Treatment of high-grade spondylolisthesis with Schanz recoil screws: our experience

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Abstract

Purpose Spondylolisthesis surgical treatment is often difficult with higher degree of slip and related techniques still debated. We have taken into consideration double thread recoil Schanz screws. This system should allow the best reduction of the slip, treating only the affected vertebrae.

Methods We retrospectively analyzed 46 patients affected by grade II or higher spondylolisthesis, treated with circumferential arthrodesis using Schanz screws. Duration of surgery, complications, reduction, and rate of fusion have been recorded.

Results We found that duration of surgery and complications were similar or slightly lower if compared to our standard Posterior Lumbar Interbody Fusion procedures. However, radiological results and clinical outcome appear better in cases treated with Schanz screws.

Conclusions Fixation system with Schanz screws seems to be effective in reducing the slip, treating only the affected level, in high grade of spondylolisthesis.

Keywords Spondylolisthesis · Reduction · Fusion · Posterior · Schanz

Introduction

Starting from the first issue of Herbiniaux, in 1782 [1], Spondylolisthesis was studied and debated by various surgeons and pathologist (Rokitansky, Killian, Capener, Wiltse, etc.) [2, 3] not only about the etiopathogenesis and classification, but also about conservative or surgical treatment and its correct timing.

Many studies have been published and a lot of treatments have been proposed for the various types and grades of spondylolisthesis, thus creating controversy about which kind of treatment is more suitable for any single case. Reducing the slip before fusion is an attractive concept, and for specific form could be advisable; in other cases the surgical reduction versus “in situ” fusion, versus decompression alone, remains controversial.

Current classifications of spondylolisthesis are those by Wiltse et al. [3], and by Marchetti and Bartolozzi [4].

The historical classification proposed by Wiltse–Newmann–McNab [3], based on the pathogenesis and anatomy, describes six forms of Spondylolisthesis: type I or dysplastic, type II or isthmic, type III or degenerative; type IV or traumatic; type V or pathologic; type VI or post-surgical.

A second classification based on etiology is proposed by Marchetti and Bartolozzi [4]. They divided spondylolisthesis into two types: congenital or developmental forms, further divided in low-dysplastic type (with normal lumbo-sacral profile and no pelvic retroversion or hyperlordosis) and high dysplastic type (with high risk of slip progression, presence of pelvic retroversion and hyperlordosis, high risk of loss of the sagittal balance) and acquired forms, sub-classified in post-traumatic, post-surgical, pathologic, degenerative. This latter classification is more practiced and well correlated with the current surgical indications.

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Another way to classify spondylolisthesis is based on the amount of slipping. Meyerding [5], in 1932, defined four grades of listhesis, dividing the underlying vertebral plate into four parts and measured the slip of the upper vertebra on it: type I (<25 %), type II (25–50 %), type III (50–75 %), type IV (>75–100 %). Later was added a type V or spondyloptosis (>100 %). An easier method is the one proposed by Tayllard [6]; it measures directly the percentage of slip between the two vertebrae (0–100 %).

There is general consensus [7–9] that majority of spondylolisthesis is asymptomatic or with mild symptoms, requiring only conservative management. In symptomatic cases (disabling low back pain, radiculopathy, sphincter dysfunction, claudication, etc.) a surgical approach is often advisable.

The etiological classification describes the concept of low and high dysplastic forms that is basic in the surgical planning. In a fundamental study, Lamartina et al. [10] in 2001 and then in 2009 [11], well discussed about the potential risks in high dysplastic spondylolisthesis. A treatment without reduction is not sufficient in such cases, as the hazard of slip worsening is very high. Lamartina also introduced the concepts of Severity Index and Unstable Zone that could be always defined and studied, when surgeons decide to treat this kind of listhesis. Other authors [12–16] proposed postero-lateral fusion only, even without decompression [17, 18], as surgical treatment, showing relative good results, in their series.

Other authors [19–25], conversely, observed a better outcome in patients, with high grade of slip, treated with circumferential fusion and reduction.

In our opinion, in presence of a high grade of slip, the optimal surgical solution for a stable fusion requires a reduction to restore physiological alignment of vertebral bodies and transverse processes. This increases the area for interbody fusion, and recovers the physiological sagittal balance. Furthermore, achieves good reduction, allows a better release of nerve roots and prevents early degenerative changes at the adjacent discs.

We tried various reduction methods, during the years: levers of various shapes and use, persuaders applied with bars and bridging at the top level, screws decoy mechanism with a long tulip and progressive inner nut, decoy screws with double thread and progressive recoiling as Schanz pedicle screws.

We treated acquired forms and low-dysplastic spondylolisthesis with this latter system of fixation and reduction. It allows a gradual and gentle reduction of the listhesis, avoiding to exert excessive tension on the vertebrae, ligaments and nerve roots too. This system also allows the treatment of listhesis acting only on one level, limiting the operative time; the risks of malposition of the screws, the post-operative pain, and than the rigidity of the spine, and also the probability of developing a junctional syndrome.

Materials and methods

We treated 46 patients with various kinds of higher than grade I spondylolisthesis between January 2006 and October 2010, at the University Department of Neurosurgery in Pavia and at the Spine Surgery Unit of the Centro Ortopedico di Quadrante in Omegna (VB). All these cases had a follow-up of at least 2 years. We measured for each case radiological reduction of slip and fusion rate, surgical complications, operative time, blood loss and clinical outcome.

We treated 19 males and 27 females; the average age was of 50.4 years (range 19–68 years). All patients underwent a single-level fusion, mainly at L5–S1 (50 %), then at L4–L5 (37 %), L3–L4 (11 %) and L2–L3 (2 %). Nearly all patients underwent interbody fusion with cages by posterior approach (PLIF) and only in two cases we have decided to reduce and stabilize with postero-lateral approach only.

The series involved patients affected by various types of spondylolisthesis: degenerative (57 % of cases), isthmic (31 %, Fig. 1), traumatic (6 %) and post-surgical (6 %). We have to remark that in the isthmic group, we included some cases of developmental or dysplastic spondylolisthesis, but all these patients showed characteristics of low-dysplastic type. We decided to exclude from the series the cases presenting signs of high dysplasia. For this latter group, we adopted the same considerations about the reduction well discussed by Lamartina [10].

Our group of patients showed a degree of slipping more than 25 % (average 40 % before surgery, range 25–80 %) according to the Tayllard [6] classification system. Using Meyerding scale [5] patients presented a listhesis of at least II degree (63 %); the grade III group was 35 % of the series, and one patient (2 %) was grade IV.

The principal symptoms complained by patients were: chronic and disabling low back pain (more than 50 % of

Fig. 1 Example of spondylolisthesis: isthmic lysis type (a) and the slippage (b)

the cases), radiculopathy pain with or without motor or sensory deficits (31 %), neurogenic claudication (15 %) and two cases (4 %) of sphincter dysfunctions.

Patients underwent surgical reduction using the dedicated instrumentation for pedicle screwing described below. We always use intraoperative fluoroscopic control, advisable for a safe surgery. During the exposure time, it is important to visualize the head of the transverse processes, for a safe screwing, in particular for the slipped vertebra. Two “standard” pedicle screws are placed in the caudal vertebra, while two double-threaded Schanz screws are placed in a convergent way, to reduce the risk of pull-out during the reduction maneuvers, in the slipped vertebra. Then two rods are tightened to the lower screws and mounted to Schanz screw clamps above. Acting on the screws in a divergent way is possible to better visualize the disc space. A wide discectomy is now performed and the vertebral plates are prepared for the interbody fusion. In this moment it is important the action of the spreader that can help to release the slipped vertebra, enhancing the correction of the listhesis. At this point, the reduction is completed using two cannulas system placed on the Schanz screws; the progressive and combined spin of the cannulas on these special screws allows a gradual but strong reduction (Fig. 2). Obtained the required realignment, interbody fusion is performed, introducing in the disc space two cages filled with morselized autologous bone. Now it is possible to lock the screws with dedicated nuts, giving a mild compression to tighten cages and restore lumbar lordosis. In addition, bone grafting on the transverse processes is advisable for additional postero-lateral fusion.

Fusion rates were assessed by static and dynamic X-rays film at 1, 3 and 6 months and by CT scan at 3 and 12 months after surgery. Radiological fusion was identified by the formation of trabecular bony bridges between contiguous vertebral bodies at the instrumented levels. This goal usually is obtained in 3 months, often linked to a clear improvement of the residual low back pain at follow-up. Without radiological confirmation of fusion, we consider

acceptable a stable and clinically silent fixation with $<3^\circ$ of segmental movement at dynamic X-ray investigations.

Clinical outcome was analyzed recording Visual Analogue pain Scale (VAS) and Oswestry Disability Index (ODI) before surgery and after 1, 6, 12 and 24 months. The majority of these data was obtained calling patients by phone and interviewing theme.

Statistical analyses were performed using Student's *t* test; *P* values below 0.05 were accepted for significance.

Results

The radicular and the low back pain evaluated by VAS improved after surgery from 7.7 ± 2.3 to 3.4 ± 2.7 (3 months later) and to 2.1 ± 2.5 (after 6 months). After this period, further clinical evaluation showed us stable conditions. Oswestry Disability Index improved from 55.4 ± 16.5 to 29.4 ± 23.3 (3 months later) and to 15.1 ± 18 (after 6 months) (Fig. 3).

Operative time was not different from the time needed for a standard PLIF (approximately 190 min), as well as mean hospital stay after surgery (3.7 days) and blood loss (about 500 ml for each procedure, but with a wide range, 220–1,400 ml).

Eight patients required blood transfusion. There were also two significant dural tears with CSF leak, treated by surgical revision. In three cases, we observed significant radiculopathy due to pedicle screws malplacement, reoperated in a few days, with good recovery. Two cases complicated with wound infections were treated with debridement and antibiotics.

Interbody fusion, confirmed by the last X-ray check or CT was achieved in the 91 % of the cases (Figs. 4, 5). The remaining four patients developed the above-mentioned situation of stable fixation without mobility at dynamics X-ray controls and were clinically stable. In our follow-up

Fig. 2 Schanz pedicle screws in the listhesis vertebra (a) and progressive reduction (b)

Fig. 3 Improvement of VAS and ODI after surgery in our series

Fig. 4 Pre-operative imaging of a case

Fig. 5 Post-operative imaging with fusion signs at 6 months

we did not observe breakage of the implants or cages migration.

The slippage was significantly improved from 40 % (see Tayllard [6]), (range 25–80 %), before surgery, to 13 % (range 0–32 %). In nearly all cases of elevated degree of slip (grade II–IV, see Meyerding [5]) we obtained a reduction to grade I. In only one case of grade IV of severity, listhesis improved only to a grade II (32 %); maybe in this case, for precautionary reasons (old woman, important degenerative changes, initial osteoporosis), surgeons decided to not force the reduction.

We did not observe significant changes in the sagittal balance at the last radiological follow-up and until today we have not reported of any significant junctional pathology in these patients.

Discussion

When surgery is indicated, the optimal treatment of spondylolisthesis is yet controversial. The aforementioned work of Lamartina [10, 11] suggested us the evaluations and pre-operative measurements to define the high dysplastic developmental spondylolisthesis (HDDS) and the

relative optimal treatment, to prevent the risks of slip progression and the worsening of the sagittal balance of these patients. In low-dysplastic listhesis and in the other etiologically different types, many authors accept as optimal treatment the decompression alone or the postero-lateral fusion in situ, to avoid the risk of iatrogenic radicular damage or pedicle fracture, if bone is not of good “quality”, or yet the possibility of a pull-out of the screws during the energetic reduction maneuvers. A different more controlled way to reduce, need the involvement of three adjacent vertebrae by creating a bridge with the slipped element in the middle, but this option increase the risks related to the additional pedicle screwing. In our opinion for spondylolisthesis of different etiology, with degree of slip more than the first grade, see Meyerding (or 25 % see Tayllard), if reduction is possible with low risks and in a gradual and controlled way, this maneuver is always advisable. The body realignment gives us a major fusion surface, increasing the rate of success, releasing the ligamentous and muscular structures at the slipped level and normalizing the load distribution in the adjacent segments, thus limiting the potential adjacent disc degeneration. Also, for authors supporting the postero-lateral fusion in situ, we have noted more difficult to obtain this kind of fusion because the distance between the heads of the transverse processes is wider than in the reduced situation. Finally, restoring a normal anatomy, with a correct lordosis, is the first step to obtain a stable sagittal balance.

The instrumentation described above, allows us to obtain gradual, controlled and stable reduction, with very low operative risks, and the results of our series support our opinion. The fundamental moments of the reduction are the extended posterior decompression, with wide foraminotomy to visualize and control nerve roots during the maneuvers; the complete excision of the disc and the correct preparation of the plates with dedicated spreaders; finally the progressive traction force applied to the Schanz screws through the cannulas is sufficient to overcome the residual stiffness of the vertebra and to realign the lumbar segment.

Treating just one single level allows us to preserve a greater degree of mobility, thus decreasing the risks of a junctional disease.

Our series support all these aspects and the instrumentation employed is very easy to use, comparable with that used for a standard PLIF. Operation time, blood loss, hospital stay and complication, in our series are similar to the series treated without reduction or mild better than the series with more level involved. Despite our follow-up is limited, the clinical and radiological outcomes appear favorable with this kind of spondylolisthesis. In particular, very suggestive is the clear decrease of the ODI and VAS at the third month, when fusion usually is obtained; starting

from this month after operation, we noted also the progression of the radiological signs of the fusion too.

Conclusion

Even if our follow-up is quite limited, we believe that Schanz pedicle screws system is effective to reduce and correct spondylolisthesis of high grade of slip. The satisfactory clinical outcomes, the high rate of fusion and the low percentage of complications, suggest us that is possible, safe and advisable to try reduction in listhesis, especially in the cases of major degree of slip, waiting further series to confirm our results.

Conflict of interest None of the authors has any potential conflict of interest.

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