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Percutaneous translaminar facet pedicle screw fixation following anterior lumbar interbody fusion

Anterior lomber füzyondan sonra perkütan translaminer faset pedikül vida fiksasyonu

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Objectives: This retrospective study was conducted to describe a novel minimally invasive translaminar facet pedicle screw fixation technique that was modified from the Magerl's method and to assess its technical feasibility and clinical efficacy.

Patients and methods: Twenty consecutive patients (19 females, 1 male; mean age 54 years; range 41 to 68 years) with degenerative spinal disease underwent anterior lumbar interbody fusion (ALIF) and supplementary percutaneous translaminar facet screw fixation under fluoroscopic guidance, in which the screw was directed to purchase with the pedicle while traversing the laminae and transfixing the facet. Spinal fusion was performed at 1, 2, and 3 levels in 10, 7, and 3 patients, respectively. The results were evaluated with the use of the visual analog scale (VAS) and the Oswestry Disability Index (ODI). The patients were evaluated by computed tomography (CT) and radiographs immediately after the operation and at the last follow-up. The mean follow-up period was 19.5 months (range 10 to 28 months).

Results: A total of 65 screws were inserted. Seven screws (10.8%) were found to have violated laminae walls on immediate postoperative CT scans. Screw-associated direct neural injury or neural compression did not occur. Facet purchases were successful in all the screws, but pedicle purchases were successful in 55 screws (84.6%). Radiologic fusion occurred in all the cases. The mean preoperative ODI score decreased from 52% to 26%, and the mean preoperative VAS scores for pain and leg pain decreased from 8.5 to 4.5 and from 6.25 to 2.3, respectively. The mean operation time was 57 minutes per level for ALIF and 47 minutes per level for percutaneous translaminar transfacet screw fixation. There was only one complication related to facet screw fixation that necessitated revision.

Conclusion: Percutaneous translaminar facet pedicle screw fixation with the use of fluoroscopy is a technically feasible minimally invasive posterior augmentation method following anterior lumbar interbody fusion.

Key words: Biomechanics; bone screws; intervertebral disk displacement/surgery; joint instability; lumbar vertebrae/surgery; prostheses and implants; spinal fusion/instrumentation/methods.

Amaç: Bu geriye dönük çalışmada, Magerl yönteminden modifiye edilerek geliştirilen yeni bir minimal invaziv translaminar faset pedikül vida fiksasyon tekniği tanımlandı ve bu tekniğin uygulanabilirliği ve klinik etkinliği değerlendirildi.

Hastalar ve yöntemler: Dejeneratif spinal hastalığı olan ardışık 20 olgu (19 kadın, 1 erkek; ort. yaş 54; dağılım 41-68) anterior lomber interbody füzyonu (ALIF) ve bunu destekleyici olarak, floroskopi rehberliğinde perkütan translaminar faset vida fiksasyonu ile tedavi edildi. Tanımlanan teknik, laminayı geçen, faseti transfikse eden vidanın pediküle tutunmasını sağlamayı amaçlıyordu. Spinal füzyon 10 hastada bir, yedi hastada iki, üç hastada üç düzeyde uygulandı. Sonuçlar ağrı yönünden görsel analog skala (GAS) ve Oswestry Sakatlık İndeksi (OSİ) ile değerlendirildi. Tüm hastalar ameliyattan hemen sonra ve son kontrollerde bilgisayarlı tomografi (BT) ve radyografilerle incelendi. Ortalama izlem süresi 19.5 ay (dağılım 10-28 ay) idi.

Bulgular: Ameliyattan hemen sonra çekilen BT görüntülerinde, uygulanan toplam 65 vidanın yedisinin (%10.8) lamina duvarlarına zarar verdiği izlendi. Vidalara bağlı direkt nöral yaralanma ya da nöral bası meydana gelmedi. Tüm vidalar fasetlere başarılı bir şekilde tutunurken, pedikül tutunması 55 vidada (%84.6) başarılı idi. Tüm olgularda radyolojik füzyon sağlandı. Ameliyat öncesinde ortalama %52 olan OSİ skoru son takipte %26'ya; ağrı ve bacak ağrısı için GAS skorları sırasıyla 8.5'ten 4.5'e ve 6.25'ten 2.3'e geriledi. Düzey başına ortalama ameliyat süresi ALIF için 57 dakika, perkütan translaminar faset vida fiksasyonu için 47 dakika bulundu. Her iki uygulama için sadece bir olguda komplikasyon görüldü; faset vida fiksasyonu ile ilgili gelişen bir komplikasyon için revizyon uygulandı.

Sonuç: Floroskopi altında yapılan perkütan translaminar faset pedikül vida fiksasyonu, ALIF sonrasında başvurulabilecek, uygulanabilirliği yüksek bir minimal invaziv posterior ogmentasyon yöntemidir.

Anahtar sözcükler: Biyomekanik; kemik vidası; intervertebral disk deplasmanı/cerrahi; eklem instabilitesi; lomber vertebra/cerrahi; protez ve implant; spinal füzyon/enstrümantasyon/yöntem.

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Anterior lumbar interbody fusion (ALIF) with cages has been used to treat a variety of spinal diseases and has gained widespread popularity, but biomechanical studies of cage-assisted ALIF have shown that it does not stabilize the vertebral motion units in extension and axial rotation.[1-5] To obtain immediate postoperative stability, and thus, enhance fusion, a supplementary posterior fixation such as facet screw fixation or pedicle screw fixation is needed.

The translaminar facet screw fixation has been used by some surgeons for decades for facet fusion or as a supplementary fixation to other fusion procedures.[6-18] However, it has usually been performed through a new skin incision on the back, with dissection and retraction of the muscles resulting in some residual back pain due to damage to, and atrophy of the muscles as well as a large operative scar. Hence, the need to insert the translaminar facet screw in a less invasive way in the augmentation of ALIF. This is especially true when ALIF is performed with the use of a minimally invasive method. Grob et al.[8] described the possible use of percutaneous translaminar facet screw as a posterior fixation method supplementary to ALIF and developed a device prototype for this purpose; however, their report lacked technical details and clinical outcomes. Jang et al.[19] were the first to report technical details of a specially designed guide-device to insert translaminar facet screws percutaneously after ALIF, but the lack of commercial availability of this device has prevented its use.

In this study, we inserted the translaminar facet screws percutaneously through stab wounds under fluoroscopic guidance without using any special device. Furthermore, modifying the insertion technique, which was originally described by Magerl,[14] we inserted the screws into the pedicles passing the facet joints with the presumption that it would provide increased biomechanical stability.

The objectives of this study were to describe this new technique of fluoroscopically assisted translaminar facet pedicle screw placement performed in a consecutive group of patients, and to evaluate the safety, accuracy and short-term clinical results of the technique.

PATIENTS AND METHODS

From March 2001 to December 2002, 20 consecutive patients (19 females, 1 male; mean age 54 years; range 41 to 68 years) with degenerative spinal disease underwent ALIF, followed by percutaneous translaminar facet screw fixation. Spinal fusion (without posterior neural decompression) was considered in the patient group based on the following indications: degenerative flat back deformity (n=8), low-grade degenerative spondylolisthesis (n=7), and degenerative disc disease (n=5). Spinal fusion was performed at 1, 2, and 3 levels in 10, 7, and 3 patients, respectively. The mean follow-up period was 19.5 months (range 10 to 28 months).

Data collection

All the patients responded to a preoperative questionnaire containing a 10-point visual analog scale (VAS) for back and leg pain, and the Oswestry Disability Index (ODI).[20] Immediately after the operation, the patients were evaluated by a CT scan and standing, plain anteroposterior, and lateral radiographs to see the trajectory of the screws and purchases of the facet joints and the pedicles. At the last follow-up, the patients answered a questionnaire containing VAS, ODI, and a question to elicit the patient's subjective improvement rate. Computed tomography scans and plain radiographs including dynamic views were obtained to check bony union. Radiologically, fusion was assessed depending on the presence of the following criteria proposed by Kuslich:[21] *(i)* the presence of bridging bones in the interbody space; *(ii)* motion of 5 degrees or less on lateral dynamic radiographs, *(iii)* absence of radiolucencies on adjacent surfaces of the cages, and *(iv)* observation of bone bridging from one vertebral body to the other on thin section, sagittal plane CT scans. An independent personnel interviewed the patients at the last follow-up and evaluated clinical outcomes according to the Macnab criteria.[22]

Operative technique

Mini-open ALIF: The patient was placed in a supine position and mini-open retroperitoneal ALIF was performed. The cages used were OIC PEEKTM (Stryker Spine, Bordeaux, France) or Osta-Pek® (Co-Ligne AG, Zurich, Switzerland). Allograft bone chips were used in the cages as the graft material in all the patients. To enhance fusion, bone marrow was aspirated from the iliac crest and mixed with allograft chips before they were packed into the cages. After insertion, the cages were spread to create room for additional grafts in

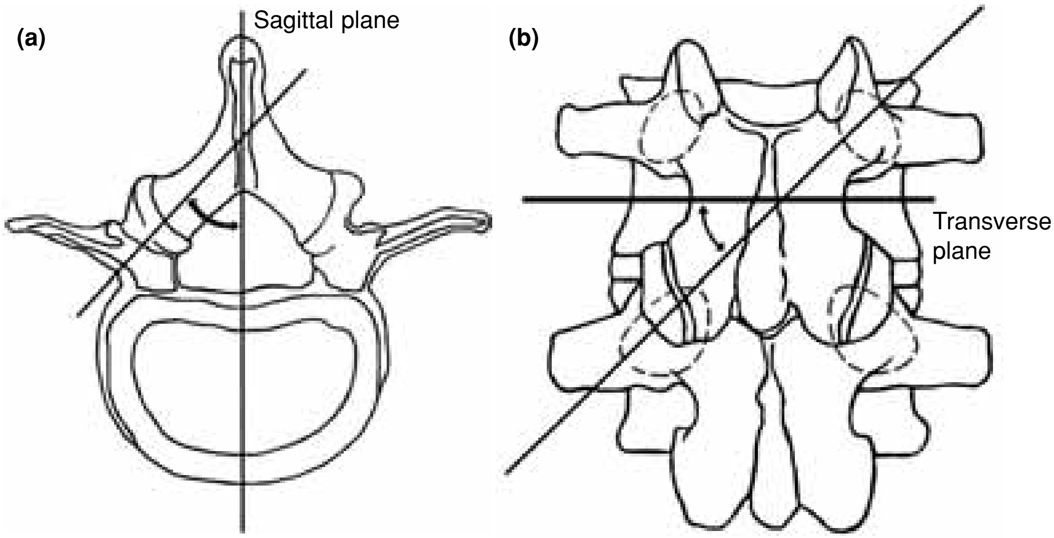

Fig. 1. Schematic drawings showing the trajectory of the translaminar facet screw. **(a)** The lateral angle of the screw path, which lies at the intersection of the following lines *(i)* the line drawn from the spinolaminar junction to the center of the laminar, the facet joint, and posterior one-third of the pedicle, *(ii)* the line representing the sagittal plane. **(b)** The caudal angle of the screw path, which lies at the intersection of the following lines *(i)* the line drawn from the pedicle of the upper vertebra through the cranial one-third of the spinolaminar junction to the superolateral quadrant of the opposite pedicle of the lower vertebra, *(ii)* the line representing the transverse plane.

cases where paired cages (OIC PEEKTM) were used. In cases where a single cage (Osta-Pek®) was used, additional grafts were placed into lateral and anterior spaces in the cage.

Percutaneous translaminar facet pedicle screw fixation: After the ALIF procedure, the patient was shifted to a prone position. The lateral angle in the axial plane, which is the same as the laminar angle, was determined preoperatively on CT scans or axial magnetic resonance (MR) images (Fig. 1a, 2). The line of this angle was extended to the skin. The distance from the midline to the skin was measured. In the operative field, a paravertebral, vertical line was drawn from the midline to this distance. Then the caudal angle of the screw trajectory was determined with the use of the fluoroscope (Fig. 1b, 3a). A line was drawn from the pedicle of the upper vertebra of the motion segment to be fused, passing the cranial one-third of the base of the spinous process, to the superolateral quadrant of the opposite pedicle of the lower vertebra. The angle made by this line and the transverse axis of the spinal column was the caudal angle. The point of the skin entry was at the intersection of the caudal angle line with the paravertebral line representing the distance from the midline of the spine. A bone biopsy needle was inserted into the skin through a stab wound at the entry point. The needle was introduced along the lateral angle and caudal angle until the tip of the needle was anchored at the cranial one-third of the base of the spinous process (Fig. 3b). Then, the stylet was withdrawn and a K-wire was inserted. With an electrically powered drill and under fluoroscopic guidance, the wire was drilled toward the superolateral

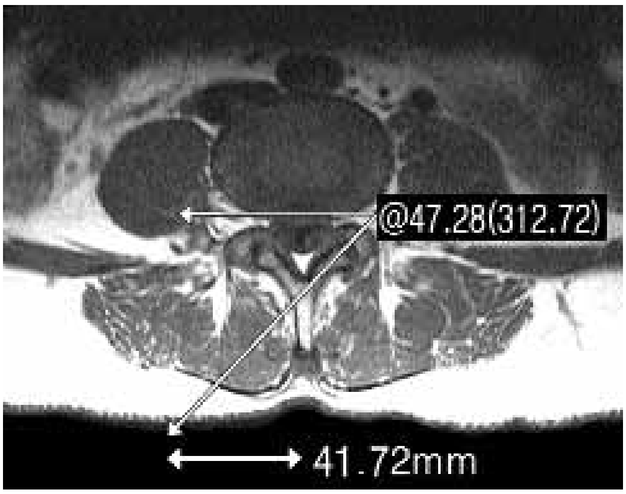

Fig. 2. The lateral angle is measured on a preoperative axial CT or MRI scan. The line of the angle is extended to the skin level to measure the distance from skin entry to the midline.

quadrant of the opposite pedicle of the lower vertebra, passing the lamina and the facet joint (Fig. 3c). A cannulated lag-screw of 46 mm or 51 mm length was inserted along the K-wire until the head of the screw engaged with the base of the spinous process (Fig. 3d). The same procedure was carried out on the opposite side (Fig. 4).

RESULTS

Screw position

A total of 65 screws were inserted. In a patient with a unilateral dystrophic facet joint, only one screw was inserted into the normal facet. Seven screws (10.8%) were found to have violated some portions of the walls of the laminae on immediate postoperative CT scans. Five screws violated the outer laminae walls, and two screws violated the inner laminae walls. Screw-associated direct neural injury or neural compression did not occur. Facet purchases were successful in all the screws (Fig. 5). Though the goal was to achieve a proper pedicle purchase in every case, this was successful in 55 screws (84.6%). Failure of 10 screws (15.4%) to perfectly purchase the pedicle resulted either from partial engagement of the screw with the pedicle or from the lack of insertion into the pedicle despite a proper advancement through the facet joint.

Clinical outcomes

The mean preoperative ODI score decreased from 52% (range 26% to 88%) to a mean of 26% (range 8% to 62%) postoperatively. The mean preoperative VAS scores for pain and leg pain improved from 8.5 to 4.5 and from 6.25 to 2.3, respectively. Radiologic fusion

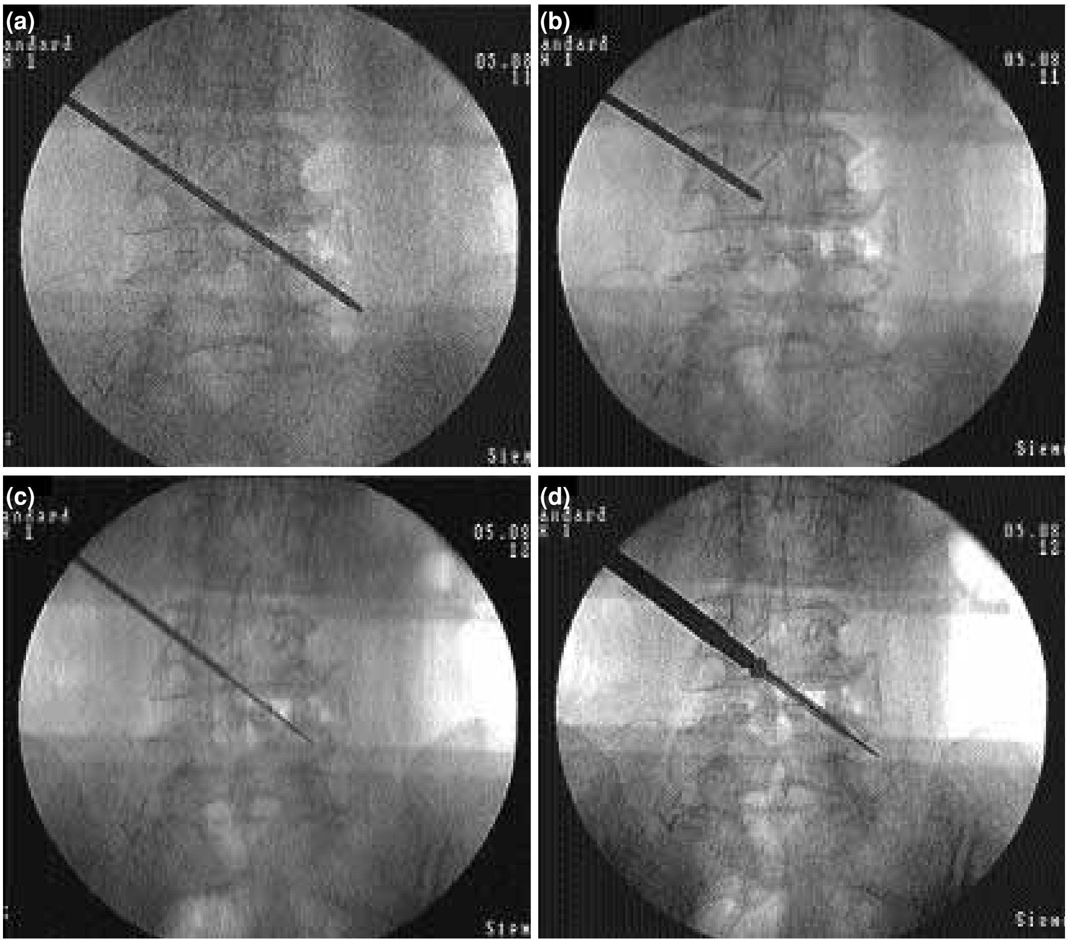

Fig. 3. (a) The caudal angle of the screw path is determined by inserting a bone biopsy needle into the skin, under fluoroscopic guidance, that passes from the pedicle of the upper vertebra to the superolateral quadrant of the opposite pedicle of the lower vertebra. **(b)** The tip of the needle is anchored at the cranial one-third of the base of the spinous process. **(c)** A K-wire is inserted with the use of an electrically powered drill. **(d)** A cannulated lag-screw is inserted until the head is engaged with the base of the spinous process.

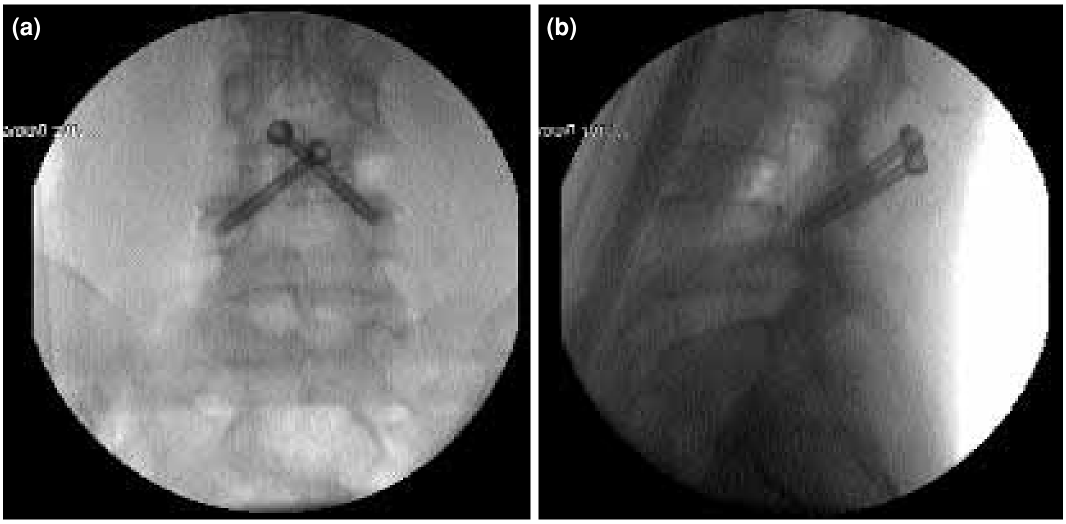

Fig. 4. (a) Anteroposterior and **(b)** lateral fluoroscopic views showing trajectories of the screws.

occurred in all the cases (Fig. 6). The mean operation time was 94 minutes (57 minutes per level) for ALIF and 79 minutes (47 minutes per level) for percutaneous translaminar transfacet screw fixation. The average blood loss was 222.5 ml (range 100 to 520 ml) and in no case was a blood transfusion needed. According to the Macnab criteria, the results were excellent in four patients (20%), good in 12 patients (60%), fair in two patients (10%), and poor in two patients. The mean subjective improvement rate scored by the patients was 73% (range 0% to 100%).

Complications

There was no complication related to ALIF, while one complication occurred in relation to facet screw fixation. A fractured tip of a superior articular process of the sacrum was noted on a postoperative CT scan in one patient, who awoke with radicular pain. The fractured fragment compressed the exiting L_5 root. The path of the screw was not incorrect, suggesting that the problem had arisen from repeated drilling through the facet with the K-wire to make a perfect path for the screw. At revision surgery, pedicle screw fixation was performed after removal of the facet screw and the fractured fragment.

DISCUSSION

Minimally invasive techniques are becoming more widespread in surgical specialties. As a minimally invasive fusion method in spine surgery, ALIF has

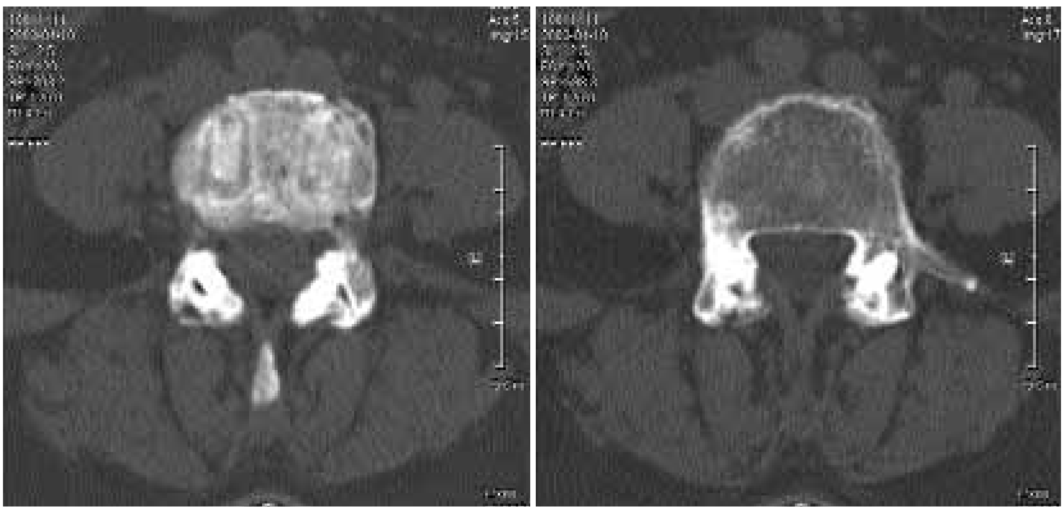

Fig. 5. Sequential CT slices of a 64-year-old female patient at the end of a year postoperatively. The screws were inserted into the pedicles perfectly and transfixed the facet joints properly. Solid bony union is seen in the cages and grafts between them.

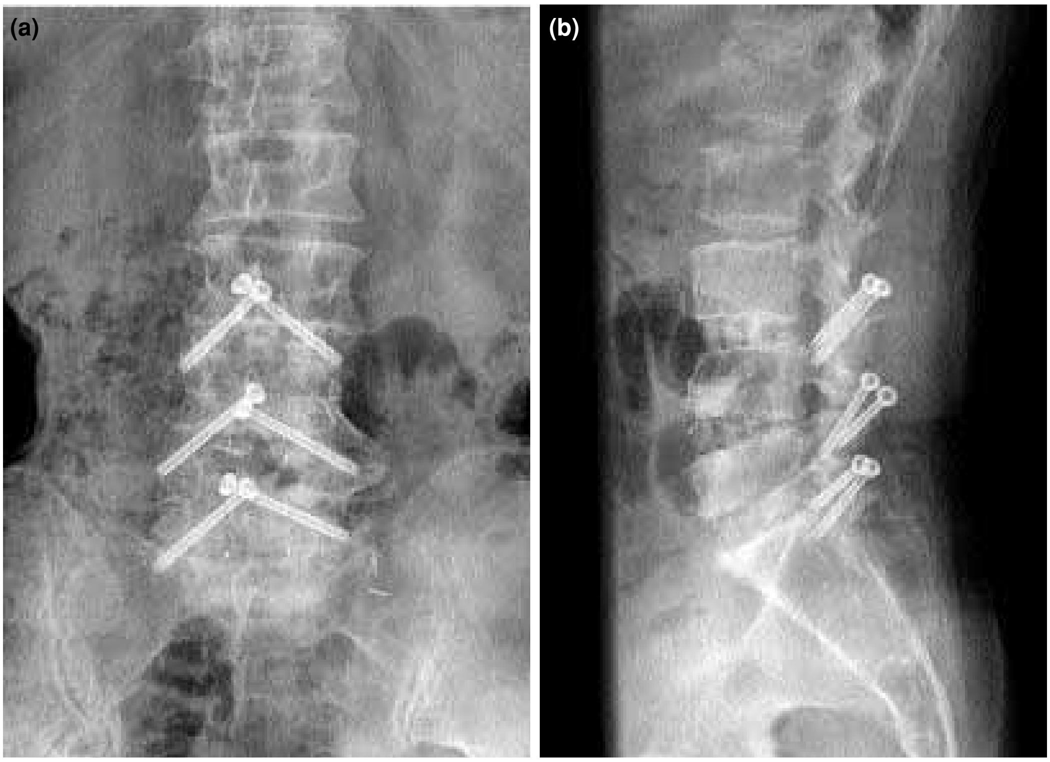

Fig. 6. (a) Anteroposterior and **(b)** lateral radiographs of a 57-year-old female patient taken at the end of a year postoperatively. In the lateral view, solid bony bridges connecting the upper and lower vertebral bodies are seen in the cages at each level.

been performed through a mini-laparotomy or laparoscopically.[23-27] Biomechanical studies of cage-assisted ALIF, however, have shown that the cages decreased the intervertebral movement in flexion and lateral bending, but provided no stabilization in either extension or axial rotation.[1-5] Oxland et al.[3] found that translaminar facet fixation was effective to stabilize extension, in which case cages did not provide stabilization. Rathonyi et al.[4] demonstrated that anterior cages, with supplementary translaminar facet screw fixation, limited motion in all loading directions. In addition to providing immediate postoperative stability, translaminar facet screw fixation enhanced fusion.[6,8-12,16-18]

When ALIF is performed through a minimally invasive method, the supplementary posterior fixation method should also be minimally invasive. Percutaneous translaminar facet screw fixation supplementary to ALIF was first described by Grob et al.,[8] but their description lacked both technical details and clinical results. Jang et al.[19] described technical details of a percutaneous translaminar facet-fixation method using a guide device, but the lack of commercial availability of this device has prevented its use. To our knowledge, this is the first report on a percutaneous translaminar facet screw fixation method that is solely fluoroscopically assisted, without the need for any special device; moreover, our results in 20 patients justify its safety and technical feasibility.

Instrumentation for the lumbar facets as a means of internal fixation was initially described by King,[13] who placed a small screw across the facet joint in conjunction with a posterior fusion. Boucher[7] modified this technique, using a longer screw directed toward the pedicle with additional cancellous bone graft. Then, Magerl[14] used a longer screw that was inserted from the base of the spinous process transversely across the contralateral lamina to transfix the facet joint, extending down into the base of the transverse process. This method was thought, by most surgeons, to confer a greater biomechanical efficacy, and therefore, gained much popularity even though it was more difficult and hazardous than the true transfacet technique and was not compared biomechanically with the latter. We theorized that, biomechanically, a more sound fixation could be obtained when the translaminar transfacet screw is directed to engage with the pedicle. Therefore, when inserting the translaminar facet screw, we tried to engage the pedicle passing the facet joint.

In a recent biomechanical study, Ferrara et al.[28] compared transfacet pedicle screw fixation with the conventional pedicle screw fixation in specimens that were instrumented with bilateral semicircular interbody spacers. They demonstrated that the former not only showed similar stability under short-term and long-term cyclic loading conditions, but also resulted in a significantly stiffer fixation in flexion. In another recent biomechanical study, the transfacet pedicle screw fixation, translaminar facet screw fixation, and the standard pedicle screw fixation were compared.[29] No differences were observed between the three fixation systems except in flexion, where the former showed a significantly greater stiffness than the other two. These reports partly support our conjecture that transfixing both the facet joint and the pedicle would give a more sound stability than just transfixing only the facet joint, even though the stability gain was shown to be only in flexion.

Recently, a percutaneous pedicle screw fixation method with a specially designed pedicle screw system has been described as a minimally invasive posterior fixation method.[30] However, the pedicle screw system has several drawbacks. It is more expensive compared to the facet screw. Furthermore, it is technically more complicated because insertion of four screws is required for one level fusion, with additional rods or plates to fix the screws. Last but not least, there is no percutaneous pedicle screw system that can be used in fusion involving more than two levels.

Therefore, considering the cost, technical difficulty, and the results of biomechanical studies showing similar stability regardless of fixation systems, there is no reason to choose pedicle screw fixation when a posterior fixation is needed to augment ALIF, except when there is spondylolysis.

An issue with the described method here is that the lateral angle of screw insertion is narrower compared to that in the original Magerl's method, thus presenting a higher potential risk for screw-induced neural tissue injuries. In fact, there were 10 screws that failed to purchase with the pedicle properly in this study and it was assumed that the failures resulted from our concern for neural damage that might happen in case too narrow a lateral angle and too medial a direction were used for the screws. The paths of the screws that failed to purchase with the pedicle in this study were established too laterally, and in this respect, were just like the original paths described by Magerl. It is our opinion that the procedure is safe if the trajectory of the screw passes the superolateral quadrant of the pedicle on an anteroposterior view, and toward the posterior third of the pedicle on a lateral fluoroscopic view.

In this study, all of the screws transfixed the facet joint successfully even though some failed to engage with the pedicle. Also, the clinical results were acceptable in terms of fusion rate and the rarity of complications. We believe that our data highly support the feasibility and clinical efficacy of this technique. The technique of facet screw fixation is relatively easy to learn if the surgeon has a good insight into the anatomy of the lamina, the facet joints, and related structures of the spine, and is familiar with fluoroscopic spine images. In conclusion, fluoroscopically-assisted percutaneous translaminar facet pedicle screw fixation is a technically feasible, safe, useful, and minimally invasive posterior fixation method that can reliably be incorporated into ALIF.

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