Rapid MRI Detection of Vertebral Numeric Variation

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OBJECTIVE. Vertebral column variation is a common, often overlooked finding on traditional spine MRI. Standard localizers do not image the entire neuroaxis, masking variation. The purpose of this study was to use a subminute automated spine survey iterative scan technique (ASSIST) to evaluate 207 patients undergoing thoracic spine MRI.

CONCLUSION. We found variation in 7.7%, with 69% of these cases going unreported. To enhance patient care and decrease medicolegal implications, we recommend ASSIST be performed on all thoracic and lumbar examinations, with variations documented.

Keywords: advanced imaging techniques, anatomy, localizer, MRI, screening, spine, variants

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Prior anthropologic and anatomic studies have divided the vertebral column into sacral and presacral groups [1]. The typical number of vertebrae in humans is considered to be seven cervical, 12 thoracic, and five lumbar for a total of 24 mobile presacral vertebrae (Fig. 1A). However, numerous clinical and anthropologic studies have shown that numeric variation in the vertebral column occurs in 2–23% of the population [2, 3]. Typical localizer sequences for spine MRI do not completely or unambiguously image the entire spinal axis, and thus this variation can be missed. This may result in spinal procedures performed at the wrong level, a common reason for litigation [1]. To improve accuracy and standardize spine labeling, we evaluated a rapid total spine MRI localizer—the automated spine survey iterative scan technique (ASSIST)—for detection and documentation of these variations [4].

Materials and Methods

Institutional review board approval with waived consent was obtained for this HIPAA-compliant retrospective research study. Two hundred nineteen consecutive ASSIST localizers performed as part of a clinical thoracic spine MRI examination were retrospectively reviewed from a hospital-based 3-T Signa Excite MRI scanner equipped with an eight-channel spine array coil (GE Healthcare). The examinations, performed between October 1, 2007, and December 23, 2008, autoimaged the entire spine in two contiguous 35-cm field of view sagittal stations (11 sections; 4 mm, skip 1 mm), typically using out-of-phase fast gradient-echo sequencing (TR/TE, 57/1.4; flip angle, 30°; bandwidth, ± 62.5 kHz; 512 × 352 matrix; 21 seconds). Of the 219 examinations, 81% were performed in outpatients (178/219), 17% were performed in inpatients (37/219), and 2% were performed in emergency department patients (4/219).

A board-certified fellowship-trained neuroradiologist and a senior radiology resident, blinded to the clinical radiology report, independently counted the number of apparent mobile presacral and transitional lumbosacral vertebrae on the total spine localizer. Transitional vertebrae were defined as those having a mixed lumbar–sacral appearance suggesting possible partial fusion to the sacrum and thus limited mobility relative to a typical lumbar vertebral body. Cases were reviewed in chronologic order on a PACS workstation and vertebral numbering was performed in a cranial-to-caudal approach. Cases were only excluded from the study if there were errors in performing the ASSIST sequence that did not allow accurate counting. Accordingly, a total of 210 cases in 207 patients were accepted for evaluation from the total of 219 cases. The patient population was 92 men (44%) and 115 women (56%). Patient ages ranged from 17 to 88 years, with a mean age of 48 ± 15 years.

Cases thought to exhibit vertebral variation were reconfirmed by referencing additional conventional MRI sequences acquired as part of the clinical MRI examination. The data were compiled and compared. The final examination report was then referenced to determine whether the vertebral variation was identified and documented by the fellowship-trained, board-certified neuroradiologist.

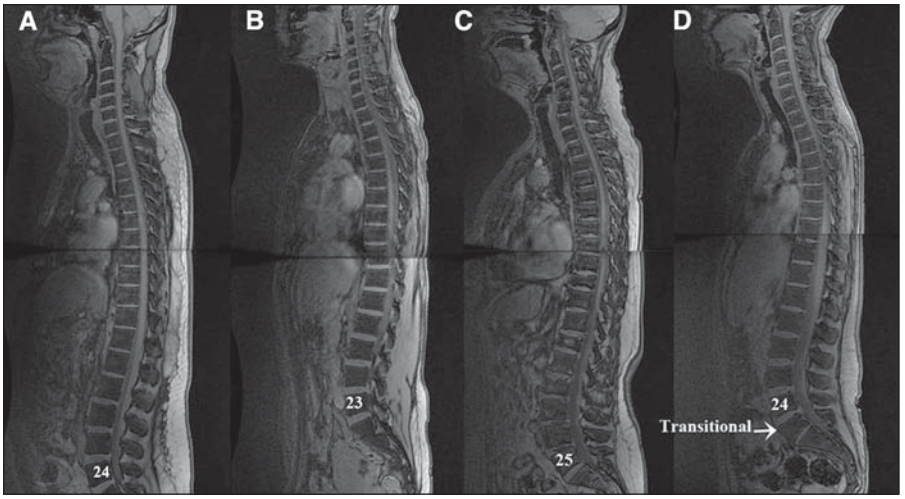

Fig. 1—Midline automated spine survey iterative scan technique (ASSIST) localizer images show variant vertebral anatomy.
A–D, Midline (typically slice 6 of 11) two-station composite (70 × 35 cm field of view) opposed-phase fast gradient-recalled echo ASSIST total spine breathhold localizer sequences show typical 24 mobile presacral vertebrae (**A**), 23 mobile presacral vertebrae (**B**), 25 mobile presacral vertebrae (**C**), and 24 mobile presacral vertebrae (**D**) with additional transitional lumbosacral segment (*arrow*).

Results

In all cases, there was concordant numbering between the two reviewers. In our series of 207 patients, we found a total of 16 patients with a variant number of vertebrae. Seven patients were found to have 23 mobile presacral vertebrae (Fig. 1B), seven patients had 25 mobile presacral vertebrae (Fig. 1C), and two patients had transitional appearing lumbosacral segments (Fig. 1D). This represents a 7.7% incidence of lumbosacral junction variation within our population, similar to prior cadaver studies [5]. When compared with the final clinical MRI reports, it was discovered that anatomic variation was only mentioned in five of these 16 cases (31%): three cases of 23 or 25 presacral vertebrae and the two with transitional segments. Thus, in 11 of 16 cases (69%), the vertebral variation went unreported even when the ASSIST localizers were available, potentially leading to future labeling discordance.

Discussion

Variation in the vertebral column arises either at the division of somites or by differences in caudal degeneration of vertebrae through *Hox* genes [2, 6]. Transitional-type vertebrae are seen at the occipitocervical, cervicothoracic, thoracolumbar, and lumbosacral junctions. Given the relatively high prevalence of numeric variation at the lumbosacral transition, accurate vertebral numbering is critical to avoid numbering discordance. We recommend the use of an ASSIST rapid total spine MRI localizer whenever thoracic or lumbosacral MRI studies are ordered. However, simply obtaining the subminute localizer is not sufficient, as shown by the high percentage (69%) of unreported vertebral variation in this study. Counting the number of vertebrae, either manually or by computer, and reporting variants are also essential in the process [4, 7]. There are a few existing techniques for automated spine numbering; however, currently, these techniques do not fully support numeric vertebral variation [8]. If there are not the typical 24 mobile presacral vertebrae, we recommend counting in a cranial-to-caudal manner with the assumption of seven cervical and 12 thoracic vertebrae. This should be clearly documented in the report and will potentially eliminate the requirement for radiographic confirmation before intervention. Not only might this improve patient care and decrease the medicolegal implications of wrong-site surgery, but variant vertebral anatomy can also be used for forensic identification purposes [9].

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