Eur Spine J (2015) 24 (Suppl 1):S107–S111
DOI 10.1007/s00586-014-3657-4

ORIGINAL ARTICLE

Osteotomies through a fusion mass in the lumbar spine

Jean-Marc Vital · Louis Boissière · Anouar Bourghli · Jean-Etienne Castelain · Vincent Challier · Ibrahim Obeid

Received: 18 September 2014 / Revised: 1 November 2014 / Accepted: 1 November 2014 / Published online: 22 November 2014

Abstract
Introduction Flat-back syndrome is one of the main causes of surgical failure after lumbar fusion and can lead to a revision surgery to correct it. Three-column pedicle subtraction osteotomy is an efficient technique to restore lumbar lordosis (LL) for fixed sagittal malalignment. The fusion mass stemming from the past surgeries makes the procedure demanding as most anatomical landmarks are missing.
Material and methods This review article will focus on the correction of this lack of LL through the fusion mass. We will successively review the preoperative management, the surgical specificities, and various types of clinical cases that can be encountered in flat-back syndromes.
Conclusion PSO in the fixed fusion mass is technically demanding. Preoperative CT-scan and preoperative navigation allow us to push the limits when anatomical landmarks disappear. Bleeding and neurologic are the two major complications feared by the surgeon. The best way to avoid these revision surgeries is to restore a proper lumbar lordosis at the time of initial surgery by considering lumbo-pelvic indexes.

Keywords Lumbar lordosis · Pedicle subtraction osteotomy · Sagittal malalignment · Revision surgery · Lumbar fusion

Introduction

Iatrogenic lack of lumbar lordosis following thoracolumbar instrumentation remains one of the main causes of surgical failure [1]. If the term of flat-back syndrome was introduced by Moe and Denis in 1976 [2], the pelvic parameters' understanding made, considering spinal fusion surgery, proper lumbar lordosis (LL) restoration unavoidable [3]. The loss of LL is actually recognized as source of disability and pain [4] leading to various symptoms including difficulties to stand upright. Initially described in ankylosing spondylitis [5], three-column pedicle subtraction osteotomy (PSO) is an efficient technique to restore LL in fixed sagittal malalignment pathologies including flat-back syndrome [6]. With a single lumbar PSO, a gain of 30° to 40° focal LL can reasonably be obtained [7]. Despite its efficiency, PSO is a technically demanding procedure and up to 35 % of major complications are reported [8]. The presence of a posterior fusion mass, induced by previous posterior fusion surgeries, makes the procedure more demanding when taking into account the loss of most anatomical landmarks (Fig. 1). This article will focus on the realization of a PSO through a fusion mass in the lumbar spine by reviewing preoperative management, surgical specificities and a presentation of clinical cases encountered when a flat-back syndrome occurs.

Preoperative management

Muscular pain, forward inclination of the trunk, inability to stand erect and walking difficulties are the main clinical manifestations of sagittal malalignment. Flat-back syndrome can occur following spinal deformity procedures but can also be encountered following degenerative short spinal fusions especially when the L4–S1 segments are fused considering that LL mostly concerns the lower lumbar spine [9]. When flat-back syndrome is suspected, radiologic parameters have been described to confirm the

J.-M. Vital · L. Boissière (✉) · A. Bourghli · J.-E. Castelain · V. Challier · I. Obeid
Orthopedic Department, Spine Unit 1, Bordeaux University Hospital, Bordeaux, France
e-mail: boissierelouis@yahoo.fr

Fig. 1 Previous posterior fusion surgeries result in a fusion mass and loss of all anatomic landmarks

Fig. 2 A preoperative CT-scan is essential for preoperative planning. In this figure, we can observe two misplaced screws, the presence of a fusion mass, the absence of laminectomy, the absence of facet joints that are completely fused and the presence of both transverse processes

diagnosis such as lumbo-pelvic indexes [10]. These indexes are important to consider as sagittal malalignment can occur without a raise of the sagittal vertical axis, radiologic manifestation of the trunk inclination [11]. Sagittal malalignment is a dynamic manifestation; static full spine radiographies can mask the trunk inclination, which may occur during the movement and effort. Considering the patient's disability and demand, a revision surgery can be proposed and the amount of correction needed must be calculated examining full spine radiographies to restore a proper balance [12, 13]. A PSO may then be considered in case of a circumferential fusion or if an important correction is needed. Considering this major surgery includes a careful preoperative planning as during the procedure time passes must be used to achieve the technical gesture to decrease bleeding time. In revision surgeries, a preoperative CT-scan seems mandatory to consider: previous instrumentation, importance of the fusion mass, an eventual laminectomy or a potential pseudarthrosis and anatomical landmarks (for instance, when a laminectomy has been performed, the facet joints are usually preserved) (Fig. 2). A preoperative MRI, despite artifacts generated by a previous instrumentation, is also needed to detect spinal stenosis, nerve root compression or the presence of iatrogenic meningocele. The PSO level is most commonly located at L3 or L4 vertebra as it offers a maximum correction possibility and is classically located at the apex of normal LL. The choice for PSO level must also be balanced according to information from previous imaging exams such as the kyphosis apex or the presence of a pseudarthrosis [14].

Surgical procedure

Since Thomasen's report in 1985 [5], PSO procedure has widely been described [15] and we will rather emphasize the specific aspects of a posterior fusion mass presence. After a classical exposure, the previous instrumentation will be removed entirely or partially depending on the number of intervertebral level previously fused. A connection to the upper part of the instrumentation with dominos is a possibility to avoid an extensive approach and increased soft tissue damage. The pedicle screws will then be placed. For lumbar spinal osteotomies, fixation to the sacrum is most frequently needed and we recommend associating iliac screws for an optimal distal fixation [16]. The instrumentation positioning can be challenging and the contribution of navigation can be particularly useful (Fig. 3) [17]. Navigation can also guide the surgeon through the surgical field to identify local anatomy during the PSO performance [18]. Before starting the vertebral resection and the spinal canal opening, we recommend to control the lateral walls, after exposing and cutting the transverse processes that are frequently still present. The lateral wall control presents many advantages: it is mostly undisturbed by previous surgeries; it enables control of the segmental vessels laterally and the dura is not exposed during this technically demanding procedure. We

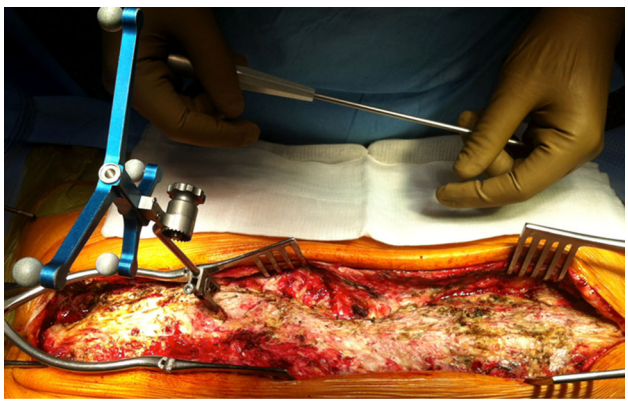

Fig. 3 Preoperative CT-scan and navigation can be particularly useful to identify the local anatomy to place the instrumentation and to guide the osteotomy

Fig. 4 Flat-back syndrome following a scoliosis surgery. We can observe L5–S1 spondylolisthesis. L3 PSO was performed to correct the sagittal malalignment

recommend continuing the dissection to the anterior wall on both sides and to put a large piece of surgicel, which will protect the soft tissues and serve as a benchmark. The spinal canal will then be opened. If possible after preoperative CT-scan examination, facetectomies will be performed but in case of a complete fusion mass the canal opening must be performed considering the PSO closure. We recommend the use of the high-speed bur for this phase of the intervention. After the dura exposure, the osteotomy will classically be performed with the osteotomes and the lateral wall removed. Special attention should be made when closing the osteotomy to avoid dura entrapment. The whole procedure should be supervised by a neuromonitoring and if possible realized by an experienced neurophysiologist.

Case presentation

The following cases summarize different clinical situations that may occur but considering flat-back syndromes. All patients were operated by the same surgeon (IO).

Flat-back syndrome following failed adolescent spinal deformity surgery (Fig. 4)

Case of a 28-year-old women presenting a L5 bilateral radicular pain and walking difficulties. She underwent a scoliosis surgery several years ago and on the preoperative

Fig. 5 Iatrogenic flat-back following L4–L5 fusion. L4 PSO was performed to correct the LL lack

Fig. 6 Postoperative flat-back syndrome after multiple surgeries. L4 PSO was performed through the fusion mass to correct the balance

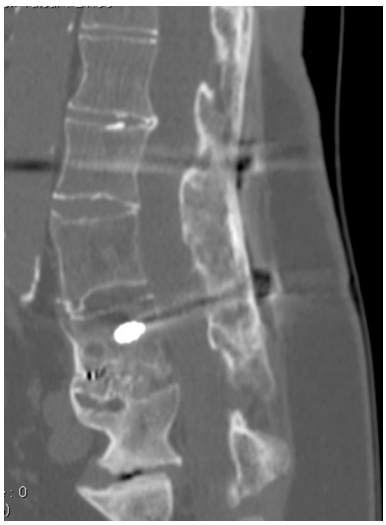

Fig. 7 Preoperative posterior fusion mass with lack of all anatomical landmarks

radiography we can observe L5–S1 spondylolisthesis associated to a severe lack of lumbar lordosis (Lumbar Lordosis Index (LLI) = 0.4) [11]. Her high pelvic incidence allows her an important pelvic retroversion to compensate her malalignment (PT = 40°). L3 PSO with resection of the disc above was performed to correct the sagittal malalignment with a 35° LL gain. L5–S1 interbody cage was also placed to prevent the pseudarthrosis risk with regard to the spondylolisthesis.

Flat-back syndrome following short lumbar segment fusion (Fig. 5)

Case of a 71-year-old man presenting walking difficulties, lumbar pain and an anterior departure of the trunk while walking. It is interesting to note on the EOS radiography that SVA is preserved. His PI of 45°, his pelvic retroversion moderately increased, and the main compensatory mechanism is thoracic hypo-kyphosis. The LLI of 0.37 signs the sagittal malalignment and L4 PSO was performed with a satisfying result and correction of the thoracic kyphosis.

Flat-back syndrome following an important spinal surgery past history (Figs. 6, 7)

Case of a 54-year-old woman, who underwent multiple previous surgeries for a thoracolumbar scoliosis. Lumbar kyphosis and a trunk ante-flexion are observed on the preoperative X-Ray. On the CT-scan, an important fusion mass is present. L4 PSO and L5–S1 Ponte osteotomies

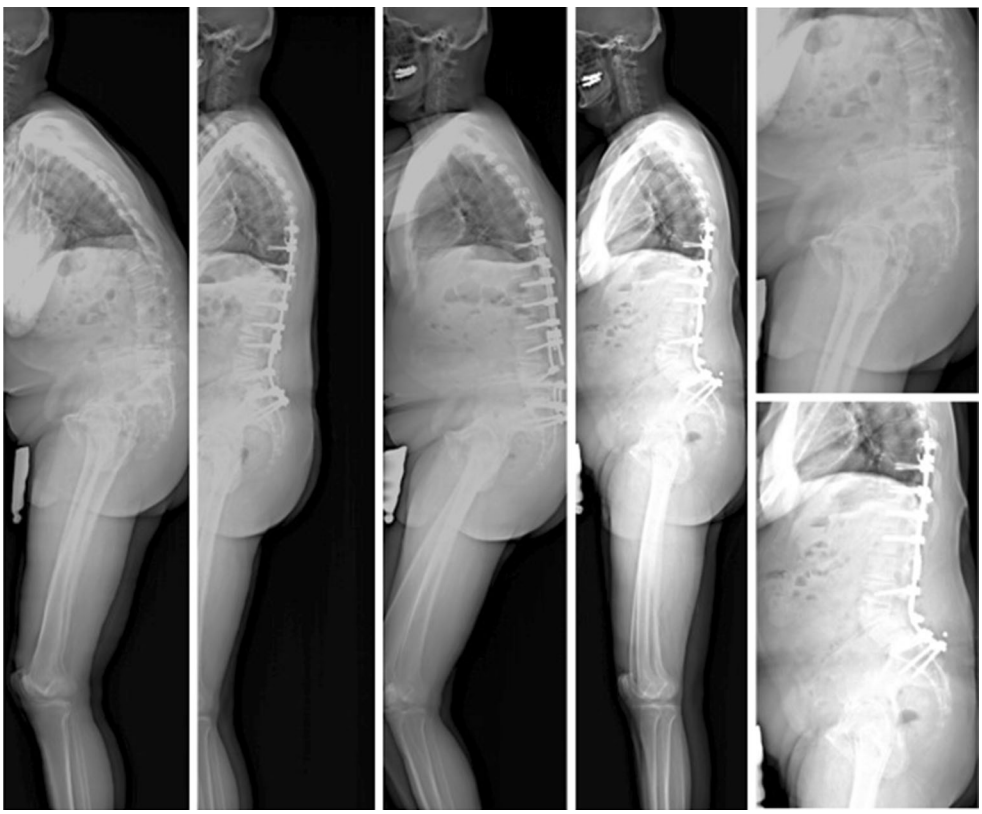

Fig. 8 Camptocormia treated successively by a L4 and L5 PSO after pseudarthrosis and lack of correction occurrence

were performed with navigation help during the surgery. This allowed a 45° increase of LL.

Flat-back syndrome following a lumbar pseudarthrosis (Fig. 8)

Case of a 50-year-old man presenting a clinical camptocormia. L4 PSO was performed with a 40° lumbar lordosis gain. Despite important correction, the postoperative LLI was 0.64 and L4–L5 pseudarthrosis with rod breaking. The treatment of the pseudarthrosis would not have corrected the remaining postoperative lack of LL. L5 PSO was performed with L4–L5 disc removal to treat simultaneously pseudarthrosis and postoperative flat back. Postoperative balance was satisfying with a 0.75 LLI. The option of realizing L5 PSO was based on the L4–L5 pseudarthrosis.

Conclusion

PSO is an efficient technique to restore lordosis in the kyphosis lumbar spine in the fixed fusion mass but it remains technically demanding. Preoperative CT-scan and preoperative navigation allow us to push the limits when anatomical landmarks disappear. Bleeding and neurologic are the two major complications feared by the surgeon. The best way to avoid these revision surgeries is to restore a proper lumbar lordosis at the time of initial surgery by considering lumbo-pelvic indexes.

Conflict of interest No fundings were received for this work.

References

1. Lazennec JY, Ramare S, Arafati N, Laudet CG, Gorin M, Roger B, Hansen S, Saillant G, Maurs L, Trabelsi R (2000) Sagittal alignment in lumbosacral fusion: relations between radiological parameters and pain. Eur Spine J 9(1):47–55
2. Moe JHDF (1977) The iatrogenic loss of lumbar lordosis. Orthop Trans 1:131
3. D-B G (2004) Composante sagittale de la statque rachidienne. Revue de Rhumatologie 71:115–119
4. Gelb DE, Lenke LG, Bridwell KH, Blanke K, McEnery KW (1995) An analysis of sagittal spinal alignment in 100 asymptomatic middle and older aged volunteers. Spine (Phila Pa 1976) 20(12):1351–1358
5. Thomasen E (1985) Vertebral osteotomy for correction of kyphosis in ankylosing spondylitis. Clin Orthop 194:142–152
6. Hyun SJ, Kim YJ, Rhim SC (2013) Spinal pedicle subtraction osteotomy for fixed sagittal imbalance patients. World J Clin Cases 1(8):242–248. doi:10.12998/wjcc.v1.i8.242
7. Kim YJ, Bridwell KH, Lenke LG, Cheh G, Baldus C (2007) Results of lumbar pedicle subtraction osteotomies for fixed sagittal imbalance: a minimum 5-year follow-up study. Spine (Phila Pa 1976) 32(20):2189–2197. doi:10.1097/BRS.0b013e31814b8371
8. Auerbach JD, Lenke LG, Bridwell KH, Sehn JK, Milby AH, Bumpass D, Crawford CH 3rd, O'Shaughnessy BA, Buchowski JM, Chang MS, Zebala LP, Sides BA (2012) Major complications and comparison between 3-column osteotomy techniques in 105 consecutive spinal deformity procedures. Spine (Phila Pa 1976) 37(14):1198–1210. doi:10.1097/BRS.0b013e31824fffde
9. Wiggins GC, Ondra SL, Shaffrey CI (2003) Management of iatrogenic flat-back syndrome. Neurosurg Focus 15(3):E8
10. Boissiere L, Vital JM, Aunoble S, Fabre T, Gille O, Obeid I (2014) Lumbo-pelvic related indexes: impact on adult spinal deformity surgery. Eur Spine J. doi:10.1007/s00586-014-3402-z
11. Boissiere L, Bourghli A, Vital JM, Gille O, Obeid I (2013) The lumbar lordosis index: a new ratio to detect spinal malalignment with a therapeutic impact for sagittal balance correction decisions in adult scoliosis surgery. Eur Spine J 22(6):1339–1345. doi:10.1007/s00586-013-2711-y
12. Lamartina C, Berjano P, Petruzzi M, Sinigaglia A, Casero G, Cecchinato R, Damilano M, Bassani R (2012) Criteria to restore the sagittal balance in deformity and degenerative spondylolisthesis. Eur Spine J 21(Suppl 1):S27–S31. doi:10.1007/s00586-012-2236-9
13. Aurouer N, Obeid I, Gille O, Pointillart V, Vital JM (2009) Computerized preoperative planning for correction of sagittal deformity of the spine. Surg Radiol Anat 31(10):781–792. doi:10.1007/s00276-009-0524-9
14. Barrey C, Perrin G, Michel F, Vital JM, Obeid I (2014) Pedicle subtraction osteotomy in the lumbar spine: indications, technical aspects, results and complications. Eur J Orthop Surg Traumatol 24(Suppl 1):S21–S30. doi:10.1007/s00590-014-1470-8
15. Obeid I, Bourghli A, Vital JM (2012) Pedicle subtraction osteotomy for postoperative flat back and sagittal imbalance. Eur Spine J 21(6):1218–1219. doi:10.1007/s00586-012-2359-z
16. Moshirfar A, Rand FF, Sponseller PD, Parazin SJ, Khanna AJ, Kebaish KM, Stinson JT, Riley LH 3rd (2005) Pelvic fixation in spine surgery. Historical overview, indications, biomechanical relevance, and current techniques. J Bone Joint Surg Am 87(Suppl 2):89–106. doi:10.2106/JBJS.E.00453
17. Hsieh JC, Drazin D, Firempong AO, Pashman R, Johnson JP, Kim TT (2014) Accuracy of intraoperative computed tomography image-guided surgery in placing pedicle and pelvic screws for primary versus revision spine surgery. Neurosurg Focus 36(3):E2. doi:10.3171/2014.1.FOCUS13525
18. Obeid I, Bourghli A, Boissiere L, Vital JM, Barrey C (2014) Complex osteotomies vertebral column resection and decancellation. Eur J Orthop Surg Traumatol 24(Suppl 1):S49–S57. doi:10.1007/s00590-014-1472-6