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Interpretation of Spinal Radiographic Parameters in Patients With Transitional Lumbosacral Vertebrae*

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Abstract

Study Design: Retrospective radiographic review.
Objectives: To understand the effect of variability in sacral endplate selection in transitional lumbosacral vertebrae (TLSV) and its impact on pelvic, regional, and global spinal alignment parameters.
Background: TLSV can have the characteristics of both lumbar and sacral vertebrae. Difficulties in identification of the S1 endplate may come from nomenclature, number of lumbar vertebrae, sacra, and morphology and may influence the interpretation and consistency of spinal alignment parameters.
Methods: Patients with TLSV were identified and radiographic measurements including pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), lumbar lordosis (LL), sagittal vertical axis (SVA), T1-pelvic angle (TPA), pelvic incidence-lumbar lordosis (PI-LL) mismatch, thoracic kyphosis (TK), and spinal inclination (T1SPi) were obtained. Radiographic measurements were performed twice with the sacral endplate at the cephalad and caudal options. Paired *t* tests assessed the difference between different selection groups.
Results: Of 1,869 patients, 70 (3.7%) were found to have TLSV on radiographic imaging. Fifty-eight (82.9%) had lumbarized sacral segments whereas 12 (17.1%) had sacralized lumbar segments. T1-SPi (mean: −1.77°) and TK (mean: 34.86°) did not vary from altering sacral endplate selection. Selection of the caudal TLSV as the sacral endplate resulted in an increase in all pelvic parameters (PI: 66.8° vs. 44.3°, PT: 25.1° vs. 12.7°, and SS: 41.6° vs. 31.6°), regional lumbar parameters (LL: −54.1° vs. 44.0°, PI-LL: 12.7° vs. 0.3°), and global parameters (SVA: 46.1 mm vs. 28.3 mm, TPA: 23.3° vs. 10.8°) as compared to selecting the cephalad TLSV. All mean differences between radiographic parameters were found to be statistically significant ($p < .001$).
Conclusions: Variation in sacral endplate selection in TLSV significantly affects spinal alignment parameter measurements. A standardized method for measuring TLSV is needed to reduce measurement error and ultimately allow more accurate understanding of alignment targets in patients with TLSV.
Level of Evidence: Level III.

Keywords: Transitional vertebra; Spinal deformity; Sagittal; Alignment

Introduction

Transitional lumbosacral vertebrae (TLSV) are vertebral segments that have the characteristics of both lumbar and sacral vertebrae. Castellvi et al. first devised a classification scheme for TLSV based on their morphologic characteristics, as well as the propensity of their adjacent nucleus pulposus to herniate [1]. These transitional segments can range from vertebrae with nonclassical variations of their transverse processes that remain a diarthrodial joint (Types I and II) to those that are fused to their adjacent segments (Types III and IV).

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The terms *sacralized L5* and *lumbarized S1* are used to categorize the transitional segment relative to normal anatomy (ie, 12 thoracic and 5 lumbar vertebrae). A sacralized L5 segment is an L5 segment (when counting caudally from the lowest rib) that has been partially fused with the sacral body, creating the appearance of 4 lumbar segments. In contrast, a lumbarized S1 is an S1 segment that is not completely fused with the rest of the sacral body, giving the appearance of a sixth lumbar vertebrae. Current techniques for defining vertebrae are based on counting the number of vertebral bodies and does not take into account the presence or lack of a mobile disc at the most caudal vertebra [2]. This has implications for both anatomical function and surgical treatment of spinal deformities because a segment with a nonmobile disc essentially functions as part of the pelvis.

Attaining balanced sagittal alignment is a primary goal for surgeons undertaking corrective surgery for adult spinal deformity. Different interpretations in defining TLSV are derived from nomenclature, the number of lumbar vertebrae, sacral morphology, and vestigial discs. Although sagittal alignment goals have been suggested, the applicability of these goals to patients with TLSV remains unknown [3]. Previous studies have attempted to normalize and understand the differences of such parameters in those with TLSV as compared to the normal population [4-6].

Because the sacral endplate is used as a landmark for measuring sagittal alignment, decisions governing S1 endplate selection in patients with TLSV may have significant implications for the interpretation of alignment goals in patients undergoing corrective surgery for adult spinal deformity. This study aims to identify how selection of the sacral endplate affects measurement of spinal sagittal parameters in patients with TLSV.

Materials and Methods

After institutional review board approval was obtained, a retrospective radiographic review of a spinal surgery database at a single institution was performed. Patients were included if they had full-body standing stereoradiographs and TLSV as defined by the presence of a true bony union between the transverse process and the sacrum (Castellvi types III and IV). Classification of TLSV was performed by an experienced spine surgeon. If x-ray imaging was unclear, computed tomography and/or magnetic resonance imaging of the lumbar spine were referenced to confirm the presence of a bony fusion. Patients with Castellvi type I or II TLSV were excluded from analysis. Lumbarized S1 and sacralized L5 were defined by counting down from the T12 vertebra (ie, the most caudal segment with ribs). The TLSV was identified as a lumbarized S1 if it appeared after L5 (thus appearing to be a sixth lumbar vertebrae) and as a sacralized L5 if it appeared after L4 (therefore appearing to have four lumbar vertebrae). To standardize the selection of lumbar vertebral number, L1 was defined as the most cephalad non–rib-bearing vertebra, regardless of the number of rib-bearing vertebrae present. Exclusion criteria included poor visualization of either the TLSV or femoral heads, congenital abnormalities, greater than grade 1

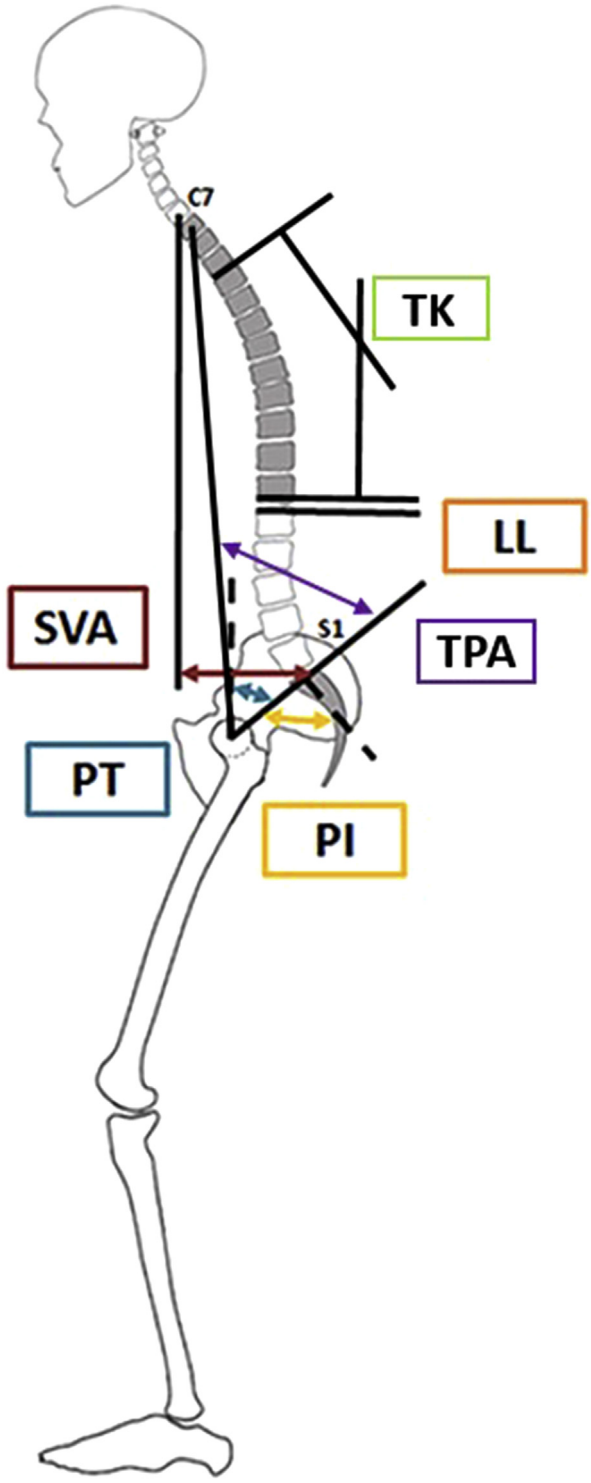

Fig. 1. Spinopelvic parameters. LL, lumbar lordosis; PI, pelvic incidence; PT, pelvic tilt; SVA, sagittal vertical axis; TK, thoracic kyphosis; TPA, T1 pelvic angle.