A minimally invasive posterior lumbar interbody fusion for degenerative lumbar spine instabilities

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Abstract Percutaneous techniques may be helpful to reduce approach-related morbidity of conventional open surgery. The aim of the study was to evaluate the feasibility and safety of mini-open posterior lumbar interbody fusion for instabilities and degenerative disc diseases. From May 2005 until October 2008, 20 patients affected by mono-segmental instability and disc herniation underwent mini-open lumbar interbody fusion combined with percutaneous pedicle screw fixation of the lumbar spine. Clinical outcome was assessed using the Visual Analog Scale, Oswestry Disability Index, and Short Form Health Survey-36. The mean follow-up was 24 months. The mean estimated blood loss was 126 ml; the mean length of stay was 5.3 days; the mean operative time was 171 min. At 24-month follow-up, the mean VAS score was 2.1, mean ODI was 27.1%, and mean SF-36 was 85.2%. 80 screws were implanted in 20 patients. 74 screws showed very good position, 5 screws acceptable, and 1 screw unacceptable. A solid fusion was achieved in 17 patients (85%). In our opinion, mini-open TLIF is a valid and safe treatment of lumbar instability and degenerative disc diseases in order to obtain faster return to daily activities.

Keywords Percutaneous pedicle screw · Minimally invasive fusion · Disc herniation

Introduction

The conventional open lumbar interbody fusion with cage (PLIF) associated with the posterior pedicle screws fixation is a widely accepted technique to treat unstable spinal pathologies. These procedures entail a long hospital stay and high costs [1].

In fact, many authors have reported the adverse effects of the large dissections and retractions of tissues that are typical of conventional lumbar surgery. The traditional posterior approach to the lumbar spine entails a very large tissue dissection in order to expose the zygapophyseal joints and transverse processes. A large tissue dissection causes an iatrogenic denervation of the articular facets, an increase in the intramuscular pressure, ischemia, and revascularization damage [2].

Tissue denervation and ischemia may be due to two possible separate or combined mechanisms: (1) direct trauma; (2) increase in the intramuscular pressure (i.e. focal compartment syndrome) following the use of retractors [3].

All these histopathological alterations induce major postoperative clinical symptoms such as persistent pain, atrophy of the lumbar muscles, and weakening of the extension strength and resistance [4].

Moreover, the conventional surgical techniques are often associated with greater amount of intra-operative blood loss.

In the past few years, many authors have reported the advantages of the mini-invasive posterior lumbar approach versus the conventional open procedures such as the reduction of intra-operative blood loss, less damage to soft tissues, relief of postoperative pain, early mobilization of the patient, shorter hospital stay, and a rapid return to an active social and working life [5, 6].

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Ongoing technological progress led to the development of specific percutaneous surgical techniques to treat lumbar degenerative diseases [7–10].

The aim of this study was to report our experience in the treatment of lumbar instabilities associated with degenerative disc disease.

Methods

From May 2005 to October 2008, at the Spine Surgery Center of the Catholic University of Rome, 20 patients—14 males and 6 females—mean age 46 years (28–59 years) underwent the index procedure: interbody fusion with cage (Traxis, Zimmer Spine) and percutaneous screws fixation (Pathfinder Zimmer Spine). Patients were treated conservatively for at least 3 months without any benefit before being operated upon. The preoperative diagnosis was degenerative spondylolisthesis in 15 patients, recurrent disc hernia with segmental instability in 5 patients. The treated levels are L3–L4 in four patients, L4–L5 in nine patients, L5–S1 in seven patients. The mean follow-up was 22 months (minimum 12 months, maximum 53 months). All patients were studied radiographically with preoperative plain, dynamic X-rays (Fig. 1a, b) and lumbar MRI (Fig. 2). Patients' symptoms were lumbar pain, neurogenic claudication, and radiculopathy.

All patients were placed in a prone position on a radiolucent carbon fiber operating table in order to have an optimal fluoroscopic visualization of the involved spine in

Fig. 2 The MRI shows the presence of a large left infraforaminal disc hernia

the antero-posterior and lateral views. In all patients, Pathfinder instrumentation and Traxis cage was implanted.

Two longitudinal small skin incisions on the contralateral side of discectomy were performed to introduce two pedicle screws. Then the fixation was completed with a rod inserted through the proximal incision in order to place

Fig. 1 The X-ray at maximum flexion and extension shows a degenerative L4–L5 spondylolisthesis

below the muscles and the fascia in a proximo-distal direction. Rods were fixed to screws in a distraction way. On the contralateral side, a single skin incision was made to perform discectomy and apply an interbody cage under an operative microscope guide. Then two pedicle screws were introduced using a minimally invasive approach.

In order to access disc space, dedicated minimally invasive 4-valve retractor (Harmony Retractor Zimmer, Abbot Spine, Austin, Texas) was utilized. The epiphyseal plates of the involved level were prepared, and the cage with autologous bone graft was introduced, and the rods were fixed to the screws in a compressive way (Fig. 3a, b).

All patients were administered an antibiotic prophylaxis with Cefazoline (2 gr i.v 30 min before skin incision).

For each patient, we analyzed surgical time, intra-operative blood loss, hospital stay, and perioperative complications.

Pain was evaluated with the Visual Analog Scale (VAS) preoperatively, at 5 days, at 2 weeks, at 1, 3, 6, and 12 months, and annually postoperatively.

The “Mean Oswestry Disability Index” and the “Short-Form 36 General Health Survey” were assessed preoperatively at 15 days, 1, 3, 6, and 12 months after surgery, and annually.

Standard X-rays were performed at 30 days, 3, 6, and 12 months postoperatively, and annually.

All patients underwent a CT scanning of treated level with sagittal and coronal reconstructions in the postoperative period in order to evaluate the position of the pedicle screws according to criteria published by Youkilis et al. [11]: (1) “good position”, the screw does not violate the pedicle cortex or violates it only for 2 mm; (2) “acceptable position”, the screw violates the pedicle cortex for more

than 2 mm, but it provides good bone fixation; (3) “unacceptable position”, the screw violates the cortex for more than 2 mm, and there are neurological symptoms. CT scan was also performed in order to assess bone fusion rate. Bone fusion was considered as solid when there was osseous continuity in and around the cages on both coronal and sagittal reconstruction images of CT scan. Non-union was defined as the presence of a visible gap on CT scans.

Statistics

Statistical analysis were conducted using χ^2 test and verified with Fisher’s exact test for Oswestry Disability Index and SF-36 data and Student’s *t* test for Visual Analog Scale data. Significance was established for $p < 0.05$.

Results

The mean operative time was 171 min, the mean intra-operative blood loss was 126 ml, and the mean length hospital stay was 5.3 days. On average, the patients started walking 3.2 days after surgery. The average pre-operative VAS score was 7.1 (5.9–8.8), at the fifth postoperative day decrease to 5.0 (3.2–6.8), at 15 days to 4.7 (2.9–6.5), at 1 month to 3.2 (2.0–4.4), at 3 months to 3.1 (1.5–3.8), at 6 months to 2.8 (0.8–3.7), and at 24 months mean follow-up to 2.1 (1–3.5) ($p = 0.03$) (Fig. 4).

The patients had an average preoperative “Oswestry Disability Index” of 52.8% (40.2–72.7%), after 15 days of 45.7% (37.6–67.8%), of 37.8% after 1 month (28.2–47.8%), of 32.5% (25.7–50.4%) after 3 months, of 30.1%

Fig. 3 The post-operative X-ray follow-up in the antero-posterior and latero-lateral views: percutaneous fixation with pedicle screws (Pathfinder), interbody L4–L5 fusion with cage with an optimal reduction of spondylolisthesis

Fig. 4 Results Visual Analog Scale score after a mean 24-month follow-up; patients $n = 20$

Fig. 5 Results of the Oswestry Disability Index after a mean 24-month follow-up; patients $n = 20$

(24.3–37.8%) after 6 months, and of 27.1% (11.2–34.8%) ($p = 0.02$) after a mean follow-up of 24 months (Fig. 5).

The Short-Form 36 Physical Health was equal to 34.5% (25.7–50.4%), to 47.7% (35.6–63.4%) after 15 days, of 71.5% (57.4–85.3%) after 1 month, of 75.4% (65.3–86.4%) after 3 months, of 82% (71.4–92.2%) after 6 months, and of 85.2% (70.2–94%) ($p < 0.001$) after 24 months of mean follow-up. The Short-Form 36 Mental Health was 25.6% (19.7–41.2%), 39.7% (28.3–49.4%) after 15 days, of 62.4% (51.5–78.3%) after 1 month, of 67.6% (59.3–78.4%) after 3 months, of 76.5% (68.3–84.5%) after 6 months, and of 80.2% (70.3–91.2%) ($p < 0.001$) after a mean 24 months follow-up (Fig. 6a, b).

Eighty pedicle screws were implanted in 20 patients; the postoperative CT scan showed that 74 screws were “well positioned”, 5 screws had “an acceptable position”, and 1 screw had an “unacceptable position” because it violated the pedicle medial cortex of L5, thus inducing an irritative radiculopathy when the patient woke up. The patient underwent revision surgery procedure in order to modify screw placement percutaneously. During a follow-up ranging from 12 to 53 months, there was no displacement

Fig. 6 Results of the SF-36 Physical and Mental Component after a mean 24-month follow-up; patients $n = 20$

of the cage or rupture of the fixation. Radiological evidence of solid fusion was observed in 17 patients (85%). Non-union was observed in three patients (15%), without hardware mobilization and successful clinical outcome at last follow-up.

We observed one superficial wound infection resolved with antibiotic therapy.

Discussion

In order to limit disadvantages related to the conventional approach, some minimally invasive techniques have been developed in the past 10 years to treat degenerative diseases. The posterior minimally invasive approach was initially utilized in cases requiring a simple decompression such as discectomy or foraminotomy.

Later, the continuous evolution of this technique and the experience acquired allow a true pedicle screw fixation and a viable interbody fusion for a minimally invasive approach.

Minimally invasive surgery requires an extensive knowledge of the topographic anatomy and the ability to work safely through small working channels. This can only be obtained with adequate visualization—direct and

radiographic—and with dedicated instruments. During the learning curve, the interbody fusion associated with a minimally invasive posterior pedicle instrumentation requires longer operative time than traditional open surgery. In our opinion, it is important to start this procedure with great caution in order to minimize the risk of intra-operative complications that are difficult to manage through small skin incisions.

On the other hand, our results are encouraging for the use of percutaneous approaches to the spine to treat traumatic and degenerative diseases. Thanks to the increasingly effective minimally invasive techniques, today it is possible to achieve results similar to traditional open surgery with the clinical advantage of minimizing the surgical trauma to soft tissues. In 1997, Foley and Smith [12] performed lumbar and cervical decompressions with an innovative tubular retraction system (METRx). Since then, the minimally invasive techniques have been upgraded and used more extensively in the clinical practice. Isaacs et al. [8] analyzed the results of 20 patients treated with posterior percutaneous screw fixation and minimally invasive cage interbody fusion, with a significant reduction of intra-operative blood loss, postoperative blood transfusions, and average length hospital stay versus conventional surgery.

We believe that one of the advantages of minimally invasive surgery is the relief of postoperative pain as shown by our results, with a decrease of the VAS already 1 month post-surgery (Fig. 4).

“Oswestry Disability Index” and SF-36 Questionnaire show a rapid functional recovery. In fact, the analysis of the results obtained with the SF-36 shows that, 1 month after surgery, some patients reach a maximum of 85.3% in the Physical Health Component with respect to a minimum of 25.7% preoperatively (Fig. 6a). The same considerable early improvement can also be inferred from the data of the Mental Health Component with a maximum of 78.3% 1 month after surgery versus a preoperative minimum score of 19.7% (Fig. 6b). These results confirm that the advantage of minimally invasive surgery is not only able to obtain an earlier physical and functional recovery, but also social and emotional acceptance, showing that the patient appreciates the surgical procedure performed.

Moreover, the mid-term results show that minimally invasive techniques not only reduce the iatrogenic tissue damage but also produce the same mechanical stability obtained with an open procedure.

Conflict of interest None.

References

1. Thomsen K, Christensen FB, Eiskjaer SP et al (1997) Volvo Award winner in clinical studies. The effects of pedicle screw instrumentation on functional outcome and fusion rates in posterolateral lumbar spinal fusion: a prospective, randomized, clinical study. *Spine* 22:2813–2822
2. Styf J, Willen J (1998) The effects of external compression by three different retractors on pressure in the erector spine muscles during and after posterior lumbar spine surgery in humans. *Spine* 23:354–358
3. Kawaguchi Y, Yabuki S, Styf J et al (1996) Back muscle injury after posterior lumbar spine surgery: topographic evaluation of intramuscular pressure and blood flow in the porcine back muscle during surgery. *Spine* 21:2683–2688
4. Kim KT, Lee SH, Suk KS, Bae SC (2006) The quantitative analysis of tissue injury markers after mini-open lumbar fusion. *Spine* 31:712–716
5. Fessler RG, Guiot BH, Khoo LT (2002) A minimally invasive technique for decompression of the lumbar spine. *Spine* 27:432–438
6. Foley KT, Holly LT, Schwender JD (2003) Minimally invasive lumbar fusion. *Spine* 15:S26–S35
7. Foley KT, Gupta SK (2002) Percutaneous pedicle screw fixation of the lumbar spine: preliminary clinical results. *J Neurosurg* 97:S7–S12
8. Isaacs RE, Podichetty VK, Santiago P et al (2005) Minimally invasive microendoscopy-assisted transforaminal lumbar interbody fusion with instrumentation. *J Neurosurg Spine* 3:98–105
9. Khoo LT, Palmer S, Laich DT, Fessler RG (2002) Minimally invasive percutaneous posterior lumbar interbody fusion. *Neurosurgery* 51:S166–S181
10. Logroscino CA, Proietti L, Tamburrelli FC (2009) Minimally invasive stabilization with long implants. *Eur Spine J* 17(Suppl 1):81
11. Youkilis AS, Quint DJ, McGillicuddy JE, Papadopoulos S (2001) Stereotactic navigation for placement of pedicle screws in the thoracic spine. *Neurosurgery* 48:771–778
12. Foley KT, Smith MM (1997) Microendoscopic discectomy. *Tech Neurosurg* 3:301–307