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Review

Lateral lumbar interbody fusion for sagittal balance correction and spinal deformity

Kevin Phan [a,b,c], Prashanth J. Rao [a,b,c], Daniel B. Scherman [c], Gordon Dandie [c], Ralph J. Mobbs [a,b,*]

[a] NeuroSpine Clinic, Prince of Wales Private Hospital, Level 7, Barker Street, Randwick, NSW 2031, Australia
[b] University of New South Wales, Sydney, NSW, Australia
[c] Westmead Hospital, Westmead, Sydney, NSW, Australia

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ABSTRACT

We conducted a systematic review to assess the safety and clinical and radiological outcomes of the recently introduced, direct or extreme lateral lumbar interbody fusion (XLIF) approach for degenerative spinal deformity disorders. Open fusion and instrumentation has traditionally been the mainstay treatment. However, in recent years, there has been an increasing emphasis on minimally invasive fusion and instrumentation techniques, with the aim of minimizing surgical trauma and blood loss and reducing hospitalization. From six electronic databases, 21 eligible studies were included for review. The pooled weighted average mean of preoperative visual analogue scale (VAS) pain scores was 6.8, compared to a postoperative VAS score of 2.9 ($p < 0.0001$). The weighted average preoperative and postoperative coronal segmental Cobb angles were 3.6 and 1.1°, respectively. The weighted average preoperative and postoperative coronal regional Cobb angles were 19.1 and 10.0°, respectively. Regional lumbar lordosis also significantly improved from 35.8 to 43.3°. Sagittal alignment was comparable pre- and postoperatively (34 mm *versus* 35.1 mm). The weighted average operative duration was 125.6 minutes, whilst the mean estimated blood loss was 155 mL. The weighted average hospitalization length was 3.6 days. Whilst the available data is limited, minimally invasive XLIF procedures appear to be a promising alternative for the treatment of scoliosis, with improved functional VAS and Oswestry disability index outcomes and restored coronal deformity. Future comparative studies are warranted to assess the long term benefits and risks of XLIF compared to anterior and posterior procedures.

1. Introduction

Open fusion and instrumentation has traditionally been the mainstay treatment for degenerative spinal deformity disorders [1]. However in recent years, there has been an increasing emphasis on minimally invasive fusion and instrumentation techniques, with the aim of minimizing surgical trauma, blood loss and reducing hospitalization [2–4]. Minimally invasive approaches for traditional access routes, including anterior lumbar interbody fusion (ALIF), transforaminal lumbar interbody fusion (TLIF) and posterior lumbar interbody fusion (PLIF) have been developed [3,5,6].

More recently, McAfee et al. [7] described another approach termed extreme lateral interbody fusion (XLIF), a variant of the ALIF procedure performed through a lateral retroperitoneal, transpsoas corridor. With the use of a split blade retractor, the interbody cage is inserted with minimal muscle dissection and disruption to ligamentous structures, allowing minimally invasive restoration of disc height and correction of sagittal and coronal deformity. This technique was later refined by Ozgur et al. [8], and has been increasingly used in the last decade for sagittal correction and degenerative scoliosis.

Several studies have reported good clinical and radiological outcomes for the XLIF procedure. In the largest prospective, multicenter study [9] on this procedure to date, significant improvements in visual analogue scale (VAS) and Oswestry disability index (ODI) scores for leg and back pain were observed in 107 patients, with successful correction of the Cobb angle from 20.9 to 15.2°. Improvements in coronal segmental angles have also been consistently reported in several studies [10–12], as well as restored segmental lordosis and disc height. However, results for regional lumbar lordosis and sagittal alignment have not been as optimistic. Some reports have also reported lower complication rates from the minimally invasive XLIF procedure compared to traditional open surgical approaches [9,13,14].

* Corresponding author. Tel.: +61 2 9650 4766; fax: +61 2 9650 4943.
E-mail address: ralphmobbs@hotmail.com (R.J. Mobbs).

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In order to assess the relative merits and risks of XLIF, a systematic review was performed to analyze the clinical and radiological outcomes of XLIF in the correction of sagittal balance and spinal deformities.

2. Methods

2.1. Literature search

Systematic literature searches were performed in six electronic databases, including Ovid Medline, PubMed, the Cochrane Central Register of Controlled Trials, the Cochrane Database of Systematic Reviews, the American College of Physicians Journal Club, and the Database of Abstracts of Review of Effectiveness of their data from inception to November 2014. To achieve maximum sensitivity in the search strategy, we combined variants of the terms: "minimally invasive lateral approach lumbar interbody fusion", "XLIF", "DLIF", "LLIF", "minimally invasive spine surgery", "extreme lateral lumbar interbody fusion", "sagittal", and "spinal deformity", as either key words or medical subject heading terms. The reference lists of all retrieved articles were reviewed for further identification of potentially relevant studies, assessed using the inclusion and exclusion criteria [15].

2.2. Selection criteria

Eligible comparative studies for the present systematic review included those in which patient cohorts underwent XLIF procedures for correction of sagittal balance or spinal deformity. When institutions published duplicate studies with accumulating numbers of patients or increased the lengths of follow-up, only the most complete reports were included for quantitative assessment at each time interval. Reference lists were also hand searched for further relevant studies. All publications were limited to human subjects and English language. Abstracts, case reports, conference presentations, editorials, reviews and expert opinions were excluded.

2.3. Data extraction and critical appraisal

The primary outcomes of interest included operative, radiographic and clinical outcomes. The operative outcomes comprised the operation duration, estimated blood loss, hospital stay, and complications. The radiographic outcomes comprised the coronal segmental Cobb angle, coronal region Cobb angle, coronal plain alignment, sagittal segmental Cobb angle, regional lumbar lordosis and sagittal alignment. The clinical outcomes comprised the preoperative and postoperative VAS and ODI scores. All data were extracted from the article texts, tables and figures. Two investigators independently reviewed and assessed the quality of each retrieved article. Discrepancies between the reviewers were resolved by discussion and consensus. The weighted averages were calculated for the studied parameters, calculated by determining the total number of events divided by total sample size.

3. Results

3.1. Literature search

A total of 243 studies were identified through six electronic database searches. Following the application of the inclusion and exclusion criteria, as well as removal of duplicate or irrelevant studies, 21 studies [9–14,16–30] were finally included in the systematic review. These comprised four prospective observational studies [9,17,20,29] and 17 retrospective observational studies, with no randomized evidence available. A total of 948 patients underwent an XLIF procedure, with a total of 1920 levels involved. The primary indications for an XLIF procedure were degenerative scoliosis, sagittal correction and spondylolisthesis. At least some form of posterior intervention was reported in patients for all included studies, including lateral screws, percutaneous screws, or open pedicle screw procedures. The median follow-up duration from the included studies was 14 months (range: 2–37). The study characteristics are summarized in Table 1.

3.2. Demographics

Overall, 33.4% of patients were male, with a weighted average age of 62.1 years. From the pooled patients, the overall body mass index was 23.2 kg/m^2, with 20.8% of patients using tobacco and 10.4% with diabetes mellitus. Approximately 8.9% of patients had prior lumbar spine surgery, specifically, 3.5% had prior laminectomy procedures and 2.4% had prior microdiscectomies. A prior PLIF was performed in 1.4% of patients (Table 2).

3.3. Functional outcomes

The majority of studies reported preoperative and postoperative VAS scores (Table 3). The pooled weighted average mean of preoperative VAS scores was 6.8, compared to the postoperative VAS score of 2.9, a reduction that was statistically significant ($p < 0.0001$). ODI scores were reported in 15 of the studies. The weighted average preoperative ODI score was 44.5, compared with the postoperative ODI score of 20.5. This difference was also significantly significant ($p < 0.0001$).

3.4. Radiological outcomes

The radiological parameters were inconsistently reported across the studies (Table 4). The coronal segmental Cobb angle was reported in only three studies. The weighted average preoperative and postoperative angles were 3.6 and 1.1°, respectively. The weighted average preoperative and postoperative coronal regional Cobb angle was 19.1 and 10.0°, respectively. From one study [10], the coronal plain alignment was 19.1 mm preoperatively, and 12.5 mm postoperatively. The weighted mean sagittal segmental Cobb angles pre and postoperatively were 8.3 and 10.7°, respectively ($p < 0.05$). The regional lumbar lordosis also significantly improved from 35.8 to 43.3°. The sagittal alignment was comparable pre and postoperatively (34 *versus* 35.1 mm).

3.5. Operative outcomes and complications

The weighted average operative duration across the pooled studies was 125.6 minutes, and the mean estimated blood loss was 155 mL. The weighted average hospitalization length was 3.6 days. The reported complications from each study are summarized in Table 5.

4. Discussion

Spinal deformities are associated with a loss of sagittal, coronal and axial balance [31], parameters which have been separately shown to be strong predictors of disability, global imbalance, decompensation and intervention failure [31,32]. In order to minimize surgical trauma, reduce potential complications and shorten hospitalization, minimally invasive surgical techniques have been introduced. In particular, lateral minimally invasive surgical instrumentation has been increasing in popularity as an alternative treatment option for adult degenerative scoliosis and restoration of