MDCT of Variations and Anomalies of the Neural Arch and Its Processes: Part 2—Articular Processes, Transverse Processes, and High Cervical Spine

OBJECTIVE. The purpose of this pictorial essay is to review the variations and anomalies of the neural arch and its processes with a focus on the articular and transverse processes. We also discuss variations and anomalies of the neural arch at the high cervical spine.

CONCLUSION. Variations and anomalies of the neural arch and its processes may be identified on MDCT studies. Familiarity with their MDCT appearances is required for characterization and may help evaluate their potential clinical relevance.

Variations and anomalies of the neural arch result from alterations in the ossification process. Patients with these findings commonly remain asymptomatic, but a few of these variations and anomalies may cause painful syndromes or may be confused with fractures and dislocations [1–3].

In Part 1 of this series [4], which also appears in this issue of the AJR, we discussed the appearances of variations and anomalies of the pedicles, pars interarticularis, laminae, and spinous process on 64-MDCT. Here, in Part 2, we review the MDCT appearances of variations and anomalies of the articular and transverse processes. We also discuss variations and anomalies of the neural arch at the high cervical spine.

Articular Processes

The articular processes arise from the junction of the pedicles and laminae. Their shape and orientation show regional differences throughout the spine, with transition points around C6 and T11. The change of orientation is gradual from the cervical to thoracic region and is rather sudden from the thoracic to lumbar region [5].

The mammillary process is a normal elevation at the posterior margin of the superior articular facet [1–3]. It arises from a secondary ossification center and may persist into adult life. A prominent mammillary process may be hard to identify on anteroposterior radiographs of the lumbar spine. On an oblique radiographic view, it is seen as a ring-shaped opacity adjacent to the pedicle. This feature, termed the “two-eyed scotty dog” sign, may be easily reproduced on oblique sagittal volume-rendered MDCT images [6] (Fig. 1).

A vertical cleft through the superior articular process may occur [7]. It can be associated with a hypoplastic pedicle or a dysplastic facet joint (Fig. 2). “Oppenheimer’s ossicle” (Fig. 3), which may be mistaken for a facet fracture [3], originates from a horizontal cleft through the inferior articular process. Accessory ossicles at the superior joint facet may also occur [3].

Articular processes may be hypoplastic (Fig. 3B) or absent. Fused facet joints may be seen in segmental anomalies and various neural arch malformations [8]. Absent facet joints may be associated with a conjoined nerve root and may cause low back pain [9].

Facet tropism is defined as asymmetry at the facet joint angles of the lumbosacral region. Some individuals show asymmetric facet joint angles (Fig. 4), but the definition of excessive tropism is arbitrary. Investigators have suggested that facet joint tropism does not significantly increase the risk of facet joint osteoarthritis or disk degeneration. However, both facet joints tend to be more sagittally oriented in patients with degenerative spondylolisthesis [10].

Transverse Processes

The transverse processes of typical cervical vertebrae are pierced by the foramen transversarium. The foramen transversarium varies in size and shape, may be anteriorly open, may be double (Fig. 5) or triple, or may be absent at C1 or C7 [2]. The anterior tubercle of the
transverse process of C7 is frequently small or absent, but it may attain a large size or may exist as a separate bone to form the cervical rib [2, 11] (Fig. 6). Cervical ribs may be rudimentary or fully developed and may cause thoracic outlet syndrome [11].

The transverse processes of the dorsal spine are thick, strong, and considerably long, particularly at D1. They have no foramen transversarium and end in a clubbed extremity. The transverse processes have a costal facet from D1 through D9 but may or may not have a costal facet at D10. They adopt a transitional triradiate configuration at D12 (occasionally at D10, D11, or L1). Persistent secondary ossification centers may occur (Fig. 7). These centers have smooth rounded borders, resembling typical accessory ossicles. These features help differentiate these anomalies from fractures.

The L1, L2, and L3 transverse processes are slender and horizontal. The L1 transverse processes lose the D12 triradiate configuration as the superior, lateral, and inferior tubercles turn into mammillary, transverse, and accessory processes, respectively [1, 2]. However, the L1 transverse process may retain a tripartite configuration (Fig. 8), may remain united, or may support a small lumbar rib [2] (Fig. 9).

The accessory processes are found at the posterior aspect of the transverse processes [1–3] (Fig. 10). On rare occasions, they may be particularly prominent [3]. Accessory and mammillary processes may join into a bony bridge, forming a foramen transversarium. Anomalous articulations between contiguous transverse processes may occur (Fig. 11).

The L4 and L5 transverse processes arise from the pedicles and posterior parts of the vertebral bodies and incline upward a little. The L5 transverse processes may be abnormally enlarged and may articulate with the sacrum or the iliac bone (Fig. 12). Bertolotti syndrome refers to the occurrence of a transverse megaapophysis in a transitional lumbosacral vertebra and is considered a possible cause of low back pain [12].

The Atlas

Congenital defects of the posterior arch of the atlas may be classified as the failure of posterior midline fusion (Fig. 13A), a unilateral defect (Fig. 13B), bilateral defects (Fig. 13C), the absence of the posterior arch with persistent posterior tubercle, or the absence of the entire arch including the tubercle [13]. These defects may be associated with atlantoaxial instability or a block vertebra. Neurologic symptoms related to stenosis or instability may occur. Coexistent midline clefs of the anterior and posterior arch may cause lateral spread of the atlas and may simulate a Jefferson burst fracture [14].

The epitransverse process is a bony exostosis that arises from the transverse process of the atlas. Its anomalous articulation with the paracondylar process of the occipital bone may cause occipitocervical pain [3] (Fig. 14).

Ponticulus posticus, also termed “arche foramen,” is a bony bridge on the posterior arch of the atlas that covers the groove for the vertebral artery (Fig. 15). It is a normal anatomic variant that may be commonly seen at radiography (Fig. 15A) and MDCT (Figs. 15B and 15C). It may rarely be associated with headache or stroke [2, 3].

The tubercle of the posterior arch of the atlas may be bifid, or it may articulate with facets on the posterior edge of the foramen magnum.

The Axis

The pedicles of the axis are usually thick and strong. Primary spondylosis of the axis refers to congenital or idiopathic clefs through the C2 pedicles. This condition may simulate traumatic spondylolisthesis (hangman’s fracture) and may be associated with myelopathy.

The superior or inferior articular facets of the axis may be fused with those of adjacent vertebrae. Radiographic psuedofusion of the C2–3 facet joints has been described [15]. This pitfall, which derives from the oblique orientation of the facet joints relative to the x-ray beam on the lateral projection, can be avoided and the relationship of C2–C3 facet joints can be easily understood by reviewing coronal MDCT reformations [15] (Fig. 16).

References

Fig. 1—Prominent L2 mammillary processes in 44-year-old woman who presented with low back and right sciatic pain.
A–C, Anteroposterior radiograph (A), axial thin-slab volume-rendered MDCT image (B), and posterior coronal volume-rendered MDCT image (C) show prominent mammillary process (arrows).
D, Thin-slab oblique sagittal volume-rendered image reproduces classic radiographic scotty dog sign. “Nose” of “Scotty dog” corresponds to transverse process (tp); “eye,” to pedicle (p); and “ear,” to superior facet (sf).
E, Oblique sagittal volume-rendered image displays so-called “two-eyed Scotty dog” sign, where prominent mammillary process (arrow) superimposes within contour of dog’s head, suggesting “dog’s eye.” Left L2 transverse process (arrowhead) shows distal downward projection, which has been described as “pig’s snout pedicle” sign on conventional radiographs.

Fig. 2—Dysplastic right L5–S1 facet joint in 43-year-old woman who presented with low back and right sciatic pain.
A and B, Axial thin-section (A) and posterior coronal volume-rendered (B) MDCT images show dysplastic right L5–S1 facet joint (arrow). Abnormal cleft through right superior S1 articular process (arrowhead) is seen.
Fig. 3—"Oppenheimer's ossicle" in 39-year-old man who presented with low back and right sciatic pain. A–C, Anteroposterior radiograph (A), coronal reformatted MDCT image (B), and left parasagittal reformatted MDCT image (C) show Oppenheimer's ossicle (arrow) at caudal aspect of left inferior L3 articular process. Right inferior L3 articular process (arrowhead, A and B) shows slight hypoplasia.

Fig. 4—Facet tropism in 38-year-old man who presented with left sciatic pain. A, Anteroposterior radiograph shows sagittally oriented left L4–5 facet joint (arrow) in patient with L5 sacralization. B–D, Axial thin-slab volume-rendered MDCT images show symmetric L2–3 facet joints (arrowheads, B), mild L3–4 tropism (arrow, C), and marked L4–5 tropism (arrow, D).

(Fig. 4 continues on next page)
Fig. 5—Double foramen transversarium in 64-year-old woman who presented with left cervical radiculopathy. Axial thin-slab volume-rendered MDCT image shows double foramen transversarium (arrowheads) at C6 transverse processes.

Fig. 6—Cervical rib in 47-year-old woman who presented with left cervical radiculopathy and dorsal pain. A and B, Axial thin-slab volume-rendered (A) and anterior coronal volume-rendered (B) MDCT images show prominent C7 transverse processes (arrows), hypoplastic costal element at right C7 transverse process (black arrowhead, A), and left cervical rib (white arrowheads).
Fig. 7—Persistent ossification center in 25-year-old woman who presented with dorsal pain after minor trauma. Axial thin-section MDCT image shows persistent ossification center at right D12 transverse process (arrow). Spina bifida occulta (arrowhead) is also noted.

Fig. 8—Tripartite configuration of right L1 transverse process in 52-year-old man who presented with right sciatic pain. Axial thin-section MDCT image shows tripartite configuration of right L1 transverse process (arrow) and small right lumbar rib (arrowhead).

Fig. 9—Lumbar ribs in 88-year-old man with stable aneurysm of abdominal aorta. Axial thin-section MDCT image shows persistent tripartite configuration of L1 transverse processes (arrows) and small lumbar ribs (arrowheads).

Fig. 10—Accessory processes in 34-year-old woman who presented with low back pain. A and B, Axial thin-section (A) and coronal volume-rendered (B) MDCT images show accessory processes (arrows) at posterior aspect of L3 transverse processes.

Fig. 11—Anomalous joint between transverse processes in 46-year-old woman who presented with left sciatic pain. A–C, Anteroposterior radiograph (A), coronal reformatted MDCT image (B), and anterior coronal volume-rendered MDCT image (C) show abnormal articulation between left L1 and L2 transverse processes (arrowhead).
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Fig. 12—L5 transitional vertebra in 40-year-old woman who presented with left sciatic pain. 
A and B, Axial thin-section (A) and anterior coronal volume-rendered (B) MDCT images show L5 transitional vertebra with left hypertrophic transverse process (arrow) that articulates with ilium and sacrum.

Fig. 13—Types of congenital defects of neural arch of atlas.
A, 88-year-old woman who presented with dizziness. Axial thin-slab volume-rendered MDCT image shows type A defect of posterior arch of atlas (arrowhead). B, 28-year-old woman who was involved in car crash and presented with cervical pain. Axial thin-slab volume-rendered MDCT image shows type B defect of posterior arch of atlas (arrowhead). Defect of right foramen transversarium (arrow) is also shown. C, 65-year-old woman who presented with cervical pain after high-energy trauma. Axial thin-slab volume-rendered MDCT image shows type C defect of posterior arch of atlas (arrowheads).

Fig. 14—Epitransverse process in 86-year-old woman who presented with visual loss. 
A and B, Axial thin-section (A) and coronal reformatted (B) MDCT images show left epitransverse process of atlas (arrow, A) and its anomalous articulation with paracodylar process (arrows, B), which joins occipital condyle (arrowhead, B).
Fig. 15—Ponticulus posticus. 
A, 37-year-old man who presented with cervical and dorsal pain. Lateral radiograph shows ponticulus posticus (arrowhead) at neural arch of atlas. 
B and C, 79-year-old man who presented with dizziness. Axial thin-slab (B) and sagittal (C) volume-rendered MDCT images show left vertebral artery (arrowhead, C) traveling across left foramen transversarium of atlas (short arrow) and under ponticulus posticus (long arrow) before entering foramen magnum.

Fig. 16—Pseudofusion of C2–C3 facet joints in 25-year-old woman who presented with cervical pain. 
A, Lateral radiograph of cervical spine shows ill-defined C2–3 facets (circle). 
B, Coronal reformatted MDCT image shows normal C2–3 facet joints (arrowheads), suggesting radiographic finding is due to oblique facet orientation relative to x-ray beam.

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The reader’s attention is directed to part 1 accompanying this article, “MDCT of Variations and Anomalies of the Neural Arch and Its Processes: Part 1—Pedicles, Pars Interarticularis, Laminae, and Spinous Process,” which begins on page W104.