Limited access surgery for 360 degrees in-situ fusion in a dysraphic patient with high-grade spondylolisthesis

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Abstract

Progressive high-grade spondylolisthesis can lead to spinal imbalance. High-grade spondylolisthesis is often reduced and fused in unbalanced pelvises, whereas in-situ fusion is used more often in balanced patients. The surgical goal is to recreate or maintain sagittal balance but if anatomical reduction is necessary, the risk of neural damage with nerve root disruption in worst cases is increased. Spinal dysraphism like spina bifida or tethered cord syndrome make it very difficult to achieve reduction and posterior

fusion due to altered anatomy putting the focus on anterior column support. Intensive neural structure manipulation should be avoided to reduce neurological complications and re-tethering in these cases. A 26-year-old patient with a history of diastematomyelia, occult spina bifida and tethered cord syndrome presented with new onset of severe low back pain, and bilateral L5/S1 sciatica after a fall. The X-ray demonstrated a grade III spondylolisthesis with spina bifida and the MRI scan revealed bilateral severely narrowed exit foramina L5 due to the listhesis. Because she was well balanced sagittally, the decision for in-situ fusion was made to minimise the risk of neurological disturbance through reduction. Anterior fusion was favoured to minimise manipulation of the dysraphic neural structures. Fusion was achieved via isolated access to the L4/L5 disc space. A L5 transvertebral hollow modular anchorage (HMA) screw was passed into the sacrum from the L4/L5 disc space and interbody fusion of L4/L5 was performed with a cage. The construct was augmented with pedicle screw fixation L4–S1 via a less invasive bilateral muscle split for better anterior biomechanical support. The post-operative course was uneventful and fusion was CT confirmed at the 6-month follow-up. At the last follow-up, she worked full time, was completely pain free and not limited in her free-time activities. The simultaneous presence of high-grade spondylolisthesis and spinal dysraphism make it very difficult to find a decisive treatment plan because both posterior and anterior treatment strategies have advantages and disadvantages in these challenging cases. The described technique combines several surgical options to achieve 360° fusion with limited access, reducing the risk of neurological sequelae.

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Fig. 1 Pre-operative X-ray demonstrating Grade III spondylolisthesis and spina bifida

Case presentation

A 26-year-old girl presented with persistent low back pain she had been experiencing for 3 months with bilateral L5 and S1 sciatica after a fall from a horse. The patient complained of intermittent urinary incontinence with episodes of saddle anaesthesia. She had 3/5 muscular power in the L5/S1 myotomes without any sensory loss in the associated dermatomes. In her medical past, she was diagnosed with dysraphism soon after birth. She presented with a sacral dimple at that time but neither stigmata nor any neurological, urological or motor deficit were present. Plain films demonstrated the spina bifida and the performed CT myelogram showed the diastematomyelia between T12 to L2 with a bony spur, the low conus at L2 and a thick filum terminale. To forestall developmental retardation and symptomatic cord tethering, she underwent filum terminale

division at the age of 3 months. The only remnants of the dysraphic condition were a slightly smaller left foot and smaller circumferential muscle diameter compared to the right leg.

An up to date X-ray reported a spondylolisthesis at L5 graded Meyerding III with hypoplastic vertebral bodies L2 to L5 with absent or poorly developed posterior elements at L4 and 5 due to a congenital partial block vertebrae formation at that level (Fig. 1). The MRI scan approved the myelographic findings with disc degeneration at the L4/5 level and lytic defect at L5 (Fig. 2). Since adequate conservative measures taken over 6 months had failed, a decision for surgical treatment was made.

Diagnostic imaging section (Figs. 1, 2)

Historical review of the condition, epidemiology, diagnosis, pathology, differential diagnosis

Spondylolisthesis normally occurs in adolescence possibly leading to increased deformity, pain and neurological compromise due to the slip of the upper vertebral endplate which is in majority seen at L5 [1]. The commonly used Meyerding classification for spondylolisthesis is based on the translational movement of the cephalad vertebra on the sacrum in the lateral plain film. A slip of more than 50% (Meyerding Grade III) is defined as high-grade spondylolisthesis. The postural sagittal balance in these cases is defined by the pelvic parameters pelvic tilt (PT) and the sacral slope (SS), with their arithmetical sum the pelvic incidence (PI). Pelvises with low PT and high SS are balanced, whereas high PT and low SS are deemed to be unbalanced [2]. In essence, unbalanced patients try to establish spinal balance by retroverting their pelvis which is reflected in high pelvic tilt in standing whole spine X-rays. The disturbed sagittal spino-pelvic alignment in

Fig. 2 Pre-operative MRI scan with dysraphic features: block vertebrae, diastematomyelia and spina bifida

Fig. 3 View at L4/5 intervertebral level after disc removal and K-wire insertion under image intensifier control

spondylolisthesis patients is compensated by increased lumbar lordosis and decreased thoracic kyphosis causing even more stress on the lumbo-sacral junction [3]. This compensatory mechanism increases shear forces in the isthmic area, which is unable to resist it, causing the vertebral slip to progress [4]. It is understandable that structural or developmental weakness of this area like dysraphism may be predisposed to high-grade slips. Dysraphic syndromes occur amongst others if neural tube closure in the embryologic development (days 18 to 48 postconceptional) has failed. Neural tube defects occur with an estimated incidence of >300,000 new cases per year with different appearances and large varieties in clinical symptoms [5]. Appearances include spina bifida and diastematomyelia, both highly associated with structural bony deformities and tethered cord syndrome (TCS). TCS is defined as an abnormally low conus position which may lead to neurological, musculoskeletal or urological abnormalities due to unphysiological shear forces to the cord [6, 7]. Surgical untethering might prevent developmental deficits but re-tethering is a common complication even if appropriate surgery is performed [8].

Rationale for treatment and evidence-based literature

Discussion of surgical treatment of high-grade spondylolisthesis is controversial and no evidence-based superiority of reduction and fusion over fusion in-situ has been defined [9]. Increased recent awareness of pelvic parameters in spinal balance and spondylolisthesis indicates a difference between patients with a balanced pelvis (a low degree of pelvic retroversion or pelvic tilt) and those with an unbalanced pelvis (a high degree of retroversion or pelvic tilt) [2]. Those with a balanced pelvis seem not to require reduction of the spondylolisthesis.

In this case, two main considerations—spinal balance and spinal dysraphism—influenced the choice of surgical strategy. Since the patient had a balanced pelvis and had previously been asymptomatic, no advantage was seen in reducing the spondylolisthesis. Different treatment options from uninstrumented posterolateral fusion to minimal-invasive anterior or transforaminal interbody fusion can be used [10–14]. Due to the patients dysraphic condition, posterior techniques requiring manipulation of the neural structures such as interbody fusion with cages or trans-sacral grafting/instrumentation, were viewed as less favourable. Access to the disc space of L5/S1 for anterior interbody in high-grade spondylolisthesis is technically challenging. Anterior L5 transvertebral fusion offers the possibility to fuse L5/S1 without directly exposing this level [15, 16]. This technique only requires exposure of the L4/L5 disc space. Traditionally a fibular strut is used for this technique, however fibular graft harvesting increases surgical time and can cause donor site pain and wound healing problems. Hollow modular anchorage (HMA) screws can be used as an alternative to fibular graft but has only been described in posterior procedures for spondylolisthesis fusion and offers limited biomechanical properties [17, 18]. This was viewed as the most favourable approach for the fusion of the anterior column. As the L4/L5 disc already showed signs of advanced degeneration and was at a mechanical disadvantage due to the congenitally united vertebrae L3 and L4, the necessary addition of an L4/L5 interbody fusion was deemed acceptable and appropriate. Since usage of femoral allograft and BMP2 is discussed controversially in the literature, the decision was made to achieve fusion at the L4/L5 level with a PEEK cage [19, 20]. Early subsidence of the intervertebral space in more than half of the cases is reported if BMP2 is used with allograft [21]. As HMA screws are generally insufficient as

Fig. 4 HMA screw packed with local bone (obtained from the drill) and BMP2

stand-alone cages, it was decided to add posterior instrumentation via a less invasive bilateral muscle split.

Procedure

The first stage of the procedure was performed with minimally invasive retroperitoneal access to the L4/5 level via midline incision of 5 cm after image intensifier level confirmation. The L4/5 intervertebral disc was exposed after retraction of the great vessels. Leg ischaemia was monitored with pulse oximetry of the left foot [22, 23]. Consecutive removal of the anterior ligament and the disc was followed by enabling K-wire placement through the L5 vertebral body (Fig. 3). A HMA screw of 58 mm length filled with local bone and bone morphogenic protein (BMP2) was inserted under image intensifier control after sequential drilling and tapping (Figs. 4, 5). Subsequently, the L4/5 disc space was fused with an interbody

cage secured with four screws and BMP2 (Fig. 6). Pulse oximetry of 100% oxygen saturation was available after release of the great vessels with a total leg ischaemia of 60 min and the wound was closed. The patient was turned prone and the old scar opened and extended from sacrum to L2. The lumbar fascia was split and a Wiltse muscle split performed bilaterally. Decortication of the transverse processes followed with application of 10 ml osteoinductive demineralised bone matrix (DBX). Under fluoroscopic control, three cannulated screws were placed on the left side at the L3, L4 and S1 level and only two on the right side of L3 and S1 due to L4 pedicle hypoplasia. The rods were connected to the screws and the wound closed afterwards. The total blood loss of anterior and posterior surgery was less than 200 ml with a total surgery time of 360 min. The implant costs including the osteoinductive agents added up to approximately 8,730 pounds.

Procedure imaging section (Figs. 3, 4, 5, 6, 7, 8)

Outcome, follow-up

The post-operative in-hospital stay was uneventful and the patient was mobilised the day after surgery. She was discharged after 3 days with satisfactory plain films. Computed tomography confirmed fusion after 6 months and the back pain improved significantly but sciatic symptoms S1 on the left side were present (Fig. 7). At the 12-month follow-up, she was completely pain free and had started to work full time with no restrictions. After 18 months, she returned to horse riding and was not limited in any other free-time activity (Fig. 8).

The chosen technique allowed fusion to be achieved with minimised surgical invasiveness, short inpatient stay and early fusion with return to activity due to the use of

Fig. 5 Transvertebral insertion of HMA screw for L5/S1 fusion after sequential drilling and tapping

Fig. 6 Anterior interbody fusion with stand-alone cage L4/5 and final implant control

Fig. 7 6-month follow-up CT scan confirming early fusion at L4/5 in the coronal and L5/S1 in the sagittal plane

Fig. 8 Follow-up X-ray after 18 months

BMP2. Donor site morbidity was avoided through the use of BMP2 and DBX. While the outcome was very satisfactory, the total cost of the procedure added up to approximately 8,730 pounds. Ideally, the cost effectiveness

of the described surgery should be evaluated in larger patient series or through patient registries.

Conflict of interest None.

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