

Is the Updated Roussouly Classification Truly Categorical? A Multicenter Analysis of 525 Asymptomatic Adults Identifying an Anteverted Transitional Sagittal Morphotype (Type 3–4AP)

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Introduction

The Updated Roussouly Classification (URC) describes sagittal spinal alignment using four discrete morphotypes defined by pelvic incidence, sacral slope, and lumbar lordosis distribution. Although widely used in adult spinal deformity assessment and surgical planning, the strictly categorical structure of URC may oversimplify the continuum of sagittal morphology. This study aimed to evaluate URC distribution in a large asymptomatic adult population and to investigate whether anteverted pelvic configurations represent a transitional sagittal phenotype between Type 3 and Type 4.

Materials and Methods

A retrospective multicenter radiographic analysis was conducted including 525 asymptomatic adults from 10 centers. Standardized standing full-spine lateral radiographs were assessed. Sagittal spinopelvic parameters (PI, PT, SS, lumbar apex) were independently measured by two observers and classified according to URC criteria. Particular focus was given to anteverted pelvic patterns characterized by low or negative PT values combined with moderate-to-high SS. Distribution patterns were compared with contemporary international normative datasets.

Results

Among 525 participants (mean age 35.1 years; 374F/151M), Type 3 was the most prevalent morphotype (31.2%), followed by Type 2 (22.4%), Type 4 (20.2%), and Type 1 (10.2%). An anteverted pelvic configuration was identified in 15.5% of Type 3 and 1.5% of Type 4 subjects, forming a pooled transitional Type 3–4AP subgroup (16.0%). This subgroup was characterized by moderate-to-high sacral slope, low or negative pelvic tilt, relatively lower pelvic incidence, and a lumbar apex distribution consistent with Type 3–4 morphology. Type 4 prevalence increased with age, whereas the Type 3–4AP phenotype was more common in younger and middle-aged individuals. Although overall distributions were comparable to international normative cohorts, the categorical URC framework did not fully capture the morphological continuum observed between Type 3 and Type 4.

Conclusion

In this large multicenter normative analysis, a distinct anteverted transitional sagittal morphotype spanning Type 3 and Type 4 was identified in 16% of asymptomatic adults. These findings support the concept that sagittal alignment exists along a morphological continuum rather than strictly discrete Updated Roussouly Classification categories. Recognition of transitional anteverted phenotypes may enhance sagittal classification frameworks and improve interpretation of alignment patterns in adult spinal deformity planning. Longitudinal studies are needed to clarify the biomechanical and clinical implications of this phenotype.

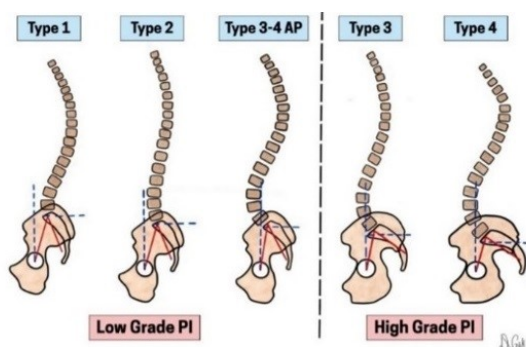


Figure. Sagittal profile distribution within the Roussouly framework

The modified Roussouly framework schematically summarizes the typical parameters of sacral slope (SS), pelvic incidence (PI), pelvic tilt (PT), and lumbar lordosis apex for each sagittal morphotype. Type 1 and Type 2 morphologies are associated with a low sacral slope ($SS < 35^\circ$); Type 1 exhibits a short lumbar lordosis with an apex located at the L5 level, whereas Type 2 demonstrates a flatter and relatively longer lordosis with a more cranially positioned apex (L4–L5 or L4). Type 3 is characterized by a moderate sacral slope (35° – 45°), a balanced lumbar lordosis, and an apex typically located at the L4 level. Type 4 is associated with a high sacral slope ($> 45^\circ$), a more cranial apex (L3 or L3–L4), and a long, pronounced hyperlordotic lumbar curve. The Type 3–4 anteverted pelvis (AP) subgroup refers to anteverted pelvic patterns observed within Type 3 or Type 4 morphologies, in the presence of low or negative pelvic tilt values, without deviations from moderate or high sacral slope ranges. In our study, this subgroup was generally associated with relatively low pelvic incidence values. The presented scheme emphasizes the integration of the original and updated Roussouly classification by illustrating the morphological continuity between pelvic morphology and lumbar lordosis shape.

