Review Article

Translaminar facetal screw (Magerl's) fixation

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Translaminar facet screw fixation (TLFS) achieves stabilization of the vertebral motion segment by screws inserted at the base of the spinous process, through the opposite lamina, traversing the facet joint, and ending in the base of the transverse process. It is simple, does not require any specialized equipment, and has the advantages of being a procedure of lesser magnitude, lesser operative time, less cost and few complication rate. Recently there is growing interest in this technique to augment the anterior lumbar fusions to achieve global fusion less invasively. In this review article, we discuss the clinical and biomechanical considerations, surgical technique, indications, contraindications and recent developments of TLFS fixation in lumbar spine fusion.

Key words: Translaminar facet screw; magrel screw; lumbar fusions; spinal fixation; spinal fusion.

Introduction

The facet joints are the only true articulations in the lumbosacral spine and effective spinal stabilisation can be achieved by instrumented fusion of these joints.[1] Translaminar facet screw fixation (TLFS) was introduced in 1983 by Magerl[2] and has gained popularity since then due to its technical simplicity and low cost. In TLFS, the screws are inserted from the base of the spinous process on the contralateral side, through the lamina to traverse the facet joint in a plane perpendicular to the joint surface and ending at the base of the transverse process. TLFS scores over the pedicle screw fixation systems, which are more widely used, as the surgical procedure is less extensive, involves a shorter surgical time, relatively lower cost and a lower complication rate.[3–6] It also has the additional advantages of being relatively less demanding in terms of equipment, technique and the training required in comparison to the pedicle screw systems. In view of these advantages, there is a growing acceptance of this technique in low-grade degenerative spondylolisthesis with instability and to augment an anterior lumbar interbody fusion to achieve a global fusion.[7–9]

This article focuses on the history and development, biomechanical aspects, indications, surgical technique and a review of the recent literature.

History

Instrumentation of the lumbar facets as a form of internal fixation was initially described in 1944 by Don King,[10] who placed small screws across the facet joints in conjunction with a posterior fusion. Boucher[11] in 1959 modified this technique using a longer screw directed toward the pedicle with additional cancellous bone graft, resulting in a lower rate of pseudarthrosis. In 1983, F. Magerl[2] of St. Gallen, Switzerland reported the use of a longer screw inserted from the base of the spinous process, through the lamina, traversing the facet joint and ending at the base of the transverse process. [Figure 1] The length of the screw is considerably longer than those previously described as the entry point is at the base of the contralateral side of the spinous process. This increased the effective working length of the screw on both sides of the facet joint thus increasing the strength of fixation. A supplemental posterolateral fusion is usually performed to further

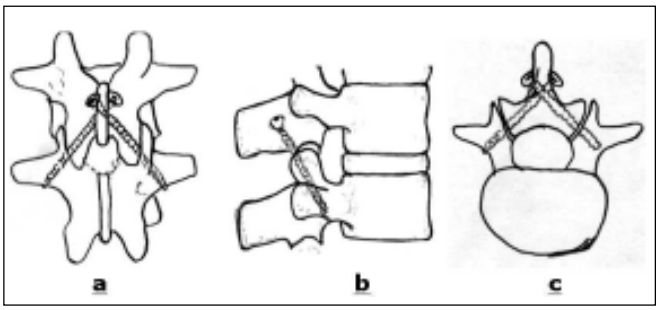

Figure 1: Facet joint fixation is achieved using two 4.5 mm cortical screws that pass from the spinoous process through the lamina and traverse the midpoint of the facet joint perpendicular to the plane of the joint as seen a) posteriorly, b) laterally and c) in the transverse plane

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reduce the rate of pseudoarthrosis.

In 1989 Markwalder[12] presented two technical variations of the method of translaminar screw fixation for unstable lumbar and lumbosacral segments. The first was a distraction-arthrodesis with an intraarticular bone graft to allow enlargement of the narrowed foramina with consequent root decompression. The second modification involved a reconstruction of a hemilamina after hemilaminectomy and facet reduction to allow reconstitution of the spinal canal and its posterior wall as well as direct treatment of the intraforaminal pathology.

Jang et al[8] from Korea devised a guide for percutaneous placement of translaminar facet screws after anterior lumbar interbody fusion. Postoperative CT scans of 18 patients who underwent a translaminar screw fixation with the guide showed that none of the screws invaded the spinal canal or injured the neural structures.

Recently, Shim et al[9] reported a fluoroscopy assisted percutaneous translaminar facet screw fixation technique after anterior lumbar interbody fusion (ALIF) without a guide device. Of the 65 screws in 20 patients, seven screws (10.8%) violated the laminar wall but none injured or compressed any neural structure. One patient sustained a superior articular process fracture following repeated drilling with L5 root compression causing radicular pain. Revision surgery with removal of the implants and the fractured fragments followed by pedicle screw fixation was required.

Biomechanical considerations

The facet joint is the only true articulation in the lumbosacral spine and it is therefore logical to fix the facet joints directly to achieve segmental stabilisation of the concerned segment. Magerl's technique[2] has significant advantages in that the trajectory of the screw permits a longer purchase of bone on either side of the facet joint and allows the screw to pass through the centre and perpendicular to the plane of the joint. This considerably increases the strength of the fixation.[13] Translaminar facetal screws function as a threaded bolt, which prevents movement in the respective motion segements without producing compression across the facet joints.

Several biomechanical studies have shown that TLFS significantly increases spinal stiffness.[14–16] Vanden Berghe et al[17] found that pedicle screw fixation and facet fixation showed similar biomechanical characteristics. Deguchi et al[1] compared the biomechanical performance of translaminar facet joint fixation technique using cortical screws and bioabsorbable poly-L-lactide pins with that of rigid pedicle screw fixation in the lumbar spine. The biomechanical performance of the translaminar screws was similar to that of the pedicle screws though the use of poly-L-lactide pins showed significantly less stiffness than either type of screw fixation.

Philips et al[18] performed anterior lumbar interbody fusion (ALIF) with two threaded cylindrical BAK cages at L5–S1 level in eight human lumbar spine specimens. The anterior fusion was supplemented with translaminar facet screw fixation and the spine was subjected to flexion and extension loads. It was found that the ALIF cages alone provided little or no stability in extension and that supplemental TLFS fixation provides significant additional stabilization.

Clinical considerations

The TLFS is ideal for short segment stabilization and fusion, as it does not interfere with the adjacent facet joints. The minimal use of hardware and technical simplicity results in less surgical exposure, shorter operating time and a lower incidence of major complications.

The screws traverse the lamina tangential to the spinal canal thereby minimizing the risk of entering the spinal canal[13] and causing neurological damage.[13,19–22] The position of the screws away from the spinal canal cause less distortion and artifacts in the post-operative MRI and CT scans. Use of titanium screws will further reduce this problem.[23]

The small volume of the metal in comparison with pedicle screw constructs may reduce the rate of infection and also provide an adequate area for placement of bone grafts.[13] The low cost of the implants is an added advantage in view of the rising costs of health care.[13]

The advantages of TLFS fixation are listed in [Table 1].

There are however some potential disadvantages with the TLFS:

1. Decompressive procedures for degenerative spinal conditions require the removal of lamina, spinous process and facet joints either partially or completely. Since these structures are needed for the passage of the translaminar screws, the decompression procedure has to be modified by undercutting the lamina and facet joints instead of completely excising them.[24]
2. Stabilisation of the anterior column is not possible with TLFS unlike the pedicle screw fixation systems, which anchor all the three spinal columns.
3. Compression and distraction maneuvers cannot be performed to widen the neural foramen and disc space as with the pedicle screw fixation systems. In certain situations, distraction can be achieved to a limited extent with TLFS by distracting the spinous processes with a spreader before inserting the screw.[19,25]

Table 1: Advantages of TLFS fixation.

• Short segment fixation.
• Less hard ware. Low cost.
• Shorter duration of surgery.
• Lower incidence of neurological injury as the screws traverse the lamina tangential to the spinal canal.
• Large surface area is available for graft placement as most of the posterior arch remains intact.
• Adjacent facet joints are not disturbed.
• Screw insertion through the lamina minimizes screw contact with muscle as only the two screw heads project above the level of the bone.
• Can be used to achieve global fusion with limited intervention from the posterior aspect.
• Artifacts in the post operative MRI do not obscure the spinal canal
• Comparatively easy learning curve.

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Indications and contraindications for TLFS

Intact spinous process, laminae and an intact anterior column that is able to resist compressive forces are pre-requisites for considering the use of translaminar facet screws.[13,19] Therefore, degenerative conditions with segmental instability which generally have no major anterior deficiency constitute the ideal indication for this technique. Pathological conditions with anterior structural defects may also benefit from translaminar facetal screws after a solid anterior reconstruction.

If a posterior decompression is being planned, a technique that preserves major parts of the laminae and spinous processes has to be used. Isthmic spondylolysis with a defect of the pars interarticularis and loose lamina and spinous process are obvious contra indications for translaminar screws. In contrast, degenerative spondylolisthesis with intact posterior bony elements, where the extent of listhesis does not usually exceed Grade I, can be stabilised with translaminar screws.

Translaminar screws can be used to augment anterior fusion to achieve a global fusion. High fusion rates can be achieved provided the biomechanical principles of the lumbar spine with an intact anterior column are respected and a meticulous operative technique is employed to enhance bony ingrowth of the graft.[12,13,19–22]

The common indications and contra indications are listed in [Table 2 and 3].

Surgical technique[2,4,5,12,13,19–22,24–26]

The patient is placed prone on a spinal frame under general anaesthesia. Using a vertical midline incision a subperiosteal exposure of the spinous process, laminae, facet joints and transverse processes is performed bilaterally. The levels are marked prior to the skin incision and reconfirmed after the exposure using a fluoroscope. A spinal canal decompression is performed when necessary ensuring that the spinous process and most parts of the laminae and facet joints are left intact. The facet capsule is incised and opening up the facet joints by gentle traction on the spinous process facilitates the curetting of the articular cartilage using small sharp curettes. Severe facet arthritis leads to the eburnation of the joint margins with marginal osteophyte formation. Trimming of the osteophytes to regain the normal joint margins and surfaces is performed to permit accurate screw alignment. The facet joint is then filled with small chips of cancellous bone.

Table 2: The common indications for TLFS

• Grade I degenerative anterolisthesis / retrolisthesis.
• Degenerative lumbar canal stenosis with instability.
• Recurrent disc herniation requiring instrumented fusion
• To achieve global fusion after ALIF with minimal instrumenta tion from the posterior approach.
• Degenerative lumbar segmental instability.
• Failed back syndrome requiring instrumented fusion.

Table 3: Contraindications for TLFS fixation

• Prior surgical removal of the spinous process
• Insufficient facets either due to a congenital anomaly or following surgical excision.
• Spondylolisthesis of more than Grade I severity.
• Lytic listhesis.
• Structural defects of the anterior column.
• Severe osteoporosis.

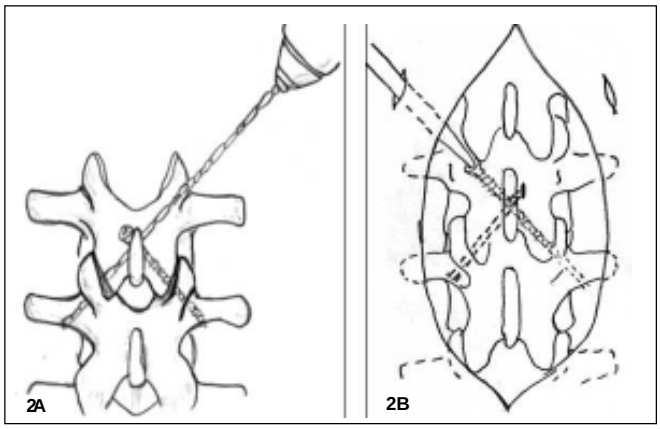

Figure 2A: The starting point of the screw is at the base of the spinous process on the contralateral side. The starting point of the first screw must be so planned (either caudal or cranial to the mid point of the spinous process) to ensure accurate placement of the second screw from the opposite side. 2B: The drill and the screw are introduced through a separate stab incision 5-7 cm lateral to the mid line

A 3.2 mm long drill attached to a pneumatic source is introduced through a separate percutaneous stab incision, about 5-7 mm away from the midline. [Figure 2A] The use of a separate stab incision obviates the need for a long midline incision and excessive retraction of the paraspinal muscles. After confirming the direction of intended screw placement, a drill hole is made at the base of the spinous process on the contralateral side, passing between the two tables of the lamina, across the centre of the facet joint and ending at the base of the transverse process of the lower vertebra. [Figure 1] Placing the first screw at the centre of the base of the spinous process makes the passage of the second screw difficult. Therefore it is ideal that the first screw is inserted at the superior part of the base of the spinous process so that the two screws do not impinge on each other. [Figure 2B] A flat probe is placed under the lamina during drilling to monitor any inadvertent drilling of the undersurface of the lamina and injury to the dura. For a lumbosacral fixation, the screws are inserted into the spinous process and exit at the ala of the sacrum.

Accurate measurement of screw length with a depth gauge may be difficult due to the direction of the drill hole and the screw placement should be reconfirmed in the anteroposterior and lateral planes using a fluoroscope. At the time of screw insertion, any listhesis should be reduced by applying a gentle traction between the spinous processes using a spreader or by direct reduction of the forward slip by manually lifting up the vertebra with a hold on the spinous process. The spinous process is the site of insertion of the screw and careful handling prevents any structural damage. Once the slip has been manually reduced the position must be maintained till the drill hole and screw insertion are completed. A 4.5 mm corticle screw (preferably titanium) is inserted into the

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Table 4: Various studies describing the use of TLFS fixation and reported clinical results

Author/Year	Sample size (No. of patients)	Follow-up	Clinical result	Fusion rate %	Fusion time	Complications
Jacobs et al[23] 1989	43	16 months	93% improved	91	6 months	No neurological complications
Grob et al[27] 1992	72 (120 segments)	24.4 months	76% of patients said that they would undergo the same procedure again	94.5	-	Screw breakage-5 Five screws did not cross the facet.Discitis -1Increased back pain-2 Dural tear-1Wrong level-1No neurological compli cations.
Reich et al[24] 1993	61	24 months	93.4% excellent to good results. 6.6%	98.4	5 months	No neurological complica tions unsatisfactory.
Humke et al[15] 1998	173	68 months	99 pts -good.70 pts - satisfactory 4 pts - bad	94	-	3% loosening.2 broken screwsDiscitis-1 Dural tear-1Temporary quadriceps weakness-1Wrong level-1Transient nerve root irritation-3

drill hole at the base of the spinous process through the previous percutaneous stab incision and the contralateral screw is inserted by following the same steps through a drill hole from a paraspinal stab incision on the opposite side. [Figure 1, 2A, 2B and 3] The translaminar screw does not function as a lag screw and hence does not need to be overtightened. The direction, orientation and length of the screws are reconfirmed at the end of the procedure. A probe is passed under the lamina to confirm that the screw has not inadvertently entered the spinal canal or the foramina before a standard closure is performed.

Clinical Results

There have been numerous reports on the excellent clinical outcome following translaminar facetal screw fixation. With the appropriate indication, the rate of pseudarthrosis is low in the literature (Marchesi et al[20] 1.5%; Jacobs et al[21] 9% and Grob et al[25] 5.5%.) These rates are not directly comparable with those following pedicular screw fixation because the indications and degrees of preoperative instability vary. Severe neurologic complications are rare with translaminar screws of the lumbar spine. The clinical and radiological results reported by various authors are out lined in [Table 4].

Jacobs et al[21] in 1989 reported the results of 43 patients who underwent translaminar facetal screw fixation and posterolateral fusion for various indications. At a mean follow-up period of 16 months, good clinical outcome was reported in 93% of the patients. Radiological fusion was noted in 91% of the patients at an average period of six months. Compared with their previously reported results of non-instrumented lumbar fusion, the use of TLFS significantly improved the clinical results and reduced the time required for fusion without posing any significant risks.

Reich et al[22] in 1993 evaluated the clinical results and fusion rates in 61 patients who underwent posterolateral spine fusion augmented with TLFS at an average follow-up of 24 months. Solid fusion was observed in 98.4% of the patients at an average of five months with excellent to good results 93.4% of the patients. None of these patients had neurological complications.

Figure 3: Radiograph of a 60-year old gentleman with neurogenic claudication secondary to degenerative spondylolisthesis and segmental instability at L4-5 level. Adequate decompression was followed by fusion and stabilization using two translaminar facetal screws

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Humke et al[13] in 1998 reported the five-year follow-up results in 173 patients who underwent the procedure for various indications like degenerative changes with or without compressive syndromes, failed back syndrome, monosegmental hypermobility and posttraumatic situations. Monosegmental TLFS was performed in 57%, across two segments in 40% and over three segments in 2% of the patients. Fusion was reported in 94% of the patients with a 3% incidence of screw loosening and two instances of asymptomatic screw breakage without radiological evidence of segmental hypermobility. Of 173 patients, the clinical results were good in 99 patients, satisfactory in 70 and poor in four patients. No neurologic complications were reported. The authors concluded that TLFS is a useful and inexpensive technique for short segment fusion in non-traumatic conditions in the lumbar and lumbosacral spine.

The rate of neurological complications are extremely low and the reported complications include a temporary quadriceps weakness in one case; transient nerve root irritation in three and one dural tear in a series of 173 patients with five year follow-up.[13] Grob et al[25] reported five broken screws in 120 operated segments. Other technical complications like failure to cross the facet joint were reported in five instances by Grob et al.[25] One instance of wrong level fixation was reported by Humke et al.[13]

Poltz et al[27] reported anterior translation of the upper fused vertebra in five patients who underwent a TLFS fixation. All these patients underwent a partial under cutting facetectomy while retaining the lateral two-thirds of the joint. They concluded that TLFS produces slight posterior distraction that pushes the upper vertebrae anteriorly. This may be an advantage for fusion of a degenerated segment when the upper vertebra has slipped posteriorly but the authors advised against using this technique in the presence of anterior translation of the superior vertebrae.

Summary

1. Translaminar facet screw is a technically simple, cost effective and reliable method of segmental stabilisation of the lumbar and lumbosacral segments.
2. TLFS is indicated in low-grade degenerative listhesis and to augment an anterior lumbar interbody fusion.
3. The procedure is associated with high fusion rates and a low complication rate.

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