An analysis of fusion cage migration in unilateral and bilateral fixation with transforaminal lumbar interbody fusion

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Abstract

Purpose To investigate if instrumentation (unilateral vs. bilateral fixation) has an effect on the rate of fusion cage migration.

Methods This clinical study of transforaminal lumbar interbody fusion involved a prospective group of 116 patients who were randomly assigned to either unilateral ($n = 57$) or bilateral ($n = 59$) fixation. Fourteen were lost to follow-up (11 from the unilateral group and 3 from the bilateral group).

Results The unilateral fixation group consisted of 20 male and 26 female patients. In the unilateral group, the mean age was 53.5 years (range, 18–77), and the preoperative diagnosis consisted of degenerative disc disease, with or without herniated disc ($n = 44$), and degenerative spondylolisthesis with spinal stenosis ($n = 2$). The bilateral fixation group consisted of 20 male and 36 female patients. In the bilateral group, the mean age was 55.7 years (range, 26–82), and the preoperative diagnosis consisted of degenerative disc disease, with or without herniated disc ($n = 40$), and degenerative spondylolisthesis with spinal stenosis ($n = 16$). A total of 17 cases of cage migration were found; of these, 11 were from the unilateral group and 6 from the bilateral group, resulting in rates of cage migration of 23 and 11 % ($p = 0.03$), respectively. In regard to migration cases, 5 were male and

12 were female. Ages ranged from 27 to 79 years (mean age, 55 years).

Conclusion We conclude that unilateral fixation is not stable enough to prevent fusion cage migration in some patients who undergo TLIF.

Keywords Transforaminal lumbar interbody fusion · Posterior fixation · Fusion cage · Cage migration

Introduction

The need for instrumentation with spinal fusion procedures is a controversial issue. Nonetheless, spinal fusion with pedicle screws is widely performed [1]. The essence of the controversy is that even though there is substantial evidence that the addition of instrumentation to spinal fusion procedures significantly improves fusion rates [2–4], its effect on clinical outcome, as compared to fusion without instrumentation, has not been clearly understood [5, 6].

The effectiveness of unilateral fixation as compared to bilateral fixation in lumbar fusion has been previously investigated. Several studies have shown that unilateral fixation is as effective as bilateral fixation in regard to clinical outcome and fusion rate [1, 7–10]. However, the results of these studies show conflicting results in regards to complications. Suk et al. [1], as well as Xue et al. [10] demonstrated that the metal failure rate for the unilateral group was higher than the bilateral group. Conversely, Fernandez-Fairen et al. [8] results demonstrated that the bilateral group had a higher screw complication rate than the unilateral group, 7.3 versus 0 %, respectively. A recent study by Feng et al. [9] compared bilateral decompression utilizing unilateral fixation via a paramedian approach to bilateral decompression utilizing bilateral fixation via a paramedian approach, and showed

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comparable clinical outcomes with no postoperative complications. However, these outcomes were measured over a very short-term of 3 months postoperatively, which can be argued is too short a follow-up to measure complications. Also, even though these studies suggest that unilateral fixation is as effective as bilateral fixation in lumbar fusion, it is important to note that most of these studies only investigated posterolateral fusion, whereas, the current study examines the effect of these fixation types on transforaminal lumbar interbody fusion procedures.

The use of interbody fusion cages in the treatment of degenerative lumbar disease has many advantages which primarily involve improved spinal stability and fusion rate. In regard to achieving successful lumbar arthrodesis, studies have shown that the use of interbody cages in transforaminal lumbar interbody fusion (TLIF) procedures result in fusion rates between 90 and 100 % [11, 12]. Further, utilization of fusion cages results in stabilization of the anterior column and restoration of foraminal and disc space height [13, 14].

The role of posterior instrumentation when combined with fusion cages has also been studied. Previous studies have shown that posterior instrumentation in combination with the interbody cage enhances stabilization, and in some cases, when combined with pedicle screws, provided the greatest stabilization of the device-spine construct [16–19]. More specifically, Uzi et al. [14] reported that posterior displacement of cages can be prevented with the use of posterior instrumentation. Later, Chen et al. [20] reported that lack of posterior instrumentation is a risk factor for cage migration in spondylolisthesis. Despite these findings, cage migration does occur in the presence of posterior instrumentation.

More recently, limited case reports demonstrate an increased chance of cage migration in patients who undergo TLIF procedures with unilateral fixation [21, 22]. The current study, which examines cage migration, is a prospective, randomized study of patients who have undergone a TLIF procedure, which investigates if instrumentation type (unilateral vs. bilateral fixation) has an effect on the rate of cage migration.

Finally, with recent studies demonstrating comparable clinical efficacy of minimally invasive (MIS) TLIF as compared to open TLIF [23], and with MIS TLIF initially involving exposure of one side, it would be advantageous to surgeons who utilize this approach to stop at that point (without exposing and fixating the other side), if the results are the same, because it avoids soft-tissue disruption of the contralateral side and may take less time [24].

Materials and methods

A prospective randomized study of 116 patients, who underwent a TLIF procedure that utilized the

polyethyletherketone (PEEK) (MOBIS®, SIGNUS, Germany) interbody fusion cage and posterior titanium polyaxial pedicle screw instrumentation (unilateral or bilateral fixation), was performed by a single fellowship trained spine surgeon. The inclusion criteria for this study were: (1) patients with degenerative spondylolisthesis, (2) patients with collapse of disc space height, herniated disc, or spinal stenosis, (3) patients with chronic lower back pain and leg pain unresponsive to conservative therapy for at least 3 months. The exclusion criteria for the study were patients with isthmic spondylolisthesis and degenerative scoliosis. Institutional ethical committee approval was obtained and all subjects gave their informed written consent before participation in the study. Information given to the participants prior to the study was that the purpose of the study was to compare the outcomes of two fixation techniques (unilateral vs. bilateral). Patients were recruited from the private practice of a single fellowship trained spine surgeon. Patients with osteoporosis were diagnosed preoperatively based on age and appearance of bone density on CT and plain films as well as medical records and history. The bone graft material that was utilized with the fusion cage, within the interbody space and within the cage itself, was bone morphogenic protein (BMP) mixed with dried cancellous bone from the bone bank, demineralized bone matrix (DBM) mixed with dried cancellous bone from the bone bank, plasma concentrate with dried cancellous bone from the bone bank, or platelet gel with dried cancellous bone from the bone bank. Bilateral posterolateral fusion was also carried out at the same levels of interbody fusions, which utilized synthetic calcium phosphate as a graft material.

Among the 116 patients, 57 were in the unilateral pedicle screw fixation group, and 59 were in the bilateral pedicle screw fixation group, as assigned by a computer-generated random list. Postoperative cage migration was compared between unilateral versus bilateral groups as well as between BMP versus non-BMP. Cage migration was defined as posterior movement of the cage past the posterior wall of the vertebral body. Correct initial positioning of the cages immediately postoperatively was confirmed by plain X-ray, whereas postoperative cage migration was determined by CT scan as well as plain films. Hospital charts, operative reports, consultations, and preoperative/postoperative office notes were analyzed. From each patient record, the following data were analyzed: age, gender, date of birth, preoperative diagnosis, surgical procedure, date of procedure, level(s) of decompression/discectomy and fusion, consultation findings, and progress notes. Surgical indications for fusion included subluxation due to degenerative disc, collapse of disc space height, chronic lower back pain and leg pain unresponsive to conservative therapy for at least 3 months, and instability secondary to decompression. Postoperative bracing was not utilized with any patients in this study.

All patients underwent a TLIF with pedicle screw instrumentation through a midline posterior approach using standard surgical protocol. All levels that underwent interbody fusion had the disc excised. The PEEK interbody cage, which had been packed with graft material, was then inserted. Graft material was packed anterior and posterior to the interbody cage. Posterior pedicle screws were then placed at the level of interbody fusion (unilateral or bilateral). A bar was then placed spanning the pedicle screws, which was torqued appropriately. Levels that underwent interbody fusion also had bilateral posterolateral fusion, which was done by decorticating the lateral gutter area between the screws and the synthetic calcium phosphate material was then packed along this area.

Results

One hundred and sixteen patients were randomized. At 6 months follow-up, 14 were lost (11 from the unilateral group, 3 from the bilateral group). The remaining 102 patients who underwent a TLIF procedure were prospectively studied. The mean follow-up period was 25.1 months. The unilateral fixation group consisted of 20 male and 26 female patients. In the unilateral group, the mean age was 53.5 years (range, 18–77), and the preoperative diagnosis consisted of degenerative disc disease with or without herniated disc ($n = 44$) and degenerative spondylolisthesis with spinal stenosis ($n = 2$). The bilateral fixation group consisted of 20 male and 36 female patients. In the bilateral group, the mean age was 55.7 years (range, 26–82), and the preoperative diagnosis consisted of degenerative disc disease ($n = 40$), spinal stenosis and/or foraminal stenosis associated with instability ($n = 12$), and degenerative spondylolisthesis ($n = 4$).

A total of 17 cases of cage migration were found (Table 1); of these, 11 were from the unilateral fixation (Fig. 1) group and 6 from the bilateral fixation group, resulting in rates of cage migration of 23 and 11 % ($p = 0.03$), respectively. In regard to the cage migration cases, 5 were male and 12 were female. Their ages ranged from 27 to 79 years (mean age, 55 years). In regard to the 17 cases of cage migration; 13 were discovered within 3 months of surgery; 2 were discovered within 4 months of surgery. Of the remaining cases of cage migration, one was discovered within 7 months of surgery and one was discovered within 9 months of surgery; these patients were totally asymptomatic and 8 weeks was the median time after surgery when cage migration was discovered.

There were a total of 17 cases of cage migration. The involved levels were L4–L5 in nine patients, L5–S1 in five patients, L3–L4 in three patients, and L2–L3 in one patient.

Of note, one patient had cage implants at two levels. Of the 17 cases of cage migration, 10 cases, or 59 %, required revision surgery, while 7 cases or 41 % were asymptomatic and there was no need for revision surgery. Of the ten patients who required revision surgery; nine of the cages had displaced past the posterior aspect of the vertebral body and laterally into the nerve root resulting in radicular symptoms. In these cases, the cages were reinserted and bone graft was repacked posterior to the cage. Unfortunately, one patient who had cage implants at two levels (L3–L4 and L4–L5) had both cages migrate posterior into the spinal canal where the patient subsequently developed symptoms of lumbar stenosis approximately 7 weeks after the initial surgery (Figs. 2, 3, 4). In this case, both cages were removed in order to decompress the spinal canal. This patient also had some left leg pain, and thus the foraminotomy on the left side at both L3–L4 and L4–L5 was extended and in addition a laminectomy and foraminotomy at L5–S1 was carried out. The bone graft was then packed into the interspace at L3–L4. This was done because a significant foraminotomy on the left side was carried out and there was less stability at that level, while at the L4–L5 level there was significant bone in the posterolateral aspect to accommodate fusion. This area was decorticated and packed with BMP mixed with bone granules as well as along the gutter of both the right and left side.

In regard to bone graft type, bone morphogenic protein (BMP) mixed with dried cancellous bone from the bone bank was utilized in 67 % of the cases ($n = 68$), demineralized bone matrix (DBM) mixed with dried cancellous bone from the bone bank in 16 % ($n = 17$), plasma concentrate with dried cancellous bone from the bone bank in 9 % ($n = 9$), and platelet gel with dried cancellous bone from the bone bank in 8 % ($n = 8$). Twelve of the 68 cases that utilized BMP as a bone graft material within the interbody space experienced cage migration, whereas 5 of the 34 cases that did not utilize BMP experienced cage migration, resulting in rates of cage migration of 18 and 15 % ($p = 0.6$, not significant), respectively.

Age, sex, and diagnosis were also not significant factors in cage migration. Also, the degree of posterior migration compared between the two groups was similar (2–3 mm past the posterior wall of the vertebral body) and was not significant. There were no cases of pedicle screw failure, breakage, loosening, or malpositioning. No other postoperative complications occurred.

Discussion

In the current study, despite the similarities between the two treatment groups in regard to demographics and preoperative diagnosis, there was a statistically significant

Table 1 Demographic and clinical data of TLIF cases with postoperative cage migration

Age (yrs)	Gender	Fixation (Uni vs. Bi)	Diagnosis	Cage level	Preop symptoms	Postop pain relief
38	F	Unilateral	Degenerative disc	L5–S1	LBP	Yes
55	M	Unilateral	Herniated disc	L4–L5	LBP radiating to left leg	Yes
79	F	Unilateral	Herniated disc	L4–L5	LBP radiating to both legs	Yes
61	M	Bilateral	Degenerative and herniated disc	L3–L4, L4–L5	LBP radiating to right leg	Yes
45	F	Unilateral	Degenerative disc	L5–S1	LBP radiating to right leg	Yes
27	F	Bilateral	Spondylolisthesis	L5–S1	LBP radiating to hips	Yes
60	F	Unilateral	Degenerative disc and Spondylolisthesis	L3–L4	LBP	Yes
67	M	Unilateral	Spondylolisthesis	L4–L5	LBP radiating to both legs	Yes
44	M	Unilateral	Degenerative and herniated disc	L5–S1	LBP radiating to both legs	Yes
41	F	Unilateral	Degenerative disc	L3–L4	LBP radiating to hips	Yes
56	F	Unilateral	Degenerative disc	L4–L5	LBP radiating to both legs	Yes
75	F	Bilateral	Degenerative disc and Spondylolisthesis	L4–L5	LBP radiating to left leg	Yes
35	F	Unilateral	Degenerative disc	L4–L5	LBP radiating to left leg	Yes
70	F	Unilateral	Spinal and foraminal stenosis	L4–L5	LBP	Yes
52	M	Bilateral	Degenerative and herniated disc	L2–L3	LBP radiating to right leg	Yes
75	F	Bilateral	Spinal stenosis and spondylolisthesis	L4–L5	LBP	Yes
53	F	Bilateral	Degenerative disc and spondylolisthesis	L5–S1	LBP	Yes

LBP low back pain

Fig. 1 Lateral radiograph of a TLIF case that utilized unilateral fixation which demonstrates postoperative posterior migration of the fusion cage

higher rate of fusion cage migration in the unilateral fixation group, as compared to the bilateral fixation group. These results are quite interesting, given the fact that the above-mentioned studies have reported that unilateral

fixation is as effective as bilateral fixation in posterolateral fusion. This has also led to some surgeons utilizing unilateral fixation with minimally invasive TLIF techniques [21, 25]. However, the results of the current study suggest that unilateral fixation provides insufficient stability to prevent cage migration in some patients.

In regard to overall biomechanical stabilization when comparing unilateral versus bilateral lumbar pedicle screw fixation, a study performed by Yucesoy et al. [15] concluded that unilateral fixation had inferior stabilization as compared to bilateral fixation when stabilizing a unilateral lesion. Chen et al. [16] as well as Burton et al. [26] performed a biomechanical analysis to compare the stability of various device-spine constructs, which included unilateral and bilateral fixation with interbody cages. Those studies demonstrated that the construct utilizing unilateral fixation with an interbody cage showed statistically reduced stability as compared to the bilateral fixation construct with interbody cage. More specifically, Burton's study demonstrated that the construct utilizing unilateral fixation with an interbody cage showed statistically reduced stability with axial rotation. In fact, that study demonstrated that the level of stability of unilateral fixation with cage during axial rotation was equivalent to a construct with cage alone (without posterior fixation), thereby demonstrating that with unilateral fixation, rotary motion within the interbody

Fig. 2 Postoperative radiographs at 2 weeks after initial surgery. Anteroposterior (a) and lateral (b) views show appropriate positioning of fusion cages at L3–L4 and L4–L5 disc space

space is least controlled. Thus, it is theorized that with this type of fixation, the interbody cage is more likely to displace by a rotary type of motion.

Previously, fusion cage migration after lumbar fusion has been associated with patients who have concomitant degenerative scoliosis, use of bullet-shaped cages, patients with osteoporotic bone, cage position on the endplate, and use of BMP as a graft material [12, 22, 26–29]. In the current study, none of the cases of cage migration involved degenerative scoliosis or bullet-shaped cages. Only 3 of the 17 cases had osteoporosis (1 from the unilateral group and

Fig. 3 Anteroposterior (arrow) (a) and lateral (b) views at 7 weeks after the initial surgery. Both cages have migrated posteriorly

2 from the bilateral group). In regard to cage position on the endplate, according to Abbushi et al. [29], this only relates to cage migration into the endplate (e.g., cage subsidence), which did not occur in the current study, nor was it measured. Our definition of cage migration was posterior movement of the cage past the posterior wall of the vertebral body.

BMP use as a graft material has been associated with cage migration in several studies. A recent study by Knox et al. [27] found that BMP use was associated with a significant risk of postoperative osteolysis and that cage migration was a potential complication from postoperative osteolysis. Further, Mroz et al. [28] performed a systemic

Fig. 4 Computed tomography scans showing the positioning of cages at 7 weeks after initial surgery. Both cages at L4–L5 (a) disc space and L3–L4 (b) disc space have migrated

review of complications related to osteobiologics used in spine surgery. Specifically, in regard to the use of BMP as it relates to cage migration, they found three studies that reported cage migration as it was associated with the use of BMP. The review was inconclusive; one study found no association between BMP use and cage migration while two did [30–32]. In the current study, we compared cage migration in TLIF cases that utilized BMP to cage migration in TLIF cases that did not utilize BMP, 18 versus 15 %

($p = 0.6$), respectively, which was not statistically significant.

Study limitations

The present study has the following limitations: (1) We did not examine whether the dimensions of the cage had an influence on migration rate. Previous studies have shown that smaller cage size is correlated with migration and that larger size cages are recommended to increase the contact area between the cage and endplate to increase the failure load [22, 29, 33, 34]. In fact, Kimura et al. [33] recommend that undersized cages should not be used at all. More specifically, the contact area between the cage and the endplate would most likely be directly related to cage width, which in turn would be associated with cage subsidence. A recent study by Le et al. [35] demonstrated an association between cage width and subsidence. Specifically, they found a subsidence rate of 14.1 versus 1.9 % was associated with 18 and 22 mm wide cages, respectively. Further, larger diameter cages have been shown to have a lower risk of cage subsidence versus smaller diameter cages [36, 37]. Cage height would also likely be associated with subsidence, because this relates to the degree of distraction needed and overdistracted has been shown to increase subsidence rates [35]. These issues of cage size seem to be more associated with cage subsidence, which was not measured or seen in any of the cases in the current study because we only measured cases of cage retropulsion. Yet, the effect of this variable cannot be excluded. (2) The bone graft material used differed within the patient population studied. Despite this, the majority of the cases utilized BMP (67 %) as a graft material and our analysis demonstrated that there was no significant difference between the cage migration rate in TLIF cases that utilized BMP as compared to the migration rate in cases that did not utilize BMP. To our knowledge, BMP is the only graft material that has been associated with cage migration. Therefore, theoretically the use of non-BMP materials would have no effect on the migration rate. Despite this, ideally, all the cases should have utilized the same graft material.

Our study demonstrates that there was a statistically significant higher rate of fusion cage migration in the unilateral fixation group, as compared to the bilateral fixation group. We conclude that unilateral fixation, though it appears to be stable enough in some patients, is not the ideal construct to prevent fusion cage migration in some patients who undergo TLIF.

It is likely with all extenuating factors being equal (e.g., device-spine construct stability, concomitant bone pathology, cage dimensions, graft material, etc.) that some patients will not experience cage migration with unilateral fixation.

Yet, when any of the above factors are marginal, it is probable that the utilization of bilateral fixation in patient who undergo TLIF can make the difference in cage migration.

Conflict of interest None.

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