Clinics of Surgery

Clinical Paper ISSN: 2638-1451 | Volume 7

Recovery of Bilateral Hip Flexion Weakness Following Extreme Lateral Interbody Fusion Due to Postoperative Pain – A prospective Study

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Keywords:

Transpsoas approach; Hip flexion weakness; Postoperative pain; Muscular injury; Extreme lateral interbody fusion; Minimally invasive spine surgery

Received: 15 May 2022
Accepted: 01 Jun 2022
Published: 05 Jun 2022
J Short Name: COS

Citation:

Samuel Schmid. Recovery of Bilateral Hip Flexion Weakness Following Extreme Lateral Interbody Fusion Due to Postoperative Pain – A prospective Study. Clin Surg. 2022; 7(11): 1-5

1. Abstract

1.1. Background Context

Extreme lateral interbody fusion (XLIF) is a relatively recent minimally invasive fusion technique of the lumbar spine. A point of criticism is the risk of postoperative weakness of the psoas ascribed to neural injury. We postulate that the resulting hip flexion weakness is merely a temporary phenomenon due to postoperative pain.

1.2. Purpose

To examine hip flexion strength in patients undergoing the XLIF procedure and evaluate clinical outcomes.

1.2.1 Design: A prospective single-center cohort study.

1.2.2. Patient Sample: Patients with chronic low back pain due to lumbar degenerative disc disease, degenerative lumbar deformity, and spondylolisthesis for at least 12 months and history of at least 6 months of unsuccessful conservative treatment.

1.2.3. Outcomes Measures: Physiologic Measures: hip flexion strength; Self-reported Measures: low back pain using the visual analogue scale (VAS) and the Oswestry Disability Index (ODI).

1.3. Methods

Patients following a one- or two-level XLIF procedure were assessed during a 3-month follow-up period. Measurements of hip flexion strength were performed with a fixed digital dynamometer, both on the operated and the non-operated side, 2 days preoperatively as well as 2 days, 6 weeks and 3 months postoperatively, by two independent examiners blinded to the side of the lumbar approach. ODI scores and VAS values for low back pain were collected at the indicated time points. The data were evaluated statistically using t-tests and correlation analyses.

1.4. Results

From May to December 2018, 17 participants (5 men and 12 women) were included in the study; the average age was 67 years (range 49–82). The lateral transpsoas approach to the lumbar spine was on the right side in 8 patients, and on the left in 9. All procedures were performed between L3 and L5. Hip flexion strength on the operated side was significantly decreased 2 days postoperatively ($p=0.0001$) and returned to almost normal values 6 weeks postoperatively. On the non-operated side, strength was also significant lower 2 days postoperatively ($p=0.004$), recovering almost completely to preoperative values within 3 months. Low back pain VAS score was significantly reduced ($p=0.003$) 6 weeks postoperatively, and ODI value decreased from 42% preoperatively to 35% at 6 weeks, and 23% at 3 months after the procedure. Correlation of the VAS score with the hip flexion force was -0.268 ($p=0.0087$).

1.5. Conclusion

The transient psoas muscle weakness following the XLIF procedure observed on the operated side is mainly caused by postoperative pain and less by muscular injury, with muscular strength almost returning to baseline values within 6 weeks after the surgery. The postoperative pain seems to be the main cause of the weakness also affecting the non-operated side.

2. Introduction

Spinal fusion is a surgical procedure that consists in joining two

or more vertebrae to treat spinal disorders such as scoliosis, spinal fractures, or disc degenerations. Several methods have been developed in the last century, and both posterior (posterior lumbar interbody fusion [PLIF] and transforaminal interbody fusion [TLIF]) and anterior (anterior lumbar interbody fusion [ALIF]) approaches are currently used [1]. In the last two decades the focus of interest has been on developing and refining increasingly less invasive techniques, e.g. ALIF, extreme lateral interbody fusion (XLIF), lateral lumbar interbody fusion, direct lateral interbody fusion, and oblique lateral interbody fusion [2]. A recent study by Shim *et al* [3]. Showed that ALIF is associated with smaller incisions, reduced hospital stays, decreased operative times, postoperative pain, blood loss, and complications, and faster recovery compared with traditional posterior approaches. XLIF, also called transpsoas approach, was first described in 2001 by Ozgur and Pimenta [4,5] and developed as a less-invasive alternative to ALIF or OLIF, since it avoids retracting the great vessels and damaging the sympathetic chain.[6] Similar to an anterior lumbar fusion, XLIF is indicated for patients with low back pain and/or radiculopathy due to sagittal malalignment, pseudoarthrosis, spondylolisthesis, segmental instability, deformity, foraminal stenosis, and lumbar degenerative disc disease [5,7]. Both ALIF and XLIF provide better deformity correction than TLIF or PLIF. The procedure is usually performed under direct visualization [5], but endoscopic-assisted XLIF has also been described [8]. To perform spondylodesis of the lumbar spine using the transpsoas approach the surgeon has to access the lateral disc space by splitting and dilating the psoas major muscle [4,9-13]. Postoperative weakness of the hip flexion in patients following XLIF surgery has been described in the literature [14]. Given the anatomic relation between the psoas and the lumbar plexus, this weakness is largely believed to be the result of a neural injury [15,16] or a neurological adverse event [17]. Because of the risk of neural injury following this procedure [15,16], Intraoperative neuromonitoring is recommended [18]. However, there is currently no report of a detailed evaluation of post-XLIF psoas injury through measurement of hip flexion strength. The primary aim of this study was, therefore, to determine hip flexion strength in patients undergoing XLIF and establish a correlation with Visual Analogue Scale (VAS) values and Oswestry Disability Index (ODI) scores for low back pain.

3. Materials and Methods

3.1. Participants

From May to December 2018, 17 Patients with chronic low back pain due to lumbar degenerative disc disease, degenerative lumbar deformity, and spondylolisthesis (Meyerding grade 1 and 2) for at least 12 months were considered eligible for the study. Prior instrumentation to the lumbar spine was an exclusion criteria. All patients had history of at least 6 months of unsuccessful conservative treatment, including assessment by the center's pain specialist and an interdisciplinary multimodal pain assessment. The different surgical options were explained in detail, and the candidates signed an informed consent after they had sufficient time to consider them. Approval to conduct the study was obtained from the Swiss state ethics committee for research in Berne, Switzerland (project ID 2018-01886).

3.2. Surgical Procedure

Every patient underwent a minimally invasive XLIF procedure of 1 or 2 levels at the L3 to L5 of the lumbar spine by the transpsoas approach, followed by percutaneous posterior fixation in the same operation. Each surgery was performed by two experienced surgeons with more than five years of experience in spine surgery with lateral approach in a European spine centre of excellence. The procedure was carried out under direct visualization with the patient in a lateral position for the lateral fusion. Then the patient was positioned in the prone position to complete the posterior percutaneous instrumentation under fluoroscopy. During the entire time of surgery Neuromonitoring (SSEP, MEP and free run EMG) was carried out. All patients were followed up for 6 weeks and 3 months.

3.3. Measurements

The strength of the psoas muscle was measured with a digital dynamometer on both sides by two examiners independently, who were unaware of the side of the approach. The evaluation was performed 2 days preoperatively, and 2 days, 6 weeks, and 3 months postoperatively. During the evaluation, patients were sitting upright, with both hips in a 90 degree flexion position and the legs hanging freely without contacting the ground; the back of the knee had to touch the seat pad. The dynamometer was attached to the floor by means of vacuum and was connected to a loop, which was pulled over the distal part of the ventral thigh proximal to the knee joint; the loop was tightened to moderate tension. Three measurements were performed on each side for every time point. Patients had to flex their hips against the resistance of the loop 3 times for 4 seconds each while the upper body remained straight. The power achieved in lbs was noted, and the mean of the 3 measurements was used in the statistical analysis. ODI scores and VAS values (0-10) for low back pain were collected at all the indicated time points.

3.4. Statistical Analysis

We used the t-test for independent samples for each time point during follow-up to evaluate if the difference in strength between the operated and the non-operated side reached statistical significance. The t-test for dependent samples was used for the statistical evaluation of differences between the individual follow-up times for both the operated and non-operated side. The same statistical procedure was used to analyze differences between preoperative and postoperative VAS values and ODI scores. Furthermore, correlation analyses between the strength of the hip flexion and the VAS values and the respective ODI scores were carried out through calculation of the Spearman's rank correlation coefficient.

4. Results

A total of 17 patients (5 men and 12 women) were eligible to participate in the study. The average age was 67 years (range 49–82). The approach on the right was used in 8 patients, and on the left in 9. All procedures were performed between L3 and L5. Neuromonitoring (SSEP, MEP and free run EMG) for the roots L2 to S1 showed no significant changes between the left and the right side and between the beginning and the end of the operative procedure.

4.1. Operated Side

Two days after the surgery, there was a significant (p=0.001) reduction in strength of hip flexion, from 26.8±7.1 to 20.7±7.5 lb, compared to the preoperative state. Strengths of 26.5±9.3 and 27.9±7.9 lb were observed 6 weeks and 3 months (p=0.46) postoperatively. The difference between strength preoperatively versus at 6 weeks and 3 months postoperatively was not significant (p=0.46) **(**Figure 1**)**. No permanent psoas muscle weakness was observed.

4.2. Non-Operated Side

Two days after the surgery, there was a significant (p=0.004) reduction in strength of hip flexion, from 30.9±8.6 to 25.5±9.3 lb, compared to the preoperative state. 6 weeks post-XLIF, strength was significantly reduced (p=0.043), to a value of 28.7±7.5 lb, compared to the preoperative state. No significant difference could be observed between the preoperative state and 3 months postoperatively (p=0.168), with a strength of 30.5±6.8 lb **(**Figure 1**)**.

4.3. Operated vs Non-Operated Side

The mean strength of the hip flexion preoperative was 25.1±8.3 lb on the operated side and 28.7±8.1 lb on the non-operated side. This difference was statistically significant (p=0.02). 2 days postoperatively, there was a significant (p=0.048) difference between the operated and non-operated side, with no significant differences observed 6 weeks and 3 months postoperatively **(**Figure 1**)**. (Figure 1: strength of the hip flexion preoperative, 2 day, 6 weeks and 3 months postoperative)

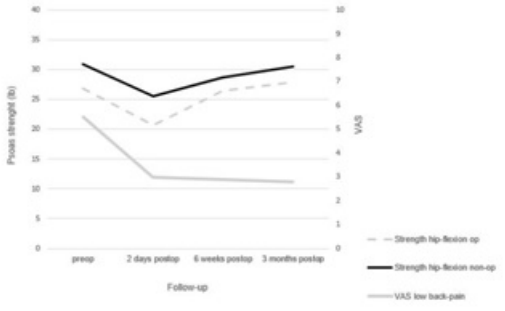

Figure 1. Strength of the hip flexion relative to VAS for low back pain.

4.4. VAS for Low Back Pain

The mean VAS value for low back pain was 5.5±2.4 preoperatively. A significant reduction could be observed 6 weeks postoperatively, with a value of 2.9±2.4 (p=0.003), and 3 months postoperatively, with a value of 2.8± 3 (p=0.04), compared to the preoperative state.

4.4. ODI

Mean ODI values were 42% preoperatively, 44% at 2 days postoperatively, 35% at 6 weeks postoperatively, and 23% at 3 months postoperatively **(Figure 2)**. (Figure 2: ODI preoperative, 2 day, 6 weeks and 3 months postoperative)

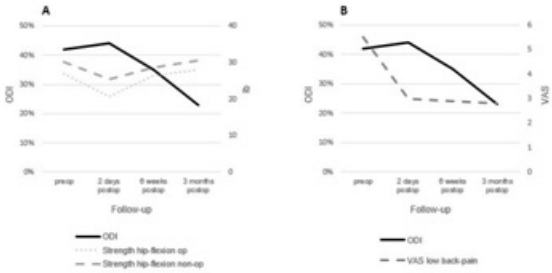

Figure 2. ODI relative to strength of the hip flexion (A) and VAS for low back pain (B).

4.5. Correlation

A small correlation (p=0.0087) between strength of the hip flexion, both on the operated and non-operated side, and the VAS for low back pain, with a correlation coefficient of -0.268, could be found in this case. A significant (p=0.03) small correlation between strength of the hip flexion on the operated side and ODI, with a correlation coefficient of -0.25, was observed, and a highly significant (p=0.00002) correlation between VAS for low back pain and ODI, with a correlation coefficient of 0.63, could be demonstrated (Figure 3).

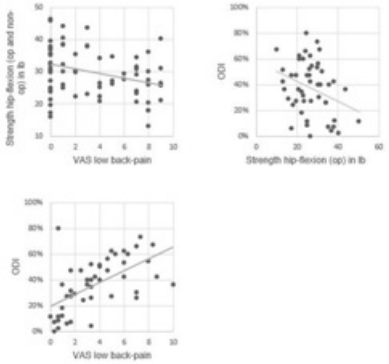

Figure 3. Correlation analysis.

5. Discussion

The primary aim of this study was to evaluate the hip flexion strength in patients undergoing a 1- or 2-level XLIF procedure between L3 and L5 and to collect and analyse the data in correlation with clinical outcome with VAS and ODI values. While other complications, such as incidence of infection, visceral injury in ALIF and neurologic injury in PLIF/TLIF procedures, and transfusion rates are less frequent [12], the weakness of the psoas muscle is considered to be one of the specific complication of the XLIF procedure. Epstein et al [15]. Described a permanent weakness of the iliopsoas in 5% of the cases following XLIF. The reason for this weakness has been widely discussed. We found significant weakness of the hip flexion 2 days postoperatively on the operated and non-operated side; on the operated side, strength returned to normal after 6 weeks. As Lee et al [19]. Described, this may be due to psoas muscle injury during the procedure. In our experience, a nerve root injury seems less likely, because the main innervation of the psoas muscle is located above L3 and we included in the study only XLIF procedures on L3-L5. Furthermore, we performed the psoas split under direct visualization to better identify the anatomic structures. To our knowledge, no clear evidence for the cause of nerve injury during the transpsoas approach has been published. Factors that increase the risk of nerve injury include performing an XLIF at the L4-L5 level, excessive posterior retraction, and prolonged deployment of the retractor [19]. Further studies are necessary to determine additional factors that increase or decrease the risk of nerve injury during the XLIF procedure. Even on the contralateral side, the lumbar plexus and the trunk seem to be at risk at the L4-L5 level in 15% of the cases [20]. We also expected a correlation between postoperative pain and muscle weakness, but this correlation was weak (-0.226). The significant weakness that was found on the non-operated side seems mainly due to postoperative pain and cannot be explained by a muscular or nerve injury. To our knowledge, this finding has not been described in prior studies. After 6 weeks, the measured hip flexion strength values almost returned to the baseline values on the operated and on the non-operated side, in concordance to what has been published by Lee et al [19]. In our patient we did not find permanent hip flexion weakness. Therefore, the presented data seem to be in agreement with the hypothesis that postoperative pain and muscle injury are the main causes for the transient psoas muscle weakness. The ODI was primary affected by the VAS and less by the transient weakness of the hip flexion, because pain is negatively affecting several subgroups of the score.

6. Limitations

The main limitation of the data presented here is the small sample size. The results will have to be corroborated in a much larger study. Nevertheless, some trends can be observed. Another limitation is, as mentioned for other studies, that two surgeons, whose practices are focused on minimally invasive spine surgery and who were therefore experienced in the procedure, performed the surgeries. This may explain the absence of nerve palsies in this study, because most complications tend to occur during the initial learning curve, when a surgeon is learning a new technique [21].

7. Conclusion

The transient psoas muscle weakness following the XLIF procedure observed on the operated side is mainly caused by postoperative pain and less by muscular injury, with muscular strength almost returning to baseline values within 6 weeks after the surgery. The postoperative pain seems to be the main cause of the weakness also affecting the non-operated side.

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