; males 60 years, females 63 years). Sites included lumbar spine ($N = 38$), thoracic spine ($N = 11$), cervical spine ($N = 6$), psoas region ($N = 2$), and sacral spine ($N = 1$). Thoracic lesions were more common in males (M:F = 12 cases:3 cases); no differences were noted in cervical (M:F = 3 cases:3 cases), lumbar (M:F = 18 cases: 15 cases), sacral (M:F = 1 case: 0 cases), or "paraspinal" (M:F = 1 case: 2 cases) locations.

In 44 cases (76%), the specimens had been submitted to the original pathologist with a clinical impression of "neoplasm", "tumor", "mass", or "lesion". Fifty-three cases (91%) were submitted with a contributor diagnosis or impression, including cartilaginous tumor ($N = 20$), "spindle cell neoplasm" ($N = 4$), giant cell tumor of bone ($N = 4$), chordoma ($N = 5$), myxoid neoplasm ($N = 3$),

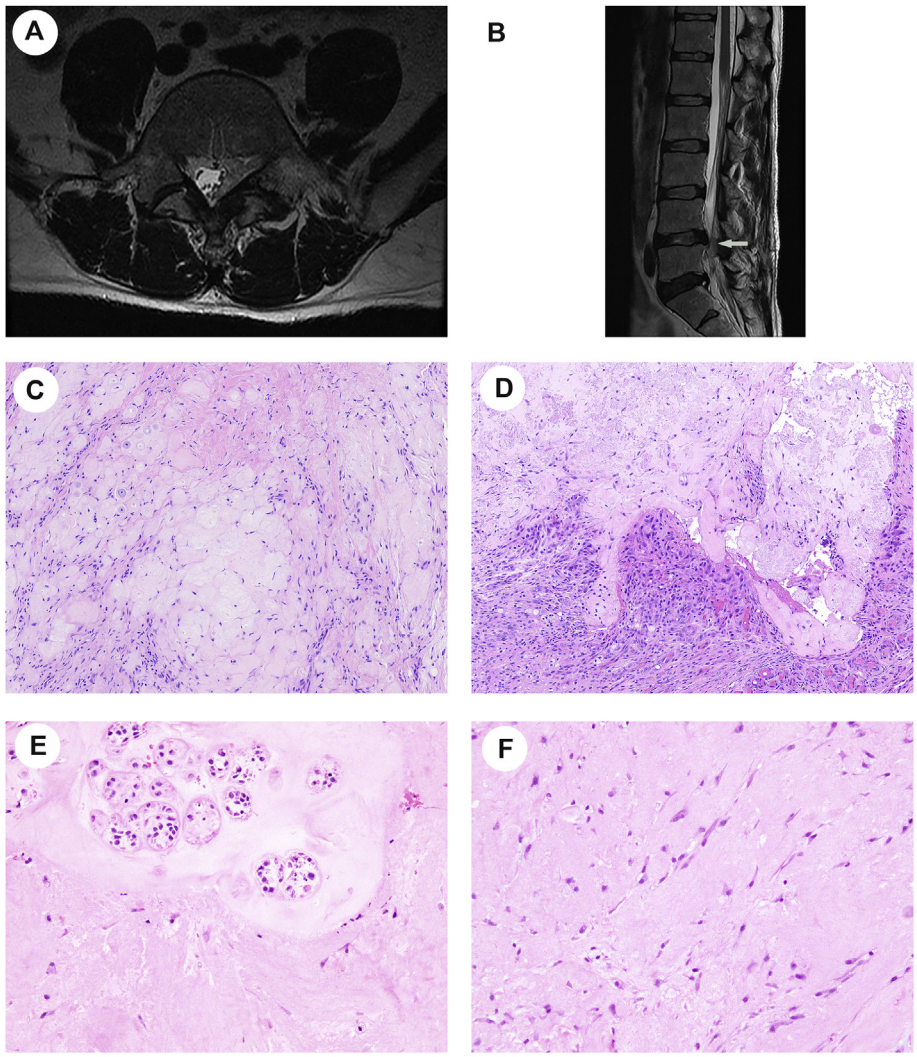


**Fig. 2** Axial (A) and sagittal (B) T2-weighted images demonstrate a mass in the left lateral central canal that causes mass effect on the thecal sac (arrows). There is an L5-S1 disc annular tear (B, arrowhead) with decrease in the nucleus pulposus signal. Findings are consistent with a posteriorly extruded disc fragment. Herniated intervertebral disc, consisting of small islands of hyalinized, degenerating nucleus pulposus, scattered viable chondrocytes within lacunae, and proliferating small capillaries (C). At the periphery, degenerating disc fragments may evoke a highly cellular capillary and myofibroblastic proliferation, simulating chondromyxoid fibroma or even dedifferentiated chondrosarcoma (D). Reactive cartilage within degenerating disc showing chondrocyte clustering and containing many chondrocytes within individual lacunae, a feature easily misinterpreted as representing the hypercellularity and bi-nucleation seen in chondrosarcoma (E). Myxoid change within a degenerating disc may simulate the "cord and chain" patterns of myxoid chondrosarcoma or chordoma (F).

vascular neoplasm ($N = 2$), metastatic carcinoma ($N = 2$), osteogenic neoplasm ($N = 2$), and others. In 15 instances (26%), the specimen was sent for second opinion at the request of the treating clinician, after a malignant diagnosis had been rendered by the original pathologist.

Immunohistochemical studies for various markers, including keratins, S100 protein, glial fibrillary acidic protein, smooth muscle actins, epithelial membrane antigen, CD31, and CD34 had been performed in an ad-hoc fashion at the referring institutions in 17 (30%) cases; in some cases, numerous immunostains were performed.

### 3.2. Radiologic findings

In almost all instances, available radiologic studies had been previously reviewed by Mayo Clinic musculoskeletal radiologists as part of the original consultation, although a detailed description of the radiologic findings was generally not included in the final pathology report. Advanced imaging studies (magnetic resonance imaging [MRI] and computed tomography) were available for re-review in 37 cases (64%). Imaging findings were consistent with a herniated/extruded disc ($N = 15$), compression fracture

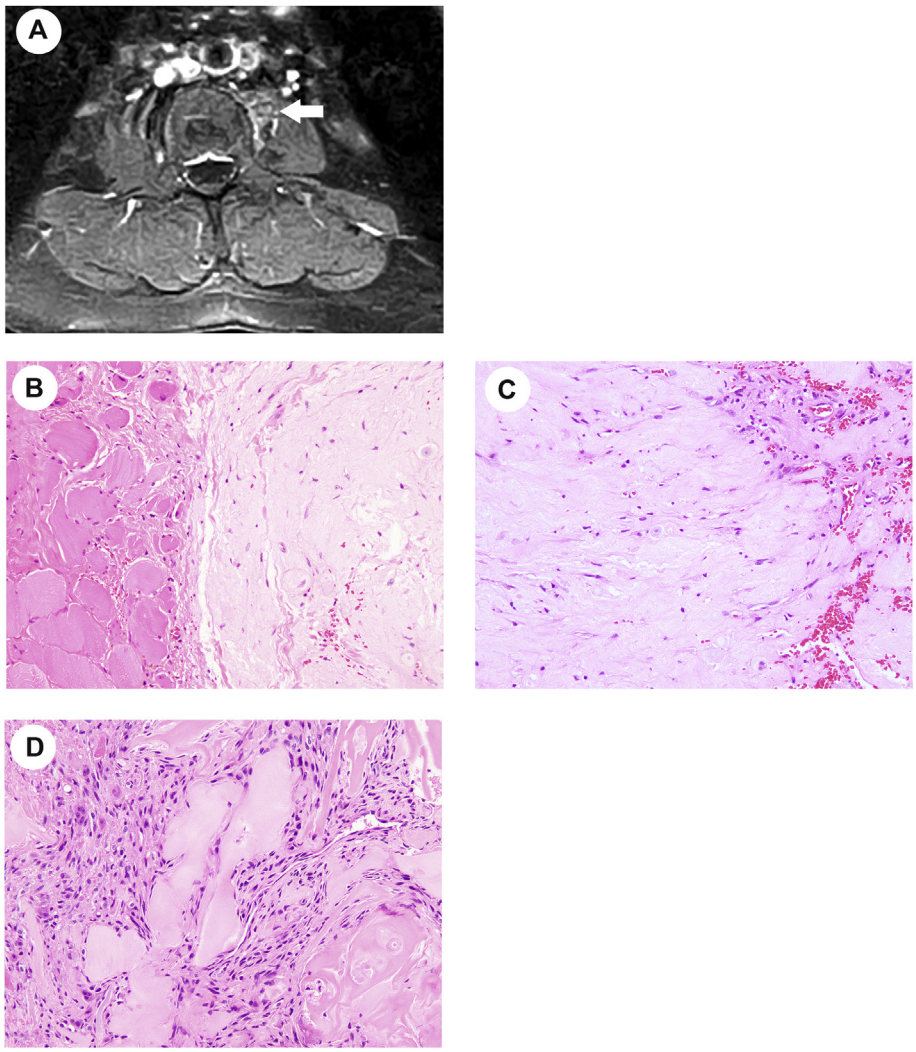


**Fig. 3** Axial T1-weighted, postcontrast MRI (A) demonstrates a heterogeneously enhancing left paraspinal mass associated with the psoas muscle (arrow), found to be a lateral disc herniation. Extreme lateral disc herniation, with extrusion of disc material into adjacent skeletal muscle, simulating chondrosarcoma (B). Florid capillary ingrowth into herniated discs may simulate angiosarcoma, although close inspection discloses well-formed vessels without endothelial atypia (C). "End-stage" herniated disc, with minute islands of hyalinized nucleus pulposus surrounded by capillaries and myofibroblasts (D). MRI, magnetic resonance imaging.

($N = 10$), synovial cyst ($N = 8$), intervertebral disc "bulge" ($N = 5$), and degenerative facet joint disease ($N = 4$). Multiple findings were present for 9 patients (eg herniated disc with associated fracture). The imaging features of posterior disc herniation, lateral disc herniation, disc material extruded into a vertebral body, synovial cyst, and compression fracture are illustrated in Figs. 2A and B, 3A, 4A and B, 5A, and 6A, respectively.

### 3.3. Pathologic findings

The great majority of submitted cases (53/58, 91%) consisted at least in part of intervertebral disc material, typically showing a variety of reactive changes, including capillary proliferation (sometime florid), "fasciitis-like" zones of mitotically active myofibroblastic ingrowth, myxoid stromal change, chondrocyte clustering, chondrocyte nuclear enlargement, and the presence of lacunae containing more than a single chondrocyte (often misinterpreted as representing bi-nucleated chondrocytes) (Figs. 2C–F, 3B–D, 4C and D). As noted in Table, these vascular, myofibroblastic, and cartilaginous reactive changes often raised concern for an endothelial, spindle cell, or cartilaginous tumor, respectively. In some instances, relatively normal intervertebral disc was misinterpreted as representing a myxoid or cartilaginous neoplasm, presumably reflecting lack of familiarity with the normal histology of this tissue. Three cases of herniated disc showed "extreme" lateral herniation, with extension of disc material into the psoas muscle and

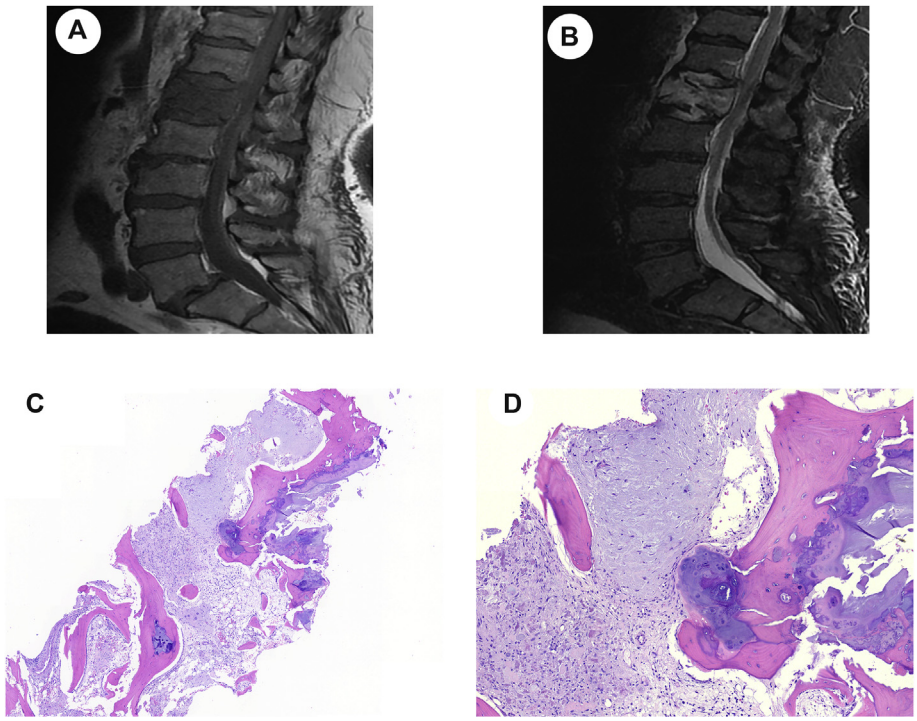


**Fig. 4** Sagittal T1 (A) and STIR (B) images of the lumbar spine demonstrate a fracture of the L1 vertebra. Intervertebral disc material can be seen extruding through the fracture into the vertebral body. When herniated disc material is extruded into vertebral bone, it can closely simulate the permeative growth pattern seen in chondrosarcoma (C). Higher-power magnification, however, shows typical features of herniated disc, with areas of relatively normal, myxoid nucleus pulposus juxtaposed to hyalinized islands of degenerating disc material and reactive stromal cells (D).

paraspinal musculature, simulating muscle invasion by a cartilaginous neoplasm (Fig. 3B). The presence of extruded disc material within bone was typically misinterpreted as representing permeative growth of a chondrosarcoma (Fig. 4C and D).

The morphologic features of 8 cases radiologically interpreted as representing "synovial cysts" included exuberant myofibroblastic and capillary proliferation, osteoclastic giant cells, dystrophic calcification, and rarely pseudocyst formation with synovial metaplasia of the lining (Fig. 5B–E). In cases of disc disease and/or synovial cyst with associated compression fracture, cellular and mitotically active osteocartilaginous matrix (fracture callus) was usually present, raising the possibility of various matrix-producing neoplasms (Fig. 6B–D). Close inspection of these foci, however, revealed reassuring features, such as "maturation" and absent hyperchromatism or atypical mitotic activity. Finally, in some instances, tissue derived from the ligamentum flavum was confused with a necrotic spindle cell malignancy, owing to its unusual hypocellular, lamellar, collagenous appearance, or with some sort of calcifying neoplasm (Fig. 7A and B).

As none of the studied cases contained a discrete neoplastic population, all of the submitted immunohistochemical studies were considered to be noncontributory.

## 4. Discussion

The results of the present study suggest that the diagnosis of paraspinal pseudoneoplasms represents an ongoing challenge for many pathologists. We believe that these difficulties are largely because of (1) lack of familiarity with the normal histology and histopathology of this anatomical region, (2) limited appreciation of the necessity for pathology-radiology correlation in the diagnosis of paraspinal masses, with poor interdisciplinary communication, and (3) general unease with the distinction of reactive processes involving paraspinal tissues from potential neoplastic mimics.

The spine and paraspinal region is remarkably complex and is composed of various bones, joints, intervertebral discs, articular surfaces, spinal ligaments, and surrounding soft tissues, including fat, fibrous tissue, nerves, and vessels. The microanatomy of the intervertebral discs is similarly complex, with 3 distinct, interdependent specialized structures: the central viscous nucleus pulposus, the outer fibrillar annulus fibrosus, and the cartilaginous end plates, a 1-mm-thick layer of cartilage that anchors the disc to the adjacent vertebral bodies superiorly and inferiorly. The nucleus pulposus, the cushioning core of the adult intervertebral disc, is derived from the notochord, whereas the annulus fibrosis, which provides the structural

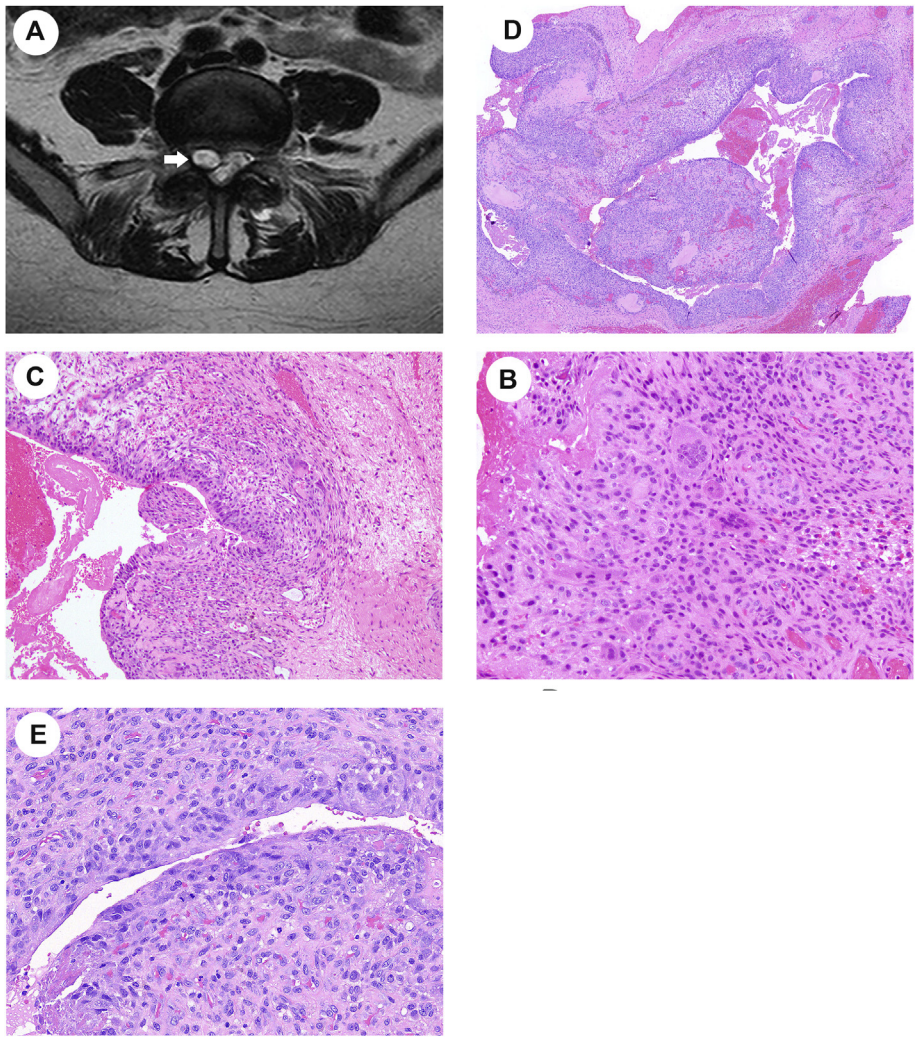


**Fig. 5** Axial T2-weighted image of the lumbar spine (A) demonstrates an extradural mass along the right lateral central canal with a peripheral T2 hypointense rim immediately adjacent to the right L4-L5 facet joint (arrow), consistent with a facet joint synovial cyst. Low-power view of facet joint synovial cyst (B). This particular example contains a well-defined layer of synovial cells, overlying a granulation tissue stroma. A synovial lining is not typically present in tissues removed from radiologic ally classical synovial cysts (C). Cellular, osteoclast-rich areas within synovial cysts may simulate giant cell tumor of bone or aneurysmal bone cyst (D). Mitotic activity is frequently present, as well (E).

properties of the disc, is derived from ventral sclerotome, which also gives rise to the vertebral bodies [1]. The annulus fibrosus firmly binds the vertebral bodies together and also keeps the nucleus pulposus under constant pressure [2]. In humans, the adult intervertebral disc is the largest avascular tissue in the body and therefore dependent on the cartilaginous end-plate for nutrient exchange via passive diffusion from the highly vascularized vertebral bodies [3]. With advancing age, the cartilaginous end-plate becomes calcified, and the bony interface becomes sclerotic, leading to decreased nutrient delivery, weakness, and degeneration of the disc [4,5]. In this setting, small tears in the annulus fibrosus or cartilaginous end-plate may develop with subsequent extrusion of disc material, neovascularization, granulation tissue formation, and myofibroblastic proliferation, all of which contribute to formation of a pseudoneoplastic, clinically appreciable mass [6–9].

Disc herniation is generally defined as displacement of a still-attached disc beyond its normal anatomic confines, whereas disc sequestration refers to complete separation of the disc and migration into surrounding tissues [6]. Most herniated/sequestered discs extrude through small defects in the annulus fibrosis in lateral or posterolateral directions (because of the strength of the anterior longitudinal ligament) or cranial-caudally through the end-plates [6,10,11]. So-called “Schmorl nodes”, which may mimic a cartilaginous neoplasm, represent herniation of

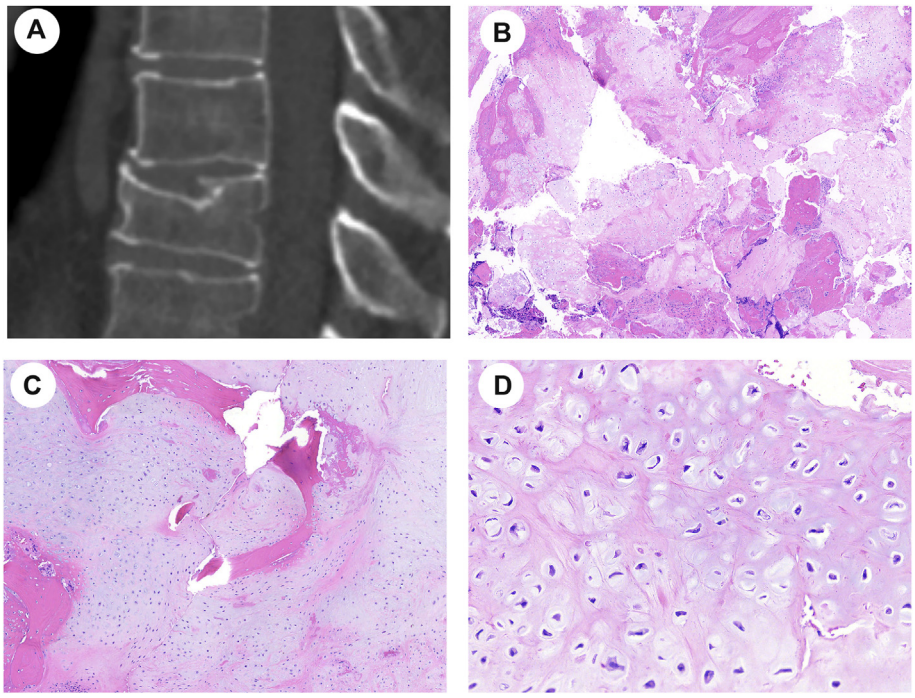


**Fig. 6** Sagittal-reformatted CT image of the lower thoracic spine (A) demonstrates a moderate compression fracture of the T10 vertebral body. Fracture callus, removed during repair of a vertebral compression fracture. In the absence of clinical history and radiologic correlation, the cellular osteocartilaginous proliferation that characterizes fracture callus in any location may raise concern for osteosarcoma (B). Fracture callus may also extend within pre-existing bone, simulating chondrosarcoma (C). Out of context, the relatively high cellularity and nuclear enlargement seen in fracture callus may be alarming (D). CT, computed tomography.

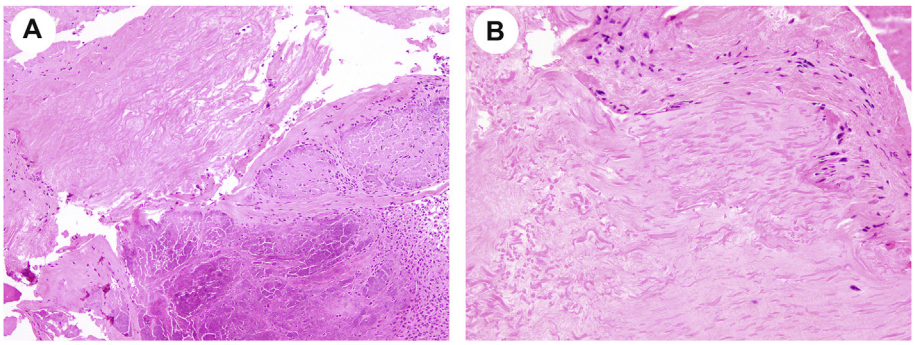


**Fig. 7** Tissue from the ligamentum flavum is often present in surgical specimens received for disc disease, compression fractures, or synovial cysts. The unusual pattern of dystrophic calcification seen in this example suggested the possibility of a phosphaturic mesenchymal tumor to the referring pathologist (A). The hypocellular, lamellar appearance of the ligamentum flavum is sometimes confused with a spindle cell neoplasm showing "bland necrosis", particularly when more cellular, reactive foci are present at the periphery (B).

the nucleus pulposus through the cartilaginous end-plate into the body of the vertebra [12,13]. Herniated/sequestered discs may extend for a considerable distance laterally, as exemplified by the 3 cases in this series that presented as masses in the psoas muscle and paraspinal musculature. "Extreme" lateral disc herniations most often involve the L3/4 and L4/5 interspaces, have been estimated to represent roughly 10% of all lumbar disc herniations [14], and are often confused clinically with a paraspinal nerve sheath tumor or retroperitoneal sarcoma [14,15].

Synovial cysts are also relatively common paraspinal pseudoneoplasms, as evidenced by the 8 cases included in this series. Lumbar intraspinal synovial cysts originate from the zygoapophaseal joint capsule and most commonly occur at the L4/5 level and to a lesser extent at L3/L4 and L5/S1 [16]. These lesions most likely arise secondary to facet joint degeneration, typically in a

background of more generalized osteoarthritis [17]. In our experience, histologic evaluation of lumbar synovial cysts with classic radiologic features seldom discloses true synovium, showing instead a variety of florid nonspecific stromal changes, most notably myofibroblastic and capillary proliferation. Occasional cases show pseudocyst formation, sometimes with what seems to represent synovial metaplasia, rather than residual preexisting synovium. Both synovial cysts and disc herniation/extrusion can occur in association with compression fractures, which show features similar to repairing fractures at other sites, with exuberant endochondral ossification and a fasciitis-like myofibroblastic/vascular proliferation.

Although we strongly suspect that most (if not all) pathologists appreciate the critical importance of pathology-radiology correlation in the diagnosis of neoplastic and non-neoplastic disease of bone, this does not seem to be the case for paraspinal lesions, many of which are referred in consultation without radiologic studies or without evidence of multidisciplinary interaction. As we hope, the present study indicates communication between the clinician, radiologist, and pathologist is at least as crucial in the evaluation of paraspinal masses as it is in lesions of bone.

MRI is generally felt to be the best imaging modality for evaluation of the spine and its contents. Migrated disc fragments typically show low signal intensity on T1-weighted and high signal on T2-weighted images [18]; contrast-enhanced MRI scans are useful to differentiate a herniated disc from a disc space infection or tumor, with peripheral enhancement usually seen around an otherwise nonenhancing disc fragment [18–22]. Unlike chondrosarcomas, herniated discs do not show destruction of bone [23]. MRI is also an excellent tool for the distinction of herniated/sequestered discs from metastases [18,24], epidural abscesses [18], nerve sheath tumors, and meningiomas [18]. In general, the presence of striking surrounding stromal edema on MRI points toward non-neoplastic processes. Facet joint synovial cysts are also well-evaluated by MRI. While some synovial cysts display simple fluid signal intensity, with homogenous low T1 and high T2 signal, others may have more complex signal, with high T1 signal secondary to hemorrhage and heterogeneous T2 signal if hemorrhage or calcification is present. However, close relationship with the facet joint, peripheral enhancement, and a peripheral T2 hypointense rim are key features that allow confident radiologic diagnosis [25] The histopathologic differential diagnosis of paraspinal pseudoneoplasms is broad and depends on the underlying process (eg disc disease, cyst, or fracture) and which reactive/degenerating element is most prominent. Awareness of the normal morphological features of the intervertebral disc and recognition of reactive/reparative features such as neovascularization and surrounding myofibroblastic proliferation should allow the distinction of disc disease from cartilaginous tumors in most instances. It should be kept in mind that extrusion of disc material into bone may closely mimic the permeative growth pattern of chondrosarcoma. Richly vascularized herniated disc material may resemble chondromyxoid fibroma, although the latter lesion is quite rare in the spine and has characteristic imaging features, with surrounding sclerosis. Herniated discs or synovial cysts with associated fracture may also mimic (chondroblastic) osteosarcoma to a degree but lack the clear-cut chromatin abnormalities, "lace-like" osteoid, and destructive growth that characterize osteosarcoma in most instances. Although osteoclastic giant cells may be present in paraspinal pseudoneoplasms, these lesions lack the sheet-like proliferation of osteoclasts and H3.3 G34W-positive mononuclear cells of giant cell tumor of bone [26–29] and the large, blood filled spaces, and *USP6* rearrangements that characterize aneurysmal bone cyst [30].

Some paraspinal pseudoneoplasms in the present series were also confused with chordoma, angiosarcoma, and phosphaturic mesenchymal tumor. Chordomas generally occur in the sacrum and clivus but may rarely involve lumbar, thoracic, cervical, and extra-axial locations [31,32]. Microscopically, chordomas are characterized by a cord and chain-like proliferation of large, eosinophilic, vacuolated, keratin, and brachyury-positive cells, features not seen in herniated discs [33,34]. Close attention to the well-formed capillaries, absence of solid or sieve-like growth, and bland nuclear features of richly vascularized discs and synovial cysts should allow their confident distinction from angiosarcoma. Finally, phosphaturic mesenchymal tumors, while remarkably protean in appearance, usually contain areas of unusual, "grungy" calcified matrix produced by very bland, FGF23 CISH-positive spindled cells, features absent in potential non-neoplastic simulants [35]. On MRI, phosphaturic mesenchymal tumors are T1 isointense, T2 hyperintense, and solidly enhancing, often with areas of dark signal [36,37].

In conclusion, the results of this study suggest that paraspinal pseudoneoplasms are a relatively common cause of diagnostic confusion, most likely related to lack of familiarity with the histopathological features of this region and most critically to the absence of multidisciplinary communication. Arguably, inappropriate immunohistochemical workups and the need for second opinion delay diagnosis, add cost, and most importantly may result in considerable anxiety for patients incorrectly thought to have a tumor involving the spine and/or paraspinal soft tissues. Awareness of these pseudoneoplasms, better understanding of the morphological features of normal and diseased paraspinal tissues, and

pathology-radiology correlation should allow for confident diagnosis in most instances.

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