Percutaneous three column osteotomy for kyphotic deformity correction in congenital kyphosis

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Introduction

Traditionally the approach to adult spinal deformity surgery involves an open exposure of the spinal column. The adult deformity population is characterized by a higher rate of comorbidities, such as diabetes mellitus, coronary heart disease and others. Therefore, significant blood loss during open spine surgery [1–3] contributes to the relatively high complication rate of up to 30 % following osteotomies [4]. Because the osteotendinous complex of the spinal column serves as a dynamic stabilizer [5], disruption during exposure might contribute to a higher risk of adjacent level diseases [6, 7].

To minimize injury to the paraspinal muscles and reduce infection risk during spinal deformity correction, a

minimally invasive technique, combining lateral transpsoas approaches (XLIF) with percutaneous posterior corrections have been established [8–10]. Closing wedge osteotomies as well as open wedge osteotomies have been advocated as single posterior approaches [11, 12].

A reported disadvantage of MIS techniques is higher radiation exposure to the patient and OR staff [13]. The use of computer assisted fluoroscopy based surgery helps to reduce this radiation exposure and simultaneously might contribute to lower misplacement rates of percutaneously inserted pedicle screws [14, 15].

Case description

The patient is a 28-year-old female with progressive back pain, secondary to a congenital kyphosis T10/L1 with block vertebrae due to incomplete segmentation [16]. The preoperative neurological status is intact. The standing lateral X-rays reveal a preoperative Cobb angle of 50°, from T10 to L1. The total thoracic kyphosis is 75°. To compensate for pathological thoracic kyphosis, lumbar lordosis increased to 65° and spinopelvic parameters to 25° for sacral slope and 15° for pelvic tilt. C7 plumb line (SVA) shifted 5 cm anteriorly. The block vertebra is associated with increased curve rigidity. Supine MRI confirm the presence of block vertebrae and absence of intradural pathology and neural compression. From the MRI and the plain X-ray, hypoplastic pedicles can be identified. Indications for surgery are progressive back pain, compensatory mechanisms of hyperlordosis as well as cosmetic aspects.

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Surgical procedure

The patient is positioned in prone position with SEP and MEP monitoring. Fluoroscopic identification of Th9–12 is performed with spinal needles. After identification of T10, a 1.5 cm midline incision is made. Paravertebral muscles are dissected from the midline. The patient tracker is then placed and an intraoperative CT scan is performed. Using intraoperative navigation images acquired via fluoroscopic scan, we identify the entry points and place transpedicular navigated K-wires bilaterally through stab incisions at T10, 11 and 12.

Due to L1 hypoplastic pedicles, a parapedicular approach with a tracker mounted Jamshidi needle is performed. Correct placement of K-wires is verified with intraoperative CT scan. K-wires are then used for guided tapping and percutaneous pedicle screw insertion. Soft tissue blades, attached to each pedicle screw, are removed to reduce pressure on skin and soft tissue, as well as easing retractor placement for decompression and osteotomy.

The midline incision is then used for monosegmental exposure of the bone surface. The spinal and transverse processes are resected and a retractor is inserted. Thereafter, a microscopic resection of the facet joints and a complete laminectomy is performed. After mobilizing the dura and segmental nerve roots, the dura is moistened and protected by cotton. Subperiosteal preparation of the lateral aspect is performed with scissors and a Cobb elevator. A 20 mm adjustable vertebral body retractor is inserted to expose the right lateral aspect of the vertebral body and to protect anterior and lateral paraspinal structures. An osteotomy at the disc level, caudal of the T11 screw and cephalad of the T12 screw is performed under fluoroscopic control, using a vertebral body osteotome. Soft tissue blades are reinserted into the screws on the right side and a temporary rod with blockers is inserted, to avoid translation of the spinal column while the contralateral side is osteotomized.

Likewise a subperiosteal preparation and a 20 mm adjustable vertebral body retractor is placed at the disc level of the left side, followed by an osteotomy, identical to the right side. To osteotomize the medial aspect of the spinal column with a straight osteotome, the dural sack is slightly shifted laterally. This procedure is repeated on the other side. The median part of the vertebral body is then resected with a 15 mm posterior vertebral body punch. The punch is advanced from the left side, until the tip is visible on the contralateral aspect of the dural sack. It is crucial to mobilize the dural sack with the dissector first, to make sure that there are no adhesions.

After removal of the exposed bone and confirmation that remaining bone will not compress the dural sack, the reduction procedure starts. All steps are performed under constant SEP and MEP monitoring. The first reduction is performed using a persuader via the left rod, after

loosening the right rod. The next step is to close the osteotomy by compression T11 towards T12. Because this correction manoeuvre did not lead to a sufficient result, the anterior wall is completely resected, to enable the combination of an open wedge procedure.

After completing the anterior wall resection from the right side, the reduction is improved in terms of a cantilever manoeuvre with bilateral persuasion of the apical screws, followed by the closure of the gap with compression of T11 against L1 as the posterior elements of T12 are completely removed. After obtaining a sufficient reduction, all blockers are finally tightened and blades are removed.

Before closure, an epidural catheter for postoperative pain management is inserted [17]. Autogenous bone from local bone resection is placed as posterior fusion material. A hemovac drain is inserted into the medial incision. Neuro-monitoring is normal throughout the whole procedure.

Postoperative information

Despite the intraoperative uncomplicated procedure with a stable patient and an EBL below 1,000 ml, the patient is transmitted to the ICU due to hospital policy. A postoperative CT scan corroborates the correct implant positioning and a sufficient correction of prior congenital kyphotic deformity to 25°. Neither intra—nor postoperative blood transfusion is necessary.

A routine 24 h antibiotic prophylaxis is performed with a third generation cephalosporin. The patient is mobilized 1 day after surgery, and the peridural catheter is removed 3 days after surgery. The total hospital stay in the spine department is 10 days. Postoperative X-ray control shows the following improvements for sagittal parameters: Kyphotic angle of the block vertebrae T10–L1 reduced to 25°; C7 plumb line through sacral plateau; total thoracic kyphosis 55°, lumbar lordosis 45°; sacral slope 25°; pelvic tilt: 15°.

Discussion and conclusion

Hyperkyphosis of the thoracolumbar junction and its compensatory mechanisms may contribute to low back pain and lead to accelerated disc degeneration [18]. To correct the sagittal imbalance, a variety of techniques including closing wedge and opening osteotomies, as well as combined anterior/posterior approaches have been advocated [11, 12, 19]. The advantages, associated with minimally invasive surgery (MIS) [5], namely less blood loss, less soft tissue trauma leading to intact muscles and osteoligamentous fixation, have recently been used in adult spinal deformity correction [8, 10]. In this case, fusion at the osteotomy level is achieved by the closing and opening

wedge techniques and posterior fusion with autogenous bone. The instrumented segments above and below the osteotomy do not require a specific fusion procedure since they are already fused and no additional segment is included into the procedure. Because of the critical anatomy with hypoplastic pedicles, and to reduce radiation exposure, the pedicle screw placement is performed using a navigation system [15]. Protection of neural structures and avoidance of neurological deficits during minimally invasive surgery is improved by using intraoperative navigation in conjunction with neuromonitoring [20]. Our patient experienced lower back pain at a young age. Despite a thoracic hyperkyphosis of 75°, she is relatively well compensated by hyperlordosis of the lumbar spine. Although preoperative sacral slope and pelvic tilt are within normal limits [21], her overall sagittal balance is anterior as noted by C7 Plumb line or sagittal vertical axis (SVA) of positive 5 cm. This imbalance is the most likely source of her back pain. This case demonstrates that with MIS techniques, the same extent of deformity correction with good clinical and radiographic results can be achieved. Postoperative SVA, thoracic kyphosis and lumbar lordosis are normalized with no adverse effect on the sacral slope or pelvic tilt. Normalizing sagittal balance will hopefully improve pressure on adjacent segments reducing the rate of further disc degeneration and occurrence of lower back pain as our patient ages. The technique presently described requires use of sophisticated equipment and attention to detail.

Conflict of interest N. Hansen-Algenstaedt is working as a consultant for Stryker, DepuySynthes and SpineArt. He receives royalties on implants from Stryker and Globus Medical.

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