Original Study

Anterior lumbar interbody fusion (ALIF) as an option for recurrent disc herniations: a systematic review and meta-analysis

Kevin Phan[1,2], Alan Lackey[1], Nicholas Chang[2], Yam-Ting Ho[1], David Abi-Hanna[1,2], Jack Kerferd[1,2], Monish M. Maharaj[1], Rhiannon M. Parker[3], Gregory M. Malham[3], Ralph J. Mobbs[1,2]

[1]NeuroSpine Surgery Research Group, Prince of Wales Private Hospital, Sydney, Australia; [2]Faculty of Medicine, University of New South Wales (UNSW), Randwick, Sydney, Australia; [3]Neuroscience Institute, Epworth Hospital, Melbourne, Australia

Contributions: (I) Conception and design: K Phan, RJ Mobbs; (II) Administrative support: GM Malham, RJ Mobbs; (III) Provision of study materials or patients: K Phan, RJ Mobbs; (IV) Collection and assembly of data: K Phan, A Lackey, N Chang, YT Ho; (V) Data analysis and interpretation: K Phan, D Abi-Hanna, J Kerferd, MM Maharaj; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Kevin Phan. NeuroSpine Surgery Research Group (NSURG), Prince of Wales Private Hospital, Level 7 Suite 7, Barker St, Randwick NSW 2031, Sydney, Australia. Email: kphan.vc@gmail.com.

Background: Recurrent intervertebral disc herniation is a relatively common occurrence after primary discectomy for lumbar intervertebral disc herniation. For recurrent herniations after repeat discectomies, a growing body of evidence suggests that fusion is effective in appropriately selected cases. Theoretically, anterior lumbar interbody fusion (ALIF) allows for comprehensive discectomy, less trauma to spinal nerves and paraspinal muscles and avoidance of the disadvantages of repeat posterior approaches. However, ALIF has also been associated with risk of vascular injury and retrograde ejaculation. This current systematic review and meta-analysis aims to assess the viability of ALIF as a surgical treatment for recurrent disc herniations.

Methods: Seven studies were identified from six electronic databases and secondary reference lists. Pre-defined endpoints were extracted from the included studies and meta-analyzed.

Results: For the 181 patients from included studies, ALIF resulted in significant average improvements in Oswestry Disability Index (ODI) scores (50.49%, P<0.001), Visual Analogue Scale (VAS) back pain scores (47.85%, P<0.001) and VAS leg pain scores (37.00%, P<0.001). Average blood loss was acceptable at 122 mL (P<0.001) and average operation duration was 89 minutes (P<0.001). Average hospital stay was 5.28 days (P<0.001). Only 22 perioperative complications were reported, with subsidence the most commonly reported complication.

Conclusions: Pooled evidence suggests that ALIF is a feasible approach for the treatment of recurrent disc herniations, demonstrating significant improvements in back and leg pain and minimal complications. These findings warrant further investigation in large prospective registries and multi-center studies.

Keywords: Intervertebral disc disease; lumbar vertebrae; spinal fusion; anterior lumbar interbody fusion (ALIF)

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Introduction

Recurrent intervertebral disc herniation is a specific pathological entity which may occur in patients who have undergone a primary discectomy for lumbar intervertebral disc herniation (1-3). It occurs when there is a return of radicular pain symptoms after a pain-free interval following a disc herniation which has been surgically treated with a discectomy. To further define this phenomenon, Swartz *et al.* recommends that a clinically relevant definition does not restrict the pain-free period to a particular minimum postoperative time-frame (2). They further suggest that

only ipsilateral disc herniation be included in the definition, hence excluding contralateral disc bulging with signs and symptomatology (2).

Risk factors for the development of recurrent disc herniation are generally classed into structural, patient or operative technique related. Patient factors include obesity, smoking, male gender, diabetes, weight lifting, young age, traumatic events and manual labour employment, which can all increase the likelihood of developing recurrent disc herniation (4-7). Structural factors largely involve the specific morphology of the annular tear or disc fragment. Annular prolapses without a sub-annular fragmentation are the most prone to recurrence when compared to a disc fragmentation and a small annular defect, a large disc fragmentation with a large posterior annular tear or fragment-contained discs with incomplete or no annular tears (8). Evidence from the literature also supports the impact of the invasiveness of discectomy on the rate of recurrence; with conservative discectomies such as a sequestrectomy (removal of extruded fragment only), prone to recurrent disc herniation when compared to an initially aggressive discectomy, with significant removal of disc nucleus (9).

Indications for an initial discectomy procedure include; persistent, recurrent or progressive radicular pain, which has failed to respond to conservative management and new or progressive neurological deficits observed clinically or with an electromyelogram. Additional indications include cauda equina syndrome, with bowel and bladder dysfunction (10). In contrast, indications for recurrent disc herniation discectomy surgeries are less well-defined. As revision surgery is more complicated, holding slightly worse patient outcomes and higher rates of complications including dural tears and nerve injury (11-13). Currently, an additional micro-discectomy procedure is the most common surgical intervention pursued for recurrent disc herniations, however primary fusion surgery has been practised with potential indications such as lumbar instability or severe axial lower back pain.

An anterior approach for discectomy and fusion may offer an alternative option for patients who suffer from recurrent lumbar disc herniation. As for anterior lumbar interbody fusion (ALIF) used in the context of degenerative disc disease (14-20), the anterior approach theoretically allows for a comprehensive discectomy, less paraspinal muscle trauma and less nerve trauma from spinal nerve retraction. Specifically for recurrent disc herniations, a repeat posterior approach may result in higher risks of dural tears, more posterior bone removal to access the disc space, and an access corridor that may be impeded by residual tissue or epidural fibrosis. These complications can potentially be avoided via an anterior approach. However, the ALIF approach is not without its own risks. These include vascular injury and retrograde ejaculation. In the current study, we assessed the available evidence of outcomes when pursuing ALIF for recurrent disc herniation through a systematic review and meta-analysis of the literature.

Methods

Purpose

To assess the viability of ALIF as a surgical treatment for recurrent disc herniations through the use of a systematic review and meta-analysis of the literature, following recommended guidelines (21,22).

Search strategy and study selection

Electronic searches were performed using Ovid Medline, PubMed, Cochrane Central Register of Controlled Trials (CCTR), Cochrane Database of Systematic Reviews (CDSR), ACP Journal Club, and Database of Abstracts of Review of Effectiveness (DARE) from their dates of inception to May 2017. To achieve the maximum sensitivity of the search strategy, we combined the terms: "disc herniation", "anterior lumbar interbody fusion", "ALIF", "anterior approach" as either key words or MeSH terms. The reference lists of all retrieved articles were reviewed for further identification of potentially relevant studies, assessed using the inclusion and exclusion criteria.

Eligible studies for the present systematic review and meta-analysis included those in which patient cohorts underwent an ALIF procedure using either integrated stand-alone cages or cages with supplemental posterior pedicle screw fixation. Studies that did not include complications as endpoints were excluded. When institutions published duplicate studies with accumulating numbers of patients or increased lengths of follow-up, only the most complete reports were included for quantitative assessment at each time interval. All publications were limited to those involving human subjects. Abstracts, case reports, conference presentations, editorials, reviews and expert opinions were excluded.

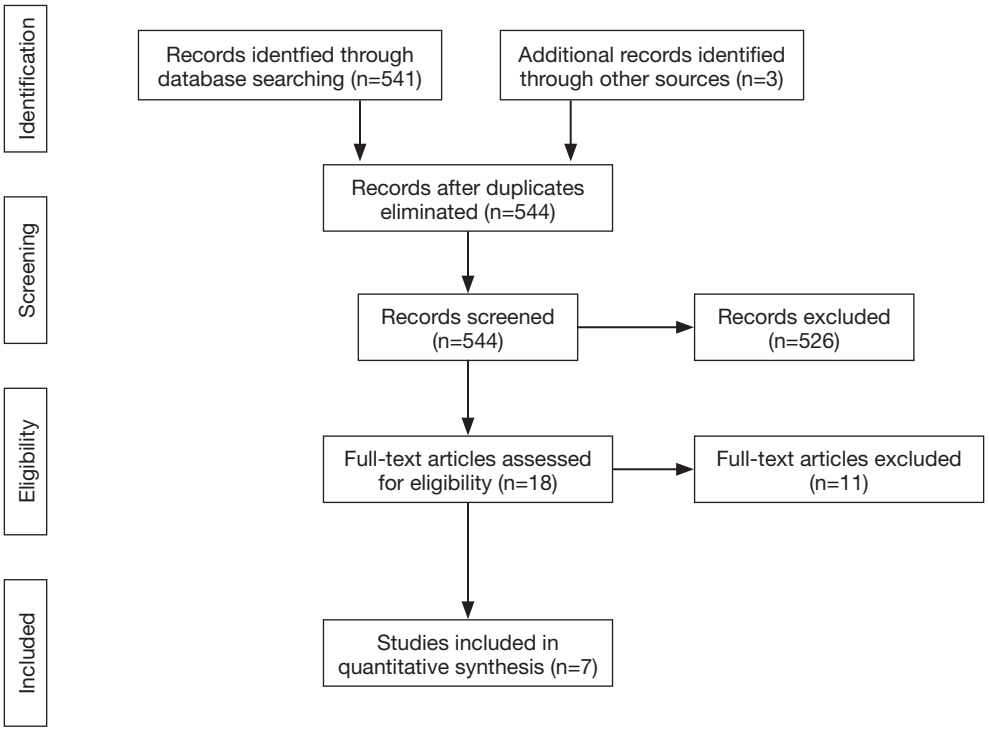

Figure 1 PRISMA chart for search strategy of the present systematic review and meta-analysis.

Data extraction, critical appraisal and treatment effect

All data were extracted from article texts, tables and figures. Two investigators independently reviewed each retrieved article (K Phan, A Lackey). Discrepancies between the two reviewers were resolved by discussion and consensus. If the study provided medians and interquartile ranges instead of means and SDs, we imputed the means and SDs as described by Hozo *et al.* (23). Since quality scoring is controversial in meta-analyses of observational studies, two reviewers (K Phan, A Lackey) independently appraised each article included in our analysis according to a critical review checklist of the Dutch Cochrane Centre proposed by MOOSE (24). The key points of this checklist include: (I) clear definition of study population; (II) clear definition of outcomes and outcome assessment; (III) independent assessment of outcome parameters; (IV) sufficient duration of follow-up; (V) no selective loss during follow-up; and (VI) important confounders and prognostic factors identified.

Statistical analysis

A meta-analysis of proportions was conducted for the available main perioperative and postoperative variables. Firstly, to establish variance of raw proportions, a Freeman-Tukey transformation was applied (25). To incorporate heterogeneity (anticipated among the included studies), transformed proportions were combined using DerSimonian-Laird random effects models (26). Finally, the pooled estimates were back-transformed. Heterogeneity was evaluated using Cochran Q and I^2 test. Weighted means were calculated by determining the total number of events divided by total sample size. Weighted Pearson's coefficient (r_s) was used to calculate correlation coefficients for meta-regression analysis of outcomes based on midpoint of study periods. All analyses were performed using the metafor package for R version 3.01. $P<0.05$ were considered statistically significant.

Results

Quality of studies

A total of 541 studies were identified through six electronic database searches and from other sources such as reference lists (*Figure 1*). After exclusion of duplicate or irrelevant references, 18 potentially relevant articles were retrieved.

Table 1 Study characteristics

Author	Year	Study period	Country	Study type	Number of patients	Age (years)	Males	Number of single level surgery	Interval from previous surgery (months)	Posterior instrumentation	FU duration (months)
Vishteh *et al.* (32)	2001	1997–1999	USA	R, OS	6	29.5 [24–58]	2/6	6/6	15.2 [3–36]	No	14 [5–24]
Sung *et al.* (31)	2004	2001–2002	Korea	R, OS	22	46 [23–60]	11/22	22/22	NR	No	18±4.9 [12–28]
Choi *et al.* (27)	2005	2000–2001	Korea	R, OS	22	45.7±10.5 [23–60]	11/22	22/22	52.8 [14–108]	No	35±8.9 [30–42]
Lee *et al.* (29)	2006	2001–2004	Korea	R, OS	54	59.5 [25–78]	22/54	36/54	45 [3–264]	Yes	24 [12–52]
Zhao *et al.* (33)	2014	2001–2012	China	R, OS	20	53.1±5.9 [44–68]	8/20	NR	NR	No	45.6±29.6 [12–110]
Kuang *et al.* (28)	2016	2012–2014	China	R, OS	22	55.4±5.5 [48–63]	9/22	17/22	NR	No	24.6±6.7
Mamuti *et al.* (30)	2016	2001–2012	China	R, OS	35	52.8 [34–70]	10/35	29/35	NR	Yes	NR

R, retrospective; OS, observational study; NR, not reported; FU, follow-up.

After detailed evaluation of these articles, 7 studies remained for assessment, including a total of 181 patients undergoing ALIF for treatment of recurrent disc herniations (27-33). All of the included 7 studies were observational and retrospective studies (*Table 1*). Only four studies reported mean follow-up equal of greater than 24 months (27-29,33). One study did not report follow-up duration (30). The mean time interval from previous surgery was only reported in three studies (27,29,32).

Patients' characteristics

Overall, 40% of patients were male, with a weighted mean age of 52.7 (range, 29.5–59.5) years. All patients had been diagnosed with recurrent lumbar disc herniations. Baselines characteristics such as height, weight, smoker status and any additional co-morbidities were not reported.

Perioperative outcomes

Perioperative outcomes from the seven studies the overall range of perioperative complications was 0.079% (95% CI, 0.021–0.137%; I^2=62.58%; P=0.014) (*Figure 2A*). Three studies reported no perioperative complications (31-33), two studies reported only one or two (27,30), while six or more complications were reported in the other two studies (28,29). Subsidence was the most frequently reported complication. These complications are summarised in *Table 2*. Average total blood loss was 122 mL (95% CI, 88.7–155.2 mL; I^2=95.14%; P<0.001) (*Figure 2B*). Average operative duration was 89 minutes (95% CI, 64.8–113.1 minutes; I^2=97.85%; P<0.001) (*Figure 2C*). Average hospital stays were 5.3 days (95% CI, 4.0–6.5 days; I^2=93.04%, P<0.001) (*Figure 2D*).

Clinical outcomes

From the 7 studies, the average improvement in Oswestry Disability Index (ODI) scores was 50.5 (95% CI, 26.8–74.2; I^2=99.42%, P<0.001) (*Figure 3A*). Average improvement in Visual Analogue Scale (VAS) back pain scores was 4.8 (95% CI, 3.05–6.5; I^2=98.37%; P<0.001) (*Figure 3B*). Average improvement in VAS leg pain scores was 3.7 (95% CI, 2.7–4.6; I^2=85.57%; P<0.001) (*Figure 3C*).

Discussion

There is currently no gold standard treatment for operative

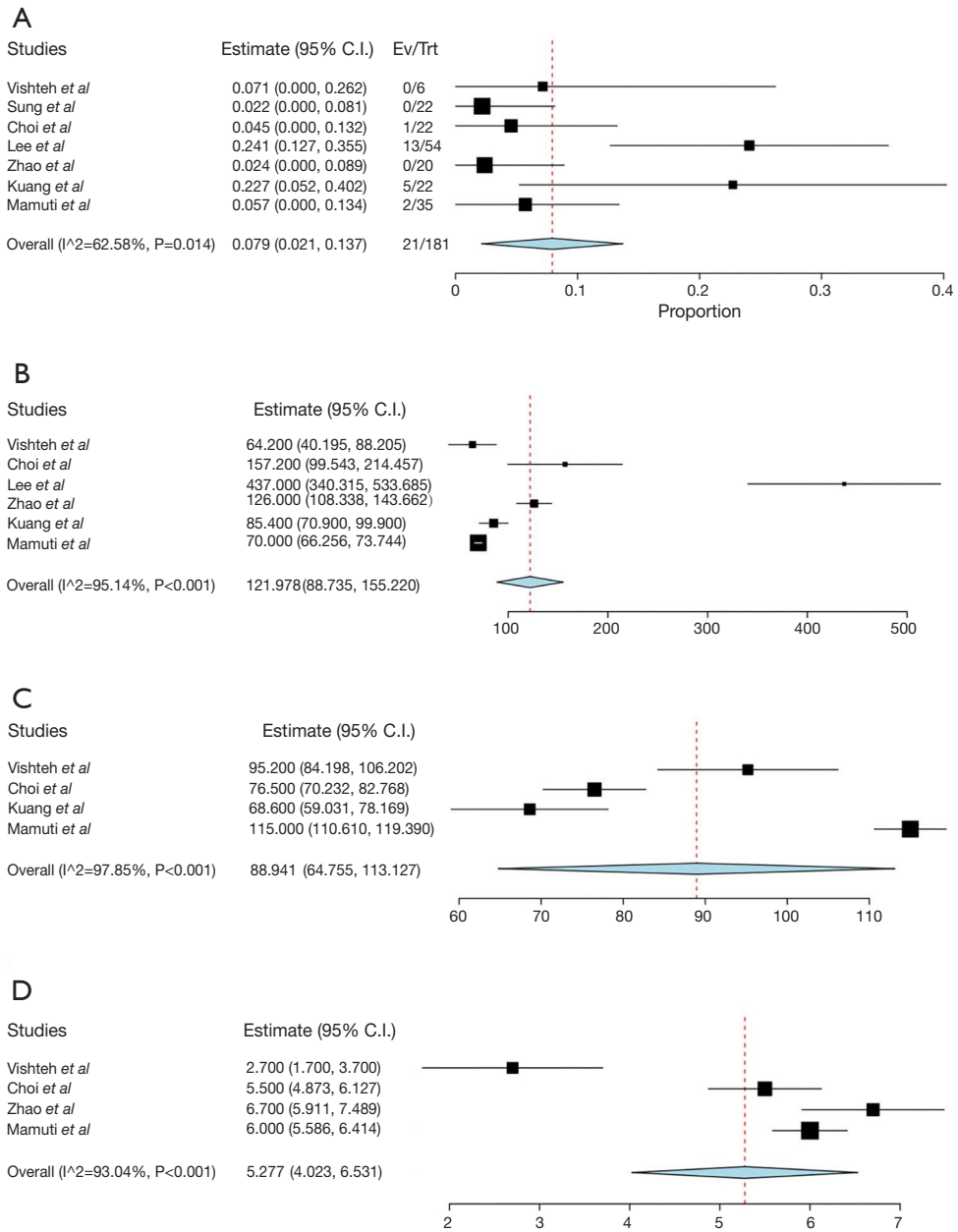

Figure 2 Forest plots for pooled data on (A) total perioperative complications; (B) total blood loss; (C) operative duration; and (D) hospital stay.

management of recurrent lumbar disc herniations (4,5,34-37). Generally the first-line treatment is an additional discectomy surgery without fusion. There is however growing evidence that fusion is efficacious in reducing dysfunction and pain in severe axial back pain, specifically when sacral tilt, and lumbar lordosis, is restored (29), although the approach remains a topic of ongoing debate. In a large scale survey across 2,560 American spinal surgeons, there was a general trend for more experienced surgeons, defined as performing greater than 200 cases a year, to include a fusion as opposed to a standalone repeat discectomy procedure in comparison to those performing <100 cases (38).

In a review by Drazin *et al.*, transforaminal lumbar interbody fusion (TLIF) was suggested to be the most efficacious fusion option when compared to posterolateral fusion (PLF) and posterior lumbar interbody fusion (PLIF),

Table 2 Perioperative complications

Author	Venous injury	Peritoneal injury	Subsidence	Blood transfusion	Reoperation	Retrograde ejaculation	Neurological deficit	Thrombo-embolism
Vishteh *et al*. (32)	0	0	0	0	0	0	0	0
Sung *et al*. (31)	0	0	0	0	0	0	0	0
Choi *et al*. (27)	1 (iliolumbar vein tear)	0	0	0	0	0	0	0
Lee *et al*. (29)	2	0	8	2	1 (removal of pedicle screw)	0	0	0
Zhao *et al*. (33)	0	0	0	0	0	0	0	0
Kuang *et al*. (28)	0	1 (rupture)	4 (no symptoms)	0	0	1	0	0
Mamuti *et al*. (30)	0	0	0	0	0	1	0	1

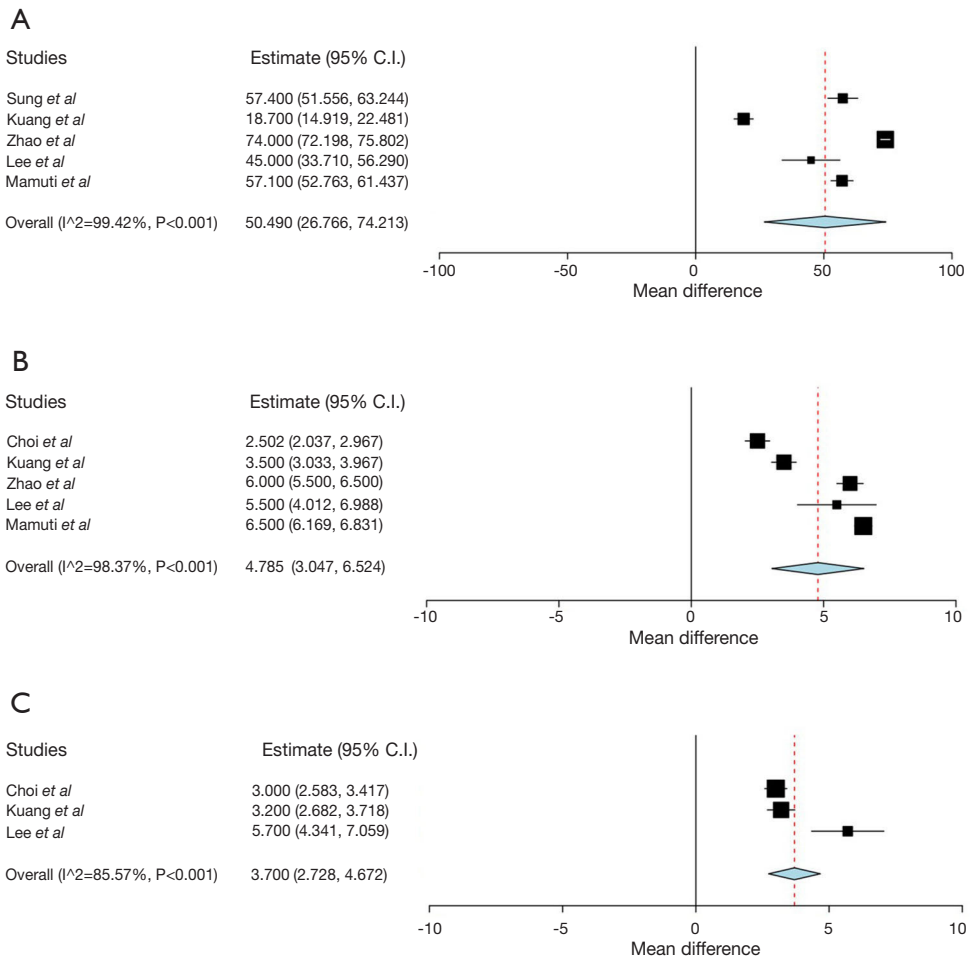

Figure 3 Changes in patient-reported outcomes from pre to post ALIF surgery for recurrent disc herniations. (A) Oswestry Disability Index (ODI); (B) Visual Analogue Scale (VAS) for back pain; (C) Visual Analogue Scale (VAS) for leg pain.

finding a mean VAS pain improvement of 54–86.5% (4). However, Drazin *et al*. (5) did not asses ALIF as a fusion option (4). Additionally Dower *et al.*'s review reported that following treatment of recurrent disc herniation by discectomy and fusion, VAS leg pain score improved by 44.9, VAS back pain scores improved by 47.1 and ODI scores improved by 41.2 (in 100 point scores).

To our knowledge, the present study is the first meta-analysis of pooled outcomes using an ALIF approach for recurrent disc herniations. In terms of surgical parameters, an acceptable total blood loss rate of 122 mL, average operative duration of 89 min and hospital stay of 5 days was achieved. Similarly to Dower *et al.* (5), We demonstrated significant improvements in VAS leg pain score, back pain score and ODI scores with an ALIF approach for recurrent disc herniations.

ALIF has several theoretical and observable advantages to other fusion approaches. This includes less injury to paraspinal muscle which results in less postoperative pain and blood loss during surgery. An anterior approach would avoid the need to dissect scar tissue produced as a result of the primary discectomy surgery and also concurrently reduce epidural bleeding. A repeat posterior microdiscectomy approach may require increased posterior bony resection or dissection around scar tissue in order to safely access the herniated discs. Further advantages come from ALIF reducing the need for nerve root retraction, hence limiting nerve irritation, and its ability to allow for a more complete discectomy with greater exposure of the disc space, reducing recurrent disc rates. Moreover, anterior access to the lumbar spine allows for larger cages to be inserted with wider contact areas, allowing for correction of the lordotic curvature of the lumbar spine and the pursuit of an increased sacral tilt. This is significant as Lee *et al.* found it to be significantly associated with outcomes postoperatively (29).

There are however some associated complications and disadvantages. The most commonly reported is injury to the associated vasculature, with other complications including, ureteral avulsion, retrograde ejaculation resulting from hypogastric plexus injury, and dural leaks which are more challenging to repair in an anterior approach. Additionally reported are retroperitoneal haematoma (39), ileus, sympathetic dysfunction, pancreatitis, bowel injury (40), lateral femoral cutaneous nerve injury (41). and retroperitoneal fibrosis (42). In some instances, the herniated disc fragment may migrate beyond the disc space, and the anterior approach may be inadequate in visualization and retrieval of the disc fragment. Furthermore, an anterior approach necessitates a fusion procedure and thus longer follow-up to assess fusion status and risks of adjacent segment disease, whereas posterior approaches can be performed without requiring fusion.

ALIF procedures should be approached with caution for patients with significant vessel calcification, abnormal aortic or vena cava anatomy, prior abdominal surgery or any potential adhesions or osteophytes in contact between the venous vascular structures and anterior spine. In these settings, mobilization of the major abdominal vessels is more difficult and can potentially be hazardous. Although compared with no access surgeon, the use of an access surgeon was associated with similar intraoperative complication rates, support from an access surgeon is recommended in cases wherein exposure may be difficult (17).

In the seven included studies, there are no direct comparisons made between discectomy and fusion and just discectomy for treatment of recurrent disc herniation. This demonstrated that we are still in the early stages of understanding the utility of fusion in recurrent disc herniation. It is therefore important that further prospective and retrospective studies directly compare fusion for recurrent disc herniation to repeat discectomy and to conservative management, so as to clarify whether symptoms such as severe axial discogenic back pain truly stand up as an indication for fusion surgery. It is interesting to note that two of the included studies (Kuang *et al.* and Lee *et al.*) were also observational studies that looked at ALIF but not specifically in recurrent disc herniation, but in revision lumbar surgery. This heterogeneity not only exists in the sample populations being analysed in this paper but also exists within the ALIF intervention itself which can be undertaken in a variety of ways, with or without the use of self-anchoring cages (28), percutaneous pedicle screw fixation (29) and the utilisation of the mini-open approach (28,30,33). Another limitation is that the correct diagnosis of recurrent disc herniation as well as the appropriate surgical treatment option is an ongoing challenge for surgeons and clinicians. There remains limited comparative data amongst surgical techniques for recurrent disc herniations.

Conclusions

Through a meta-analysis of the current literature, this study found ALIF to be a safe and feasible approach for the treatment of recurrent disc herniations. This

was demonstrated through significant improvements in preoperative ODI and VAS back and leg pain scores, with minimal complications. The anterior approach may be appealing in particular scenarios where there is extensive scar tissue from the initial procedure requiring extensive bony resection or cases of lumbar instability.

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None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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