Answer to the Letter to the Editor of T.A. Mattei concerning “Far lateral approaches (XLIF) in adult scoliosis” by P. Berjano and C. Lamartina (Eur Spine J. 2012 Jul 27. [Epub ahead of print])

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We agree with Dr. Mattei in considering that the proposed classification [1] addresses well the cases with severe sagittal imbalance without coronal imbalance (Type IV) and those with significant coronal imbalance with moderate sagittal imbalance (Type III) but does not clearly include those cases with both significant coronal and sagittal imbalance. While recognizing that the category has not been well represented in the proposed classification, the authors consider that these patients would be better classified in the sagittal imbalance group (Type IV). The reasons for this are two: 1. sagittal imbalance is the most important predictor of HRQoL and outcomes in adult deformity patients; 2. as the classification has been proposed as a guide for treatment, sagittal plane deformity in patients with both coronal and sagittal imbalance dictates in the authors' opinion one important step in the surgical strategy, that is the choice of the technique that allows to obtain the amount of correction needed.

After publication of their classification of adult scoliosis regarding type of lateral access fusion the authors have been still involved in an active discussion on the value and limitations of the classification. They feel that the classification can be improved and completed. Furthermore, the classification probably raises a major point in the comprehension of adult deformity and thus it deserves being improved and extended. Sagittal imbalance with or without scoliosis, and de novo adult scoliosis [2], are different from adolescent idiopathic scoliosis (AIS), because they are in their nature a consequence of degenerative disc disease (DDD), and their clinical manifestations are closely related

to DDD. Idiopathic scoliosis in the adult and secondary scoliosis, frequently also present in the adult with symptoms that arise mainly from disc degeneration. This took us to expand the concept and propose a new “Classification of Degenerative Disc Disease in Subjects with Lumbar or Thoracolumbar Deformity” currently under manuscript preparation. In this classification, we have introduced some variations that in our opinion improve the completeness and usefulness of the classification. First, the classification is no longer a “classification of adult scoliosis regarding type of lateral access surgery strategy” but focuses a wider field, that of the interpretation of disc disease in adult patients with deformity. Second, categories have been redefined (Table 1) in order to make of it an exhaustive and exclusive classification. Third, the classification helps identifying the goals of treatment in each category, helping the surgeon to devise his own surgical strategy (whatever the surgical method is).

Regarding the other interesting question pointed out in his letter, Dr. Mattei shows a case with lumbar scoliosis (38°) and both mild coronal (the picture does not allow an exact measurement, but lateral displacement of the coronal dens and C7 plumbline does not seem to be more than 4 cm)(Fig. 1) and severe sagittal imbalance. In this case, we agree that a good strategy to improve coronal alignment is to begin with multilevel lateral access partial release and fusion. This will result in a better correction of the lumbar coronal deformity. Regarding the more relevant (in terms of outcomes) sagittal deformity, Dr. Mattei shows how the five-level XLIF procedure has been able to increase the L1–L4 lordosis from 0° to 34° after the anterior procedure (we have estimated that the total L1–S1 lordosis has increased from 31° to nearly 38°) and finally to 20.4° (L1–S1 47° after L5–S1 ALIF and posterior L1–S1 instrumentation). It is well known that spinopelvic harmony

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Table 1 Classification of degenerative disc disease in subjects with lumbar or thoracolumbar deformity

Type I: Localized nonapical DDD	Deformity affects little the surgical plan DDD is localized far from the apex of the curve. No degeneration or instability in adjacent discs (in the direction of the apex) No sagittal or coronal imbalance	Treatment as needed with usual rules for degenerative disc disease, limited to diseased discs
Type II: Localized apical DDD	Deformity affects the surgical plan DDD is localized near the apex of the curve. No DDD far from the apex Lumbar curve magnitude usually below 25–30° Cobb No sagittal or coronal imbalance	Surgery can be mainly limited to the diseased discs but should also include all the apical area. Little or no correction is needed. In case of rigid adjacent curves, care should be taken to avoid overcorrection resulting in decompensation
Type III: Extensive DDD	DDD extends to all the curve (and in occasions also beyond). Lumbar curve magnitude usually above 25–30° Cobb No or minor sagittal or coronal imbalance	Surgery must usually be extended to all the curve (including every degenerated disc). Some correction is needed to indirectly decompress the canal and to avoid progression of adjacent curves. In case of rigid adjacent curves, care should be taken to avoid overcorrection resulting in decompensation. If minor sagittal imbalance is present, it should be corrected
Type IV: Imbalanced spine Type IV a: Sagittal imbalance Type IV b: Sagittal and coronal imbalance	Severe sagittal imbalance (more than 25–30° of sagittal plane correction are needed)	Surgery must achieve full correction of sagittal imbalance. Surgical strategy must allow obtaining and keeping this correction. Though desirable, coronal imbalance correction is less critical regarding surgical outcomes

(a numeric correspondence between pelvic incidence and lumbar lordosis values) pelvic tilt (PT) and Sagittal Vertical Axis (SVA) are important predictors of surgical outcomes [3]. Other less popular, independent predictor of surgical is spinopelvic balance [4] (a ratio between the difference in absolute values between lumbar lordosis and thoracic kyphosis and the pelvic incidence value), described in a paper that has confirmed the value of SVA as predictor of surgical outcomes. Furthermore, theoretical pelvic tilt can be predicted for a given patient based only on pelvic incidence [5], and postoperative pelvic tilt and SVA can be predicted with a high degree of confidence with validated formulae [6]. Literature also provides a method to estimate “ideal” lumbar lordosis from pelvic incidence [7]. In the case presented in their letter, pelvic incidence (PI) can be estimated from postoperative lateral films within the limits of visibility of S1 endplate (we have calculated it to be nearly 67°, after double checking with the relative position of S1 endplate—better visible in preop. films—and the anterior surface of the sacrum—visible in both preop. and postop. films (Fig. 2). This would mean that the theoretical pelvic tilt of this patient should be 18°. Assuming that the thoracic kyphosis was 35 degrees (in our opinion, patients with pelvic incidence more than 60 degrees have seldom thoracic kyphosis below that magnitude unless a pathologic compensatory thoracic lordosis is present) application of

Lafage’s formula to the postoperative alignment (maximum lumbar lordosis equals 49 degrees), the postoperative pelvic tilt of this patient would be 30°. Postoperative SVA would be estimated as + 65 mm if the patient was 60 year old and + 73 mm if he or she was 75 year old. Other estimations of thoracic kyphosis would in any case cause an imbalanced spine with this pelvic incidence and this postoperative lumbar lordosis (the combination 49° lordosis and 15° kyphosis would cause a 26° pelvic tilt; on the other side, 49° lordosis and the most likely 50° kyphosis would estimate 32° of pelvic tilt). In other words, in spite of the increase in lumbar lordosis after multilevel XLIF, it is likely that the patient showed by Dr. Mattei had a postoperative sagittal imbalance or compensated imbalance. It would be interesting to be able to see the final full spine lateral standing films of this patient to verify if our calculations were wrong.

This takes to the key point of the argument in favor of multilevel XLIF procedures to obtain sagittal realignment. To our knowledge, current literature does not support that standard XLIF procedures provide sufficient sagittal alignment in sagittally imbalanced patients, though it can provide some increase in lordosis and it can be statistically significant. It’s the authors’ experience that XLIF procedures provide an increase in lumbar lordosis of 5–6° per level on average (in occasional discs or cases a XLIF procedure can increase more substantially the lordosis, but

Fig. 1 Mild coronal imbalance is present in this case of adult scoliosis. C7 coronal plumbline is within the lateral edge of S1 pedicle, indicating an estimated lateral displacement under 4 cm

we don't feel that the standard XLIF procedure can predictably produce corrections near 10° per level). In surgery for sagittal imbalance, the key point is restoring as much lordosis as needed to restore a physiological pelvic tilt and to reduce to less than 2.5 cm [4] the anterior translation of C7 plumbline from posterior S1 endplate. In our current understanding of the problem, sagittal undercorrection correlates with poor results and increased revision rate, and should not be accepted unless full correction cannot be tolerated by the patient. This made the authors suggest that multilevel XLIF could be useful without additional

Fig. 2 Postoperative lateral spine films including the hip joints allow for calculation of total lumbar lordosis and pelvic incidence

osteotomies to correct mild sagittal imbalance (cases with less than 20° of correction needed). In severe cases, it's our experience that the amount of correction needed ranges 30° to 70° or more (Fig. 3). So, at the present moment we still consider that posterior osteotomies are the only reliable method to obtain such amount of correction (Fig. 4). This is the reason why we classify coronal deformity with mild sagittal imbalance as Type III and severe sagittal imbalance (with or without coronal imbalance) as Type IV, reflecting that the presence of severe sagittal imbalance guides (at the present moment) the choice of the most relevant part of surgery. If the technique of release of the anterior longitudinal ligament by lateral approach and reconstruction with hyperlordotic cages [8] proves to be reliable, safe and reproducible to increase lordosis to a greater extent than the standard XLIF procedure, it could change the role of this approach in the treatment of severe sagittal imbalance.

Fig. 3 A case of severe sagittal imbalance. Pelvic incidence 54° . Pelvic tilt 40° , SVA 22 cm, lumbar kyphosis 1° . Predicted values for a good alignment are lumbar lordosis 64° and pelvic tilt less than 16°

Conflict of interest Pedro Berjano is a consultant of Nuvasive and Zimmer Spine for Surgeon's Education Activities. Claudio Lamartina is a consultant of Zimmer Spine and DePuy Synthes for Surgeon's Education Activities.

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Fig. 4 The same patient in Fig. 3, postoperatively. L4 pedicle subtraction osteotomy (PSO) creates a lordosis of 49° at L3–L4. Global lumbar lordosis is corrected to 64° . Pelvic tilt is restored to 15° . SVA -3.8 cm. PSO was felt to be the only technique that could reliably obtain the amount of correction needed in this case

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