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Minimally Invasive Transforaminal Lumbar Interbody Fusion – An Overview of its Benefits and Pitfalls

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Abstract

Minimally invasive spine surgery has been on the rise in the last decade, providing the auditorium of spine surgeons with state of the art solutions to common clinical situations. Avoiding extensive soft tissue injury in mini-open Transforaminal lumbar interbody fusion (TLIF) resulted in measurable clinical benefits like decrease of blood loss, less pain and faster rehabilitation postoperatively. Advanced technical support and the need for superb lighting down the working corridor became imminent. Although it has been difficult to show any long-term advantages of the technique, a decrease in occurrence of adjacent segment disease might be a path to its future research. However, increased radiation exposure and learning-curve associated complications warn against embracing mini-open TLIF too enthusiastically.

Keywords: Less invasive spine surgery; Mini TLIF; Indications; Comparison; Benefits

Introduction

Decreasing soft tissue injury has been the principle goal of less invasive surgery, whether doing an arthroscopic meniscectomy or performing a laparoscopic cholecystectomy. Unsurprisingly, spinal procedures have not been immune to the trend. What started with a microsurgical discectomy in 1977 [1], eventually lead to percutaneous transpedicular screw placement in 1995 [2]. With the advent of minimally invasive transpedicular vertebrectomy with expandable cage reconstruction in 2011 [3], few frontiers still exist.

Transforaminal lumbar interbody fusion (TLIF) has been traditionally used to address all sorts of lumbar degenerative pathology. Whether being technically simple cases like recurrence of a herniated disc with concomitant back pain or a challenging scenario of a major vertebral slip, the idea has always been quite simple. With the aim to provide optimal environment for inter-vertebral bone growth, immediate primary stabilization with four screws, two connecting rods and an interbody device has been introduced [4]. Same principle applies to the minimally invasive TLIF with one major difference – less trauma to the surrounding tissue (Table 1). Minimizing damage to the para-vertebral muscles with a special set of instruments to achieve the same agenda has been a hallmark of the method [5].

Table 1: Comparison of open and minimally invasive TLIF characteristics (NS – not significant).

	Open TLIF	Minimally invasive TLIF	Significance P
Muscle damage (increase in creatine kinase)	28.9 (± 3.3)	12.7 (± 3.2)	< 0.001[9]
Blood loss (ml of blood)	526 (± 168)	188 (± 70)	< 0.001[9]
Radiation exposure time (in seconds)	45.3 (± 11.7)	28.9 (± 8.2)	< 0.05[17]
Fusion rate	97.5%	97.5%	< 0.001[12]
Overall complication rate	20%	15%	NS[12]
Infection rate	4.6%	1.2%	0.0001[13]
Surgery time at plateau (minutes)	103 (± 18)	98 (± 25)	NS[9]
Postoperative pain (VAS scale)	6.1 (± 1.2)	4.7 (± 1.6)	< 0.001[9]
Hospital discharge (days after surgery)	5.2 (± 1.0)	3.5 (± 0.8)	< 0.001[9]
Return to work (weeks after surgery)	17.1 (1.7 to 35.9)	8.5 (4.4 to 21.4)	0.02[10]
Postoperative narcotic use (weeks after surgery)	4.0 (1.4 to 4.6)	2.0 (1.0 to 3.0)	0.008[10]
Clinical result after 2 years (ODI improvement)	17.1 (± 9.5)	15.7 (± 8.9)	NS[10]
Adjacent Segment Disease rate	19%	8%	NS[16]

Benefits of Minimally Invasive TLIF

By performing blunt dissection with the use of dilators of increasing size, detachment of the multifidus muscle from its bony origins is avoided [6]. Minimal laceration of the muscle decreases blood loss substantially, making transfusion of homologous blood a rare necessity [7]. Muscle fibers are split to slowly adapt to the pressure-reducing retractor, which instead of being fixed within the tissue remains mounted to the operating table (Figure 1). The even distribution of traction force exhibited thereby on all surrounding muscle prevents point-to-point increments of intramuscular tissue pressure and decreases the chance of muscle necrosis [8].

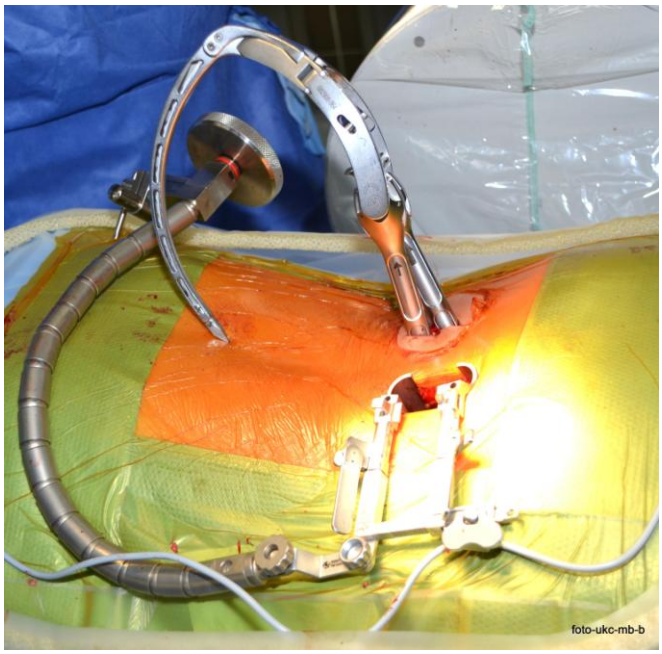

Figure 1: Mini-open Transforaminal lumbar interbody fusion (MI-TLIF) with minimally invasive implantation of a self-distracting intervertebral cage through a narrow muscle corridor (lower field of image) and percutaneous transpedicular screw and rod introduction (upper field of image).

Postoperative levels of muscle-damage marker enzymes like creatine kinase seem to be consistently lower compared to open surgery [9]. Consequently, less pain in the postoperative period leads to a decrease in analgesics use, faster rehabilitation, and earlier discharge from the hospital and earlier return to work [10]. Combining all of the above, it has been postulated that the minimally invasive procedure might be less expensive than the traditional open surgery by as much as 20%. However, with questionable clinical benefit two years after surgery [11]. Studies have also suggested a decrease in overall complications rate, most notable the rate of postoperative infection, with comparable fusion results to the open technique [12, 13].

Inadvertent damage to the medial branch of the ramus posterior of the spinal nerve, which occasionally occurs during open surgery, can be avoided, making denervation of the multifidus muscle with its subsequent atrophy a remote possibility in the minimally invasive procedure [14]. In addition, limited exposure of the upper-most facet joint makes it less vulnerable to intraoperative periarticular damage (Figure 2). Recent studies showing a decrease of revision surgery for adjacent segment disease five years after the primary procedure might support that statement [15, 16].

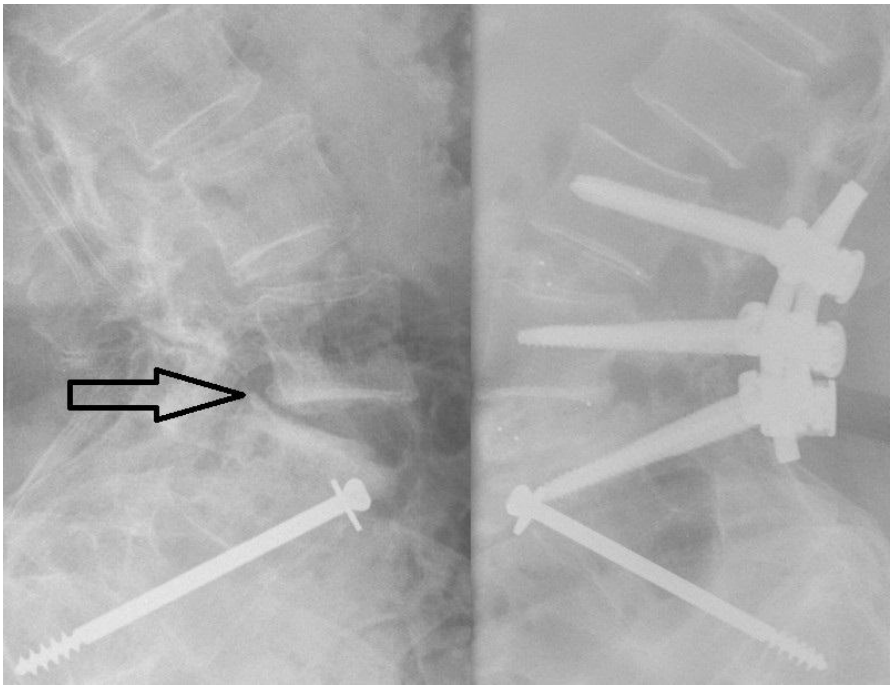

Figure 2: Adjacent segment degeneration of L3-L4 level (left field of image) 25 years after anterior lumbar fusion with a long femoral nail for a two-level spondylolisthesis L4-L5 and L5-S1 (subsequent open Transforaminal lumbar interbody fusion as shown in right field of image).

Pitfalls of Minimally Invasive TLIF

Although much more effort has been put into showing the advantages of the minimally invasive technique, implementing it into everyday surgical practice has its downside as well. Inferior exposure makes routine pedicle screw placement according to the anatomical landmarks impossible. Intra-operative exposure to radiation increases both for the patient as well as the surgeon, especially at the beginning of the learning curve or when confronted with a more difficult case [17]. With thyroid carcinoma, lymphoma and eye cataract under review in the community of spine surgeons, these factors should be carefully weighted when trying to improve screw accuracy [18].

Although learning a new technique is a fun and stimulating experience, a surgeon must recognize the amount of time and effort needed to conquer it [19]. No matter how well prepared, the first dozen of patients are always a challenge, with new intra-operative complications specific to the technique just around the corner (Figure 3). Limited operating field can nevertheless be associated with complications such as nerve root injury or dural laceration, hard-to-control epidural bleeding, less than optimal removal of disc material. Vertebral end-plate damage and interbody cage malpositioning or postoperative dislocation (Figure 4) could result in delay or even lack of fusion [20]. In order to minimize the unwanted events, stringent adherence to the operative technique without shortcuts is needed from the start.

Figure 3: Intraoperatively unnoticed fracture of inferior articular process after percutaneous introduction of a rod in minimally invasive TLIF for L4-L5 degenerative spondylolisthesis.

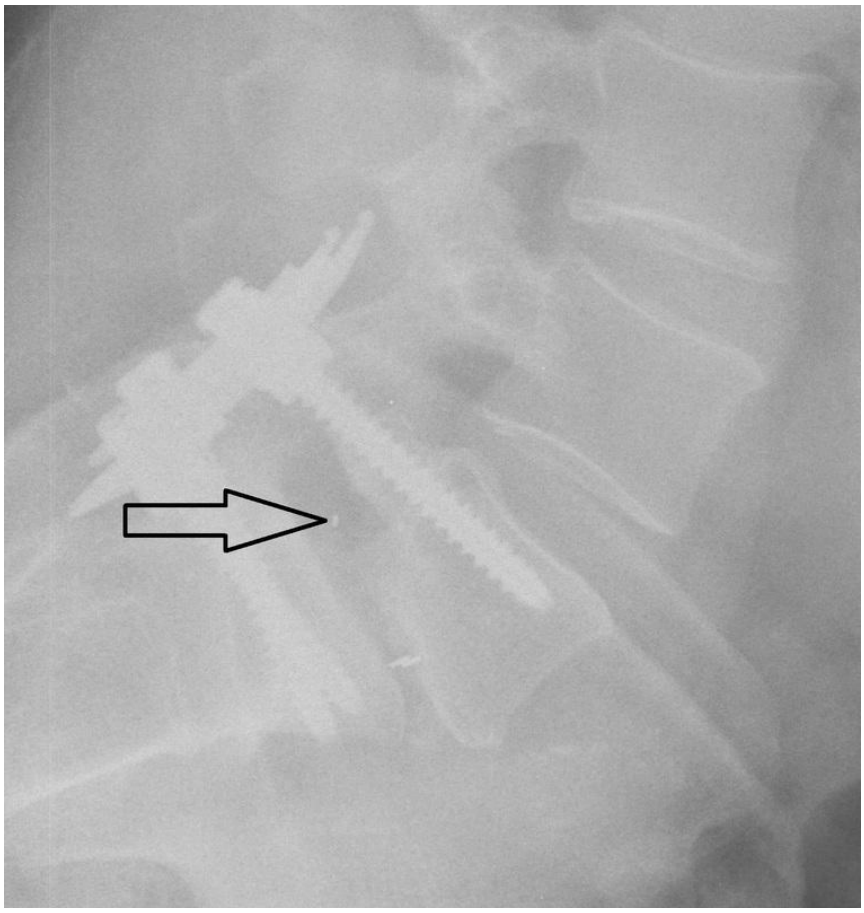

Figure 4: Dislocation of an intervertebral cage 3 weeks postoperatively after minimally invasive TLIF for L5-S1 isthmic spondylolisthesis.

Performing the procedure for an unchallengeable straightforward indication is also highly recommended. In our experience, performing mini-open TLIF in a patient with degenerative spondylolisthesis and concomitant absolute central canal stenosis is not the best treatment modality. Thorough decompression might prove to be impossible. On the other hand, the technique could work perfectly in a patient with isthmic spondylolisthesis and concomitant neuroforaminal stenosis. Indirect decompression of the contralateral foramen can be readily achieved by reduction of the slip. Even more, an extraforaminal herniated disc with concomitant mechanical back pain might be an ideal indication for a spine surgeon in need of persuasive evidence (Figure 5).

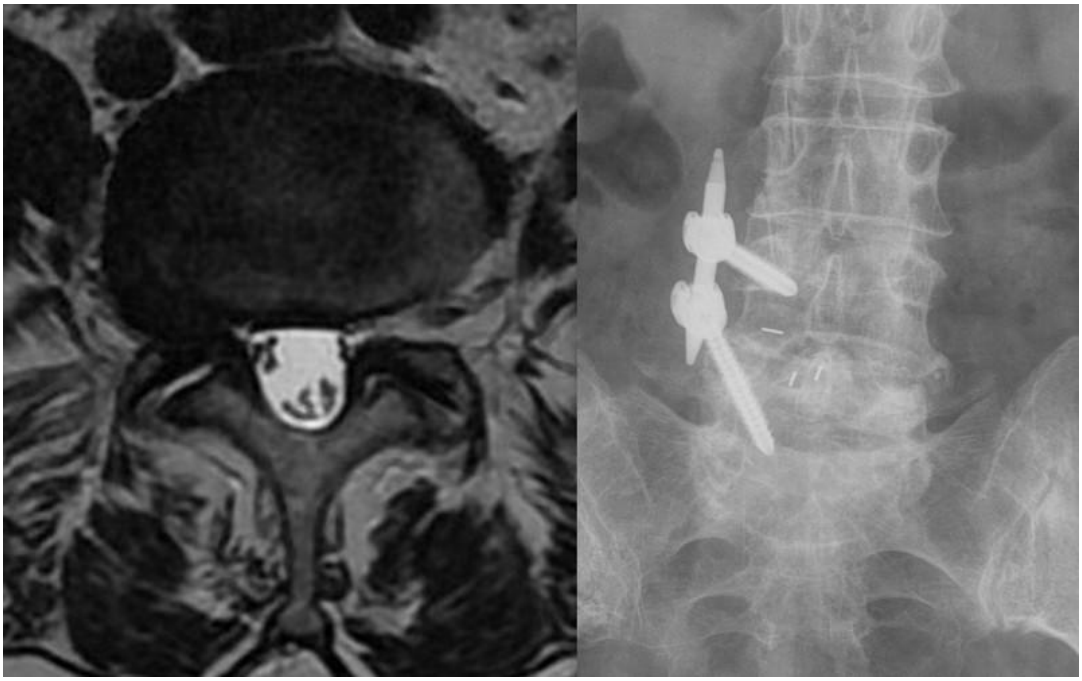

Figure 5: Extraforaminal herniated disc (left field of image) with consequent right-sided L4-L5 mini-open TLIF (right field of image).

Several technical considerations should also be taken into account. Appropriate lighting, with either loupes or an operating microscope, is mandatory for safe and efficient approach. Thorough knowledge of the spinal anatomy from previous open surgery is paramount in order to confidently face the small working area deep inside the convergent-trajectory wound [8]. Obligatory instruments, which enable the narrow minimally invasive muscle-sparing corridor, are usually provided by the manufacturer, which might limit surgeons' preference for another material.

Conclusion

Minimally invasive transforaminal lumbar fusion is potentially a morbidity reducing technique. However, careful selection of appropriate patients is mandatory in order to show its maximum benefit. In summary, minimally invasive TLIF is an attractive tool for the surgeon to use in a way, which suits him and the patient best.

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