J NEUROSURG SCI 2014;58(Suppl. 1 to No. 2):97-100

Surgical challenges of fixed spine: how to restore a fixed imbalance?

M. BOZZARO, F. TARTARA, M. AJELLO, A. FIUMEFREDDO, N. MARENGO
F. PECORARO, D. GARBOSSA, F. ZENGA, A. DUCATI

Department of Neurosurgery
University of Turin, Turin, Italy

During the last years the importance of sagittal balance in spine surgery has become even more important. Restoring the correct balance of the spine is crucial to warrant the success of every surgical procedure preventing the failure of the devices, junctional fractures, pullout of the screws, thus having an enormous importance in terms of postoperative quality of life and relief of back pain.[1, 2] Every surgical procedure should therefore be planned preoperatively on the basis of the patient's pelvic incidence, eventual pelvic tilt increase, loss in lumbar lordosis and thoracic kyphosis (Figure 1).[3, 4]

The goal of surgery is to have the C7 plumbline above the posterior edge of S1 endplate, and to have an harmonic succession of cervical lordosis, thoracic kyphosis, lumbar lordosis and a non everted pelvis. The rule that grossly regulates the succession of the thoraco-lumbo-pelvic curves is TK=PI=LL-10°.[5-9]

Surgical considerations

In sagittal imbalance it is important to restore the correct alignment and this can be achieved working on the segmental lordosis of the disc when performing an intersomatic fusion and on the osseous structures in cases of important hypolordosis (>20°), in witch osteotomies have to be performed to gain a more lordotic shape of the vertebral bodies.

In some cases the imbalance is related to the presence of a misalignment due to the presence of fixed curves that can't be treated without forcing the osseous structures.

This may happen in cases of severe arthrosis, previous surgical fusions, fusion of the discal space, ankylosing spondylitis, and other situations that represent a surgical challenge.

The importance of the correction of fixed curves is the possibility to restore the correct amount of lordosis in the lumbar spine, to reduce hyperkyphosis in the thoracic spine, to decompress nervous structures and to avoid hyperkyphotic angle above long arthrodesis that may lead to junctional fractures.

A partial correction of a lumbar hypolordosis without the correction of a fixed hyperkyphosis, will leave the C7 plumbline far from falling in the right point of the S1 endplate (Figures 1-3).

If the fixed curve is due to a fused disc it may be possible to force the reopening of the discal space. This is of major importance in L5-S1 where the maximal amount of lordosis should be obtained and where the most important discopathies usually occur. Fusion of the discal space usually starts from the posterior edge, from lateral to medial. For this reason, when approaching the spine by a posterior way care should be taken in removing osteophytes and fusions of the lateral part of the disc before forcing the opening of the space. The most effective approach to achieve a correct opening of the discal space is an anterior approach. Usually the anterior part of the anulus is not fused and it's possible to gently force the reopening of the discal space with

Corresponding author: M. Bozzaro, Dipartimento Neuroscienze, Università di Torino, Via Cherasco 15 10126, Torino, Italia.
E-mail: y.mbozzaro@yahoo.it

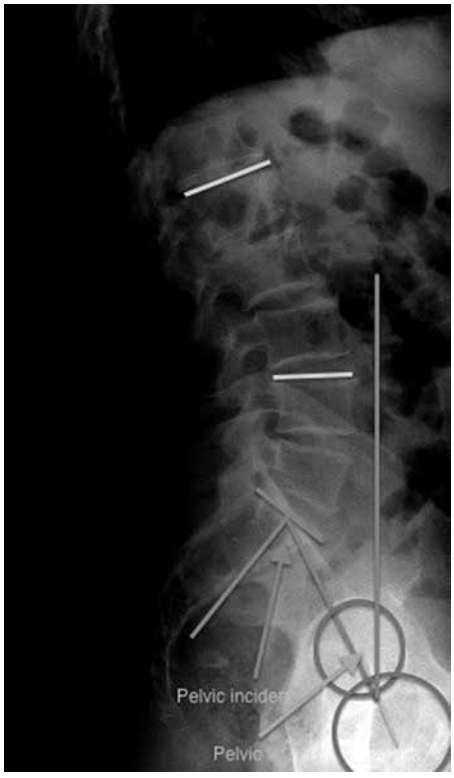

Figure 1.—Loss in lumbar lordosis and thoracic kyphosis.

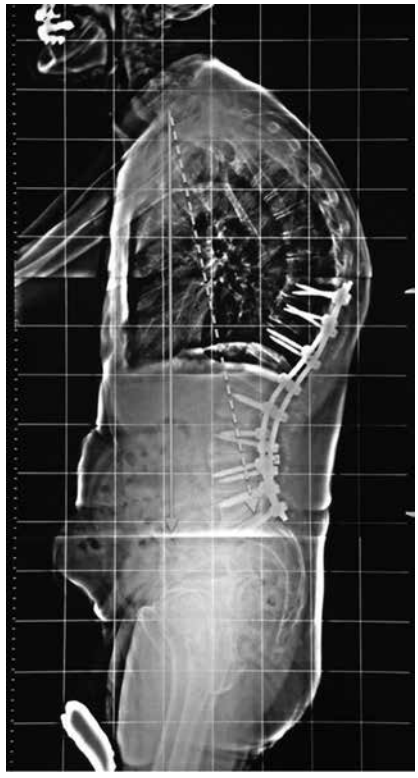

Figure 2.—Partial correction of a lumbar hypolordosis.

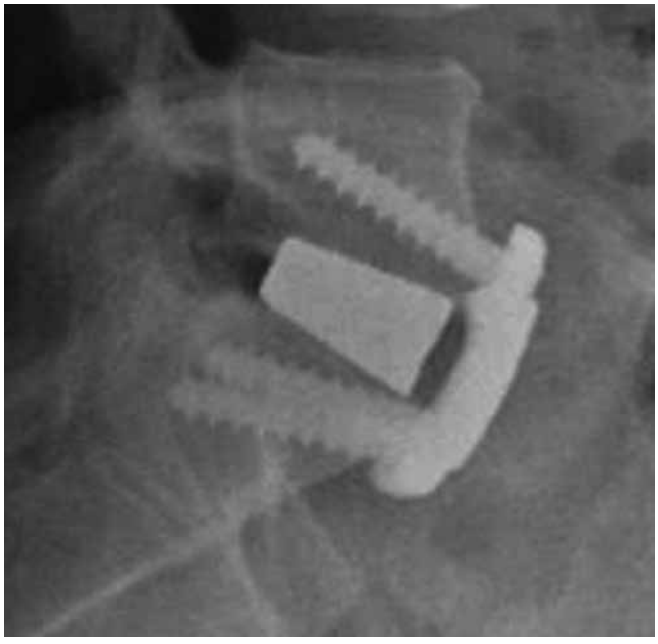

Figure 3.—Partial correction of a lumbar hypolordosis.

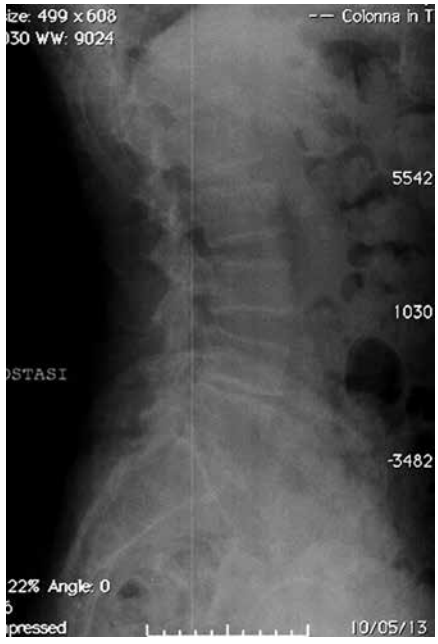

Figure 4.—Before surgery: flat L4-L5 disc.

Figure 5.—After PLIF 12° of segmental lordosis.

a Cobb elevator and distractors and to directly put a cage to maintain the achieved correction.

The posterolateral interbody fusion is a very useful procedure to correct segmental hypolordosis by using short lordotic cages put as anterior as possible and fixing the segment with pedicular or transarticular screws. These procedures are very effective and permit to obtain an average amount of 10-13° of segmental lordosis also in almost fused discs (Figures 4, 5).

In cases of long fixed deformieties an osteotomy is usually needed.

The Smith-Petersen and the Ponte osteotomy (SPO) are two similar techniques that are used to treat hyperkyphotic segments. They consist of a posterior column removal that permits to use the middle column as the fulcrum for a posterior compression. When performed at multilevel segments these techniques warrant a gain of almost 10° of lordosis for each level. These procedures are very useful in the correction of fixed hyperkyphotic thoracic segments, in particular in ankylosing spondylitis.

In case of a straight fixed spine these techniques may even not work, and it's necessary to perform three columns osteotomies.

Actually three possible procedures are usually performed: pedicular subtraction osteotomy (PSO), corner osteotomy and total vertebral resection.

The PSO consists of the removal of all the posterior structures and of an osteotomy performed via a transpedicular way to remove a lordotic wedge and after it to close the osteotomy with a fracture of the anterior wall, and to better fuse the osteotomized vertebra adjacent cages can be placed.[10-12]

In the corner osteotomy, after the removal of the posterior column, the osteotomy is performed in the direction of the cranial disc space that is also removed and replaced with a cage. Both procedures are really effective and permit to obtain up to 30-40° of lordosis for each level. Because of the invasiveness a great blood loss (=/>1500 cc) should be expected. The great amount of correction that can be obtained by this way should be considered because not every part of the column can tolerate such an important lordotic angle in particular in the thoracic segment, so it's necessary to plan the amount of lordosis and therefore the importance of the osteotomy that can be performed for each level. It should also be remembered that the maximum amount of lordosis should be in the L4-S1 part so the osteotomy should be performed as caudal as possible.

Conclusions

The treatment of the either monosegmental or multilevel long fixed spine due to degenerative pathology, ankylosing spondylitis or previous intervention is a challenging surgery that should always take in care four rules:

1. always calculate spinopelvic parameters (also in monosegmental pathology);
2. plan the surgical strategy;
3. never treat spine without correcting the sagittal balance;
4. never leave rigid kyphotic angles above the instrumented spine.

Following these rules as far as we know the best results may be achieved in terms of clinical outcome, sagittal balance alignment pelvic tilt restoring and prevention of further complications due to instrumentation failure or adjacent segment disease.

References

1. Lafage V, Schwab F, Patel A, *et al*. (2009) Pelvic tilt and truncal inclination: two key radiographic parameters in the setting of adults with spinal deformity. Spine 34:599-606.
2. Lamartina C, Berjano P, Petruzzi M, *et al*. (2012) Criteria to restore sagittal balance in deformity and degenerative spondylolisthesis. Eur Spine J 21:27-31.
3. Mac-Thiong JM, Roussouly P, Berthonnaud E, Guigui P (2010) Sagittal parameters of global spinal balance: normative values from a prospective cohort of seven hundred nine Caucasian asymptomatic adults. Spine 35:1193–1198.
4. Boulay C, Tardieu C, Hecquet J, Benaim C, Mouilleseaux B, Marty C, Prat-Pradal D, Legaye J, Duval-Beaupère G, Pélissier J (2006) Sagittal alignment of spine and pelvis regulated by pelvic incidence: standard values and prediction of lordosis. Eur Spine J 15:415–422.
5. Rose PS, Bridwell KH, Lenke LG, Cronen GA, Mulconrey DS, Buchowski JM, Kim YJ (2009) Role of pelvic incidence, thoracic kyphosis, and patient factors on sagittal plane correction following pedicle subtraction osteotomy. Spine 34:785-91.
6. Schwab F, Lafage V, Patel A, Farcy JP (2009) Sagittal plane considerations and the pelvis in the adult patient. Spine 34:1828–1833.
7. Bernhardt M, Bridwell KH (1989) Segmental analysis of the sagittal plane alignment of the normal thoracic and lumbar spines and thoracolumbar junction. Spine 14:717–21.
8. Gelb DE, Lenke LG, Bridwell KH, *et al*. (1995) An analysis of sagittal spinal alignment in 100 asymptomatic middle and older aged volunteers. Spine 20:1351–8.
9. Jackson RP, Hales C (2000) Congruent spinopelvic alignment on standing lateral radiographs of adult volunteers. Spine 25:2808–15.
10. Smith-Petersen MN, Larson CB, Aufranc OE (1969) Osteotomy of the spine for correction of flexion deformity in rheumatoid arthritis. Clin Orthop Relat Res 66:6-9.
11. Bridwell KH, Lewis SJ, Lenke LG, Baldus C, Blanke K (2003) Pedicle subtraction osteotomy for the treatment of fixed sagittal imbalance. J Bone Joint Surg Am 85(3):454-63.
12. Cho KJ, Bridwell KH, Lenke LG, Berra A, Baldus C (2005) Comparison of Smith-Petersen versus pedicle subtraction osteotomy for the correction of fixed sagittal imbalance. Spine 30(18):2030-7.

Conflicts of interest.—The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.