

Research Article

Lumbar Fusion PROMs: Before and After WHO Declared COVID-19 a Pandemic

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Background

The World Health Organization (WHO) declared COVID-19 a pandemic on March 11th, 2020. Few studies have compared patient-reported outcome measures (PROMs) before and after this declaration among lumbar fusion recipients.

Objective

To compare PROMs and achievement of minimal clinically important difference (MCID) among lumbar fusion recipients before vs. after the arrival of the COVID-19 pandemic.

Methods

A single-surgeon retrospective registry was searched for patients who underwent single- or double-level lumbar interbody fusion (LIF) via anterior (ALIF), lateral (LLIF), or a minimally invasive transforaminal (MIS TLIF) approach. A cut-off day of surgery (March 11th, 2020) was used to divide patients into two groups: those receiving fusion from the

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cut-off date to October 2021 (19-month period), vs those receiving fusion between August 2018 and the cut-off date (19-month period). Patients not meeting this day of surgery criteria were excluded, along with those undergoing surgery for etiologies of infection, malignancy, or trauma. Demographic characteristics and perioperative variables were collected for each cohort, along with the following PROMs: Visual Analog Scale (VAS) back/leg, Oswestry Disability Index (ODI), Patient Health Questionnaire-9 (PHQ-9), and Patient Reported Outcome Measurement Information System physical function (PROMIS-PF) preoperatively and at 6-weeks, 12-weeks, 6-months, and 1-year following fusion. Demographic, perioperative and PROM characteristics were compared with Student's t-test for independent samples (continuous) or chi-squared analyses (categorical). Multiple regression analysis was performed to evaluate the effect of pre-pandemic vs. pandemic status on mean PROMs, while accounting for baseline difference in type of fusion received. MCID achievement was determined by thresholds established in literature for delta PROMs, while intergroup comparison in rate of achievement was evaluated with chi-squared analysis.

Results

180 subjects met inclusion criteria of this study, with 124 in the pre-pandemic cohort and 56 in the pandemic cohort. Mean age was 56.2 years, with most patients being non-obese (52.8%) and male (57.2%) (Table 1). Majority of patients presented with degenerative spondylolisthesis (48.3%), followed by isthmic spondylolisthesis (38.3%), recurrent herniated nucleus pulposus (15.0%), and degenerative scoliosis (14.4%), with no intercohort differences in spinal pathology. MIS TLIF was the most frequent procedure among included patients (36.1%), followed by LLIF (35.0%), and ALIF (28.9%). The pre-pandemic cohort had a significantly higher proportion of LLIF recipients, while the pandemic cohort had a significantly higher proportion of ALIF recipients ($p=0.019$). Most patients had single-level surgery (87.8%), with 12.2% receiving double-level fusion. No significant difference was observed in the number of operative levels among groups. Mean operative time was 148.4 minutes with mean estimated blood loss of 72.2 mL, with no difference in mean values between groups (Table 2). While the pre-pandemic cohort significantly improved for all VAS back, all VAS leg, ODI 12-weeks to 1-year, all PHQ-9, and PROMIS-PF 12-weeks to 1-year ($p\leq 0.025$, all), the pandemic cohort significantly improved for VAS back 6-weeks to 6-months, VAS leg 6-weeks, ODI 6-months, PHQ-9 6-months, and PROMIS-PF 12-weeks/6-months, only ($p\leq 0.025$, all). No significant differences were observed in mean PROMs at any timepoint. After multiple regression accounting for differences in the type of fusion procedure performed, PHQ at preoperative was significantly higher in the pre-pandemic cohort ($p=0.019$), but no other intercohort differences were observed (Table 3). MCID achievement across all PROMs did not significantly differ at any timepoint (Table 4).

Conclusion

Less lumbar procedures were performed in an equivalent time period of 19 months before and after the WHO announcement of COVID-19 as a pandemic on 3/11/20. While patients receiving fusion after this date experienced scattered statistically significant improvements across PROMs compared to pre-pandemic counterparts, mean PROM ratings and MCID achievement rates for pain, disability, depression, and physical health were generally equivalent. The COVID-19 pandemic is therefore unlikely to significantly alter clinical outcomes following lumbar fusion.

INTRODUCTION

On a yearly basis, approximately 266 million individuals worldwide are diagnosed with degenerative disease of the lumbar spine (Ravindra et al. 2018). These degenerative diseases, including disc degeneration, spondylolisthesis, and lumbar spinal stenosis, are frequent causes of back pain and disability (Ravindra et al. 2018; Mobbs et al. 2015). Understandably, the constant symptomatic presentation of these diseases leads many individuals to experience de-

creased mobility and a reduced quality of life (Ravindra et al. 2018; Mobbs et al. 2015). In an effort to manage the symptoms of lumbar degenerative diseases, conservative treatments, such as physical therapy, are initially performed; however, if conservative measures fail, surgical treatment can be undertaken (Fornari et al. 2020). Lumbar interbody fusion (LIF), which in many cases is an elective procedure, is commonly performed for these degenerative pathologies (Mobbs et al. 2015).

COVID-19 was declared a worldwide pandemic by the World Health Organization (WHO) on March 11, 2020 (Cucinotta and Vanelli 2020). This pandemic immensely increased healthcare utilization, which ultimately halted elective surgical procedures, including LIF (Jain et al. 2020; Verma et al. 2020; Rizkalla et al. 2020). For this reason, it is likely that many patients at the time who wanted to undergo a LIF procedure to improve the symptoms of their degenerative diseases were not able to, unless the procedure was urgent (Rizkalla et al. 2020). Given that Cushnie et al. observed that longer preoperative symptom duration for lumbar degenerative stenosis led to less improvement in patient-reported pain and disability (Cushnie et al. 2019), the COVID-19 pandemic may have played a role in the reported patient-reported outcome measures (PROMs) following LIF.

Furthermore, the COVID-19 pandemic has been associated with higher rates of psychological distress (Xiong et al. 2020). Considering the established role that preoperative mental health plays in worse postoperative outcomes following minimally invasive transforaminal lumbar interbody fusion (MIS TLIF) (Yoo et al. 2020), patients' mental health during the pandemic may have affected their perception of improvement following surgery.

With the ever-evolving nature of this virus, it is important to understand the impact that the COVID-19 pandemic may have on patients' perception of their surgical outcomes. For this reason, our study compares patient-reported outcome measures (PROMs) and achievement of minimal clinically important difference (MCID) among lumbar fusion recipients before and after the start of the COVID-19 pandemic.

METHODS

PATIENT POPULATION

Patient informed consent and Institutional Review Board Approval (ORA #14051301) were obtained prior to the initiation of this study. A retrospective database of a single surgeon was searched for patients who underwent single- or double-level anterior lumbar interbody fusion (ALIF), lateral lumbar interbody fusion (LLIF), or a minimally invasive transforaminal lumbar interbody fusion (MIS TLIF). Patients were divided into two groups based on a cut-off date for surgery (March 11th, 2020): patients receiving fusion from the cut-off date to October 2021 (19-month period), versus those receiving fusion between August 2018 and the cut-off date (19-month period). Patients who were excluded either did not meet this day of surgery criteria or underwent surgery for etiologies of infection, malignancy, or trauma.

DATA COLLECTION

Demographic characteristics and perioperative variables were collected for each cohort. Demographic characteristics included age, gender, obesity status, ethnicity, smoker status, hypertensive status, diabetic status, American Society

of Anesthesiologists (ASA) score, and insurance type. Perioperative characteristics included spinal pathology, mean operative time (minutes), mean operative blood loss (milliliters), procedure type, and operative level. Spinal diagnosis listed consisted of recurrent herniated nucleus pulposus, isthmic spondylolisthesis, degenerative spondylolisthesis, degenerative scoliosis, central stenosis, and foraminal stenosis. Patient reported outcome measures (PROMs) were also collected preoperatively and at 6-weeks, 12-weeks, 6-months, and 1-year postoperative timepoints. PROMs collected included Visual Analog Scale (VAS) back/leg, Oswestry Disability Index (ODI), Patient Health Questionnaire-9 (PHQ-9), and Patient Reported Outcome Measurement Information System physical function (PROMIS-PF).

STATISTICAL ANALYSIS

Stata 16.0 (StataCorp LP, College Station, TX) was used to perform data analysis. Demographic, perioperative and PROM characteristics were compared with the Student's t-test for independent samples and chi-squared analyses for continuous and categorical variables, respectively. To evaluate the effect of pre-pandemic versus pandemic status on mean PROMs, while accounting for baseline difference in type of fusion received, multiple regression analysis was performed. Thresholds established in the literature for delta PROMs determined the MCID achievement values utilized. The intergroup comparison of MCID achievement rate was evaluated with chi-squared analysis.

RESULTS

DESCRIPTIVE ANALYSIS

The final cohort included 180 subjects, with 124 and 56 in the pre-pandemic and pandemic cohorts, respectively. The mean age was 56.2 years, with most patients being non-obese (52.8%), male (57.2%), and Caucasian (68.0%). The majority of patients were non-diabetic (89.4%), non-smokers (94.4%), without hypertension (67.2%), had an ASA classification <2 (74.6%), and private insurance (67.8%). No differences were observed in demographic characteristics ($p>0.050$, all; [Table 1](#)). The majority of patients presented with degenerative spondylolisthesis (48.3%), followed by isthmic spondylolisthesis (38.3%), recurrent herniated nucleus pulposus (15.0%), and degenerative scoliosis (14.4%). The majority of patients also presented with findings of central stenosis (96.7%) and foraminal stenosis (84.4%). No differences were observed among the proportion of individuals diagnosed with each of the aforementioned pathologies. However, procedure type differed significantly: The pre-pandemic cohort had significantly more LLIF performed, while a significantly greater proportion of patients received ALIF in the pandemic cohort ($p=0.019$). Nonetheless, the number of levels operated on did not significantly differ (with most being single-level surgeries [87.8%]), and neither did operative duration (mean of 148.4 minutes) or estimated blood loss (mean of 72.2 milliliters) ([Table 2](#)).

Table 1. Patient Demographics

Characteristic	Total (n=180)	Pre-Pandemic (n=124)	Pandemic (n=56)	*p-value
Age (mean $\pm$ SD, years)	56.2 $\pm$ 11.6	56.7 $\pm$ 11.6	55.2 $\pm$ 11.7	0.427
Obesity				0.641
Non-Obese	52.8% (95)	51.6% (64)	55.4% (31)	
Obese	47.2% (85)	48.4% (60)	44.6% (25)	
Gender				0.101
Female	42.8% (77)	38.7% (48)	51.8% (29)	
Male	57.2% (103)	61.3% (76)	48.2% (27)	
Ethnicity				0.880
Caucasian	68.0% (121)	68.6% (85)	66.7% (36)	
African-American	9.6% (17)	9.7% (12)	9.3% (5)	
Hispanic	15.2% (27)	14.5% (18)	16.7% (9)	
Asian	3.4% (6)	4.0% (5)	1.9% (1)	
Other	3.9% (7)	3.2% (4)	5.6% (3)	
Diabetic Status				0.568
Non-Diabetic	89.4% (161)	90.3% (112)	87.5% (49)	
Diabetic	19.6% (19)	9.7% (12)	12.5% (7)	
Smoking Status				0.156
Non-Smoker	94.4% (167)	92.7% (115)	98.1% (52)	
Smoker	5.7% (10)	7.3% (9)	1.9% (1)	
Hypertension Status				0.419
Non-hypertensive	67.2% (121)	65.3% (81)	71.4% (40)	
Hypertensive	32.8% (59)	34.7% (43)	28.6% (16)	
ASA Classification				0.406
<2	74.6% (132)	72.7% (88)	78.6% (44)	
$\geq$ 2	25.4% (45)	27.3% (33)	21.4% (12)	
Insurance				0.083
Medicare/Medicaid	5.6% (10)	8.1% (10)	0.0% (0)	
Workers' Compensation	26.7% (48)	25.0% (31)	30.4% (17)	
Private	67.8% (122)	66.9% (83)	69.6% (39)	

ASA = American Society of Anesthesiologists; CCI = Charlson Comorbidity Index; SD= standard deviation

Boldface indicates significance

PRIMARY OUTCOME MEASURES

While the pre-pandemic cohort improved from preoperative to all postoperative PROM timepoints (with the exception of the 6-week ODI/PROMIS-PF) ($p \leq 0.025$, all), the pandemic cohort experienced significant postoperative improvements at VAS back through 6 months, VAS leg at 6 weeks, ODI/PHQ-9 at 6 months, and PROMIS-PF at 12-weeks/6-months only ($p \leq 0.037$, all). Upon comparison of mean PROMs, however, no significant differences were observed between cohorts ($p > 0.050$, all). After accounting for procedure type with multiple regression, while preoperative PHQ-9 was significantly lower in the pandemic cohort ($p = 0.019$), no postoperative differences in any PROM (VAS back/leg, ODI, PHQ-9, PROMIS-PF) were observed between the two cohorts ($p > 0.050$, all) (**Table 3**). MCID achievement rates were also comparable between the cohorts, with no

substantial differences or trends in attainment observed for any PROM studied ($p > 0.050$, all) (**Table 4**).

DISCUSSION

Patients suffering from spinal disorders resulting in impaired/loss of mobility are vulnerable to aggravation of co-existing medical conditions and at increased risk for urinary tract infection (UTI), deep vein thrombosis (DVT), and pneumonia (Rizkalla et al. 2020). Consequently, the literature has suggested this patient population is at higher risk of contracting coronavirus disease 2019 (COVID-19) infection of the lungs (Rizkalla et al. 2020). On March 11, 2020, COVID-19 was declared a worldwide pandemic by the World Health Organization (WHO) (Cucinotta and Vanelli 2020). At a time when elective procedures were universally shut down, many policies had to be adapted in order for procedures like spinal surgery to resume in a manner that is

Table 2. Perioperative Characteristics

Characteristic	Total (n=180)	Pre-Pandemic (n=124)	Pandemic (n=56)	*p-value
Spinal Pathology				
Dspond	48.3% (87)	49.2% (61)	46.4% (26)	0.731
Ispond	38.3% (69)	33.9% (42)	48.2% (27)	0.067
rHNP	15.0% (27)	15.3% (19)	14.3% (8)	0.857
Degenerative Scoliosis	14.4% (26)	16.1% (20)	10.7% (6)	0.339
Central Stenosis	96.7% (174)	96.8% (120)	96.4% (54)	0.286
Foraminal Stenosis	84.4% (152)	83.9% (104)	85.7% (48)	0.752
Procedure				0.019
ALIF	28.9% (52)	30.7% (38)	48.2% (27)	
LLIF	35.0% (63)	34.7% (43)	16.1% (9)	
MIS TLIF	36.1% (65)	34.7% (43)	35.7% (20)	
Operative Levels				0.678
Single-Level	87.8% (158)	87.1% (108)	89.3% (50)	
Double-Level	12.2% (22)	12.9% (16)	10.7% (6)	
Operative Time (Mean $\pm$ SD; min)	148.4 $\pm$ 62.8	147.7 $\pm$ 70.9	149.8 $\pm$ 39.1	0.836
Estimated Blood Loss (Mean $\pm$ SD; mL)	72.2 $\pm$ 133.4	77.5 $\pm$ 160.2	61.5 $\pm$ 44.1	0.489

Dspond = degenerative spondylolisthesis; Ispond = isthmic spondylolisthesis; rHNP = recurrent herniated nucleus pulposus; mL = milliliters; ALIF = anterior lumbar interbody fusion; LLIF = lateral lumbar interbody fusion; MIS TLIF = minimally invasive transforaminal lumbar interbody fusion; SD= standard deviation

*p-values calculated using Student's t-test for continuous variables and chi-square analysis for categorical variables

Boldface indicates significance

safe for patients and that reduces transmission and exposure of the coronavirus in the healthcare setting (Verma et al. 2020; Rizkalla et al. 2020). For instance, it was suggested that patients who tested negative for the virus should preferably receive operative treatment at ambulatory surgery centers (ASCs) (Rizkalla et al. 2020). Patients requiring procedural management in an inpatient setting were recommended to be managed in hospitals with separate units for patients with COVID-19 versus those without (Rizkalla et al. 2020). Other effects on healthcare delivery that affected spine practices include regulations restricting volume of surgical cases, in-person clinical endeavors, and access to full staffing, thus exacerbating financial strains for providers (Weiner et al. 2020). These changes induced significantly greater worry among privademic and private practice spine providers versus those practicing in an academic setting ($p=0.0025$), as revenue in the formerly mentioned settings is largely dependent on the level of clinical output (Weiner et al. 2020). This is evident in the sample sizes between groups in our study, with 124 patients receiving LIF in the pre-pandemic group, but only 56 patients receiving fusion in the pandemic group.

The advent of COVID-19 has also led to considerably higher rates of anxiety (by >40%), depression (by >30%), post-traumatic stress disorder (PTSD) (by >40%), and stress (by >70%), demonstrating the powerful influence of the pandemic on wellness (Xiong et al. 2020). With the introduction of isolation and restrictions on previously routine activities, the pandemic has also induced a decrease in optimism and compromised quality-of-life for many individuals (Öztürk Çopur and Karasu 2021). As Patient-Reported

Outcome Measure (PROMs) scores are used by spine surgeons to monitor quality-of-life outcomes from a patient's perspective, the introduction of the pandemic may have significant implications on spine surgeons' ability to rely on these scores as an accurate representation (Lee et al. 2020). Therefore, the purpose of this study was to compare patient reported outcome measures (PROMs) and achievement of minimum clinically important difference (MCID) rates across PROMs among lumbar interbody fusion (LIF) recipients before and after the declaration of the pandemic.

PERIOPERATIVE CHARACTERISTICS

One difference in perioperative variables was in the proportions of patients receiving a particular procedure. Three approaches of LIF were included in the patient cohort: anterior (ALIF), lateral (LLIF), and minimally invasive transforaminal (MIS TLIF) approach. ALIF in particular has proven to be efficacious and is the predominant surgical technique for discogenic lower back pain (Mobbs et al. 2015). The anterior retroperitoneal approach allows for adequate access to the entire ventral surface of the exposed disc which allows for a comprehensive discectomy and direct insertion of the implant (Mobbs et al. 2015). LLIF involves accessing the disc space through a lateral retroperitoneal, transpsoas approach (Mobbs et al. 2015). LLIF is more suitable for spinal pathologies that require access to the interbody disc from T12/L1 to L4/L5 and is not suitable for the L5/S1 level (Mobbs et al. 2015). Moreover, the TLIF approach offers direct, unilateral access to the intervertebral foraminal space while reducing direct dissection and

Table 3. Mean Patient Reported Outcomes

PROM	Pre-Pandemic Mean ± SD	*p-value	Pandemic Mean ± SD	†p-value	**p-value	††p-value
VAS back						
Preoperative	6.1±2.6	-	5.8±2.5	-	0.484	0.782
6-weeks	4.2±2.8	<0.001	3.2±2.5	0.007	0.152	0.266
12-weeks	3.1±2.5	<0.001	3.6±2.9	0.004	0.470	0.627
6-months	3.1±2.5	<0.001	2.5±2.2	<0.001	0.484	0.544
1-year	3.0±2.9	<0.001	2.8±2.9	0.109	0.802	0.945
VAS leg						
Preoperative	5.4±2.9	-	5.3±3.0	-	0.828	0.386
6-weeks	3.4±2.7	<0.001	2.6±2.6	0.022	0.223	0.474
12-weeks	2.2±2.5	<0.001	2.5±2.7	0.167	0.680	0.586
6-months	2.8±2.9	<0.001	2.4±2.7	0.066	0.731	0.789
1-year	2.5±2.8	<0.001	2.1±2.4	0.087	0.709	0.922
ODI						
Preoperative	37.6±14.8	-	40.0±20.1	-	0.436	0.700
6-weeks	33.7±18.1	0.158	33.6±17.1	0.470	0.980	0.846
12-weeks	22.6±15.5	<0.001	27.4±13.7	0.052	0.229	0.406
6-months	22.5±18.6	<0.001	22.1±17.2	0.003	0.933	0.068
1-year	20.7±22.0	<0.001	20.7±15.9	0.236	0.999	0.948
PHQ-9						
Preoperative	5.7±5.7	-	3.9±5.1	-	0.095	0.019
6-weeks	4.4±4.8	0.025	3.8±4.2	0.743	0.635	0.116
12-weeks	3.3±4.7	<0.001	2.4±4.2	0.239	0.460	0.263
6-months	3.1±4.7	<0.001	2.7±4.2	0.037	0.793	0.496
1-year	3.9±4.7	0.024	2.4±4.1	0.631	0.413	0.242
PROMIS-PF						
Preoperative	38.4±23.5	-	38.4±23.5	-	0.553	0.790
6-weeks	38.4±23.5	0.070	35.9±23.2	0.517	0.173	0.304
12-weeks	41.6±7.5	<0.001	41.1±7.8	0.007	0.824	0.792
6-months	44.3±8.4	<0.001	45.0±9.3	0.009	0.761	0.625
1-year	45.2±9.5	<0.001	44.4±6.7	0.078	0.818	0.509

*p-values calculated using paired sample t-test to determine preoperative to postoperative improvement in Pre-Pandemic cohort

†p-values calculated using paired samples t-test to determine preoperative to postoperative improvement in Post-Pandemic cohort

**p-values calculated using Student's t-test to compare mean PROMs between both cohorts

††p-values calculated using multiple regression to evaluate the influence of pre-pandemic vs. post-pandemic grouping on mean PROMs while accounting for baseline difference in type of lumbar fusion received (ALIF, LLIF, MIS TLIF)

Boldface indicates significance

surgical trauma to spinal muscles (Mobbs et al. 2015). TLIF can be performed via an open procedure, or more recently has moved towards an MIS technique with smaller incisions and the use of microscopy (Mobbs et al. 2015). The MIS TLIF approach may further reduce access-associated muscle injury, reduce blood loss, and improve overall postoperative recovery (Mobbs et al. 2015). Patients in the pandemic group were treated with a higher percentage of ALIF procedures while patients in the pre-pandemic group underwent a higher percentage of LLIF procedures. However, for our PROM comparison analysis, multiple regression was additionally performed to determine differences while accounting for LIF type; however, no significant postoperative

differences were noted. Thus, while confounding bias may have affected our results, this effect was likely minor.

No other differences were observed among perioperative characteristics, showing that the presence of the COVID-19 pandemic likely does not influence surgical workflow (i.e., operative duration, estimated blood loss). A recent study highlighting protocols for safe and effective spinal procedures in the current day and age of a pandemic revealed that older patients with a high comorbidity burden were more likely to require ICU admission, ventilation, and/or blood transfusion (Wilson et al. 2020). Therefore, the authors recommended that surgeries should be limited or prioritized for younger, healthier patients during the pandemic (Wilson et al. 2020). Additional factors should also

Table 4. Minimum Clinically Important Difference

PROM	Pre-Pandemic %, (n)	Pandemic %, (n)	*p-value
VAS back			
6-weeks	43.2%	66.7%	0.128
12-weeks	50.8%	53.9%	0.839
6-months	59.7%	87.5%	0.126
1-year	57.6%	50.0%	0.731
Overall	62.2% (61)	63.6% (14)	0.903
VAS leg			
6-weeks	42.0%	40.0%	0.905
12-weeks	47.7%	44.4%	0.855
6-months	45.6%	75.0%	0.255
1-year	57.6%	50.0%	0.731
Overall	55.1% (54)	57.9% (11)	0.823
ODI			
6-weeks	21.0%	14.3%	0.563
12-weeks	33.9%	40.0%	0.652
6-months	59.7%	55.6%	0.758
1-year	51.5%	14.3%	0.072
Overall	49.0% (48)	48.2% (13)	0.939
PHQ-9			
6-weeks	8.6%	15.4%	0.445
12-weeks	4.6%	7.1%	0.696
6-months	4.5%	0.0%	0.541
1-year	8.3%	0.0%	0.428
Overall	12.8% (11)	11.5% (3)	0.866
PROMIS-PF			
6-weeks	37.5%	88.9%	0.120
12-weeks	40.4%	70.0%	0.085
6-months	61.9%	57.1%	0.752
1-year	70.6%	60.0%	0.632
Overall	67.2% (45)	63.2% (12)	0.744

*p-values calculated using chi-square analysis

Boldface indicates significance

be taken into account when scheduling less common, yet more resource-intensive procedures (Wilson et al. 2020).

CLINICAL OUTCOMES

The PROMs evaluated in the present study included: PROM Information System physical function (PROMIS-PF), Patient Health Questionnaire-9 (PHQ-9), Visual Analog Scale (VAS) back/leg, and Oswestry Disability Index (ODI). These surveys were provided preoperatively, and at 6 weeks, 12 weeks, 6 months, and 1 year following LIF.

The patients in the pre-pandemic cohort of our study demonstrated statistically significant and lasting improvement in all PROMs including physical function, mental health, back pain, leg pain, and disability until 1 year postoperatively. One-hundred and twenty-four patients were assessed in the pre-pandemic cohort, which allows the clinical outcomes from our results to provide strong evidence

that pre-pandemic lumbar fusion procedures were efficacious across all studied parameters through 1 year following surgery.

Meanwhile, the pandemic cohort (n=56) assessed in this study demonstrated more variable clinical outcomes. Significant improvements were noted, but they were sparse in quantity. Twelve-week and 6-month outcomes for physical function showed significance while only the 6-month results showed significance for depression. Six weeks to 6 months was significant for back pain, but only the 6-week postoperative time point showed significance for leg pain. Moreover, disability showed significance only at the 6-month postoperative time point. As such, no significant improvements were observed at the final timepoint (1 year) for any PROM. The lower frequency of significant improvements may indicate an impediment to recovery in Health-Related Quality of Life (HRQOL) among patients receiving

surgery during the COVID-19 pandemic. Terai et al. studied 855 patients receiving spine surgery in a private clinical setting, reporting that exercise routines ($p=0.004$) and subsequently HRQOL ($p<0.001$) were significantly lower among pandemic surgical patients (Terai et al. 2021). The authors speculate this may have partially been a result of going out less frequently during the COVID-19 pandemic (Terai et al. 2021). As such, rehabilitation progress among pandemic LIF recipients may be delayed, potentially explaining our findings of scattered improvements among this patient population. Additionally, the COVID-19 pandemic has had dramatic effects on mental wellness, invoking feelings of fear, uncertainty, anxiety, and increasing the risk for psychiatric illness (i.e. panic attacks, depression, PTSD, obsessive compulsive disorder, etc.) (Anjum et al. 2020). With no finite ending to the pandemic, and constant introductions of new strains and isolation recommendations, improvements in PHQ-9 may have been subsequently deterred due to the effects of COVID-19. However, it is worthwhile mentioning that a lack of improvements for the majority of PROM timepoints could be attributed to the smaller size of the pandemic group ($n=56$), making significance more difficult to discern.

Upon comparison of mean scores using Student's t-tests, no significant differences were noted between patients receiving surgery before and after declaration of the pandemic for any PROM. MCID achievement rates were also similar between groups. Multiple regression analysis was also utilized to evaluate the influence of pre-pandemic versus pandemic grouping on mean PROMs while accounting for the baseline difference in the type of lumbar fusion received (ALIF, LLIF, MIS TLIF). After accounting for this difference, significance was seen only at the preoperative timepoint for the PHQ-9 survey (with no postoperative differences in depression ratings). Aside from this difference, all other mean PROM scores and MCID achievement were similar between the two cohorts, suggesting that pre-pandemic and pandemic patients observe similar outcomes and clinically meaningful improvements in physical function, mental health, back pain, leg pain, and disability. This aligns with the findings of Cohen et al., an orthopedic study that evaluated PROMs between pre-pandemic and pandemic patients undergoing upper extremity surgery of the hand or wrist (Cohen et al. 2021). As stated by the authors, with little to no influence on difference in mean quality-of-life outcomes (as also demonstrated in our research), physicians can be more confident in the interpretation of PROMs during the COVID-19 pandemic (Cohen et al. 2021). Patients receiving fusion during the pandemic may also be reassured that perceived outcomes and clinically meaningful improvements will likely be uncompromised. This conclusion is unique to our study, as no other spinal literature to our knowledge has evaluated PROMs among spine procedure recipients before and after the inception of COVID-19. Nevertheless, to ensure optimal improvement across mental and physical health, pain, and disability, spine surgeons

should encourage patients to continue recommended rehabilitation and exercise during the pandemic.

LIMITATIONS

All data was collected from procedures of a single surgeon at an academic institution, limiting the generalizability of our findings. The size discrepancy between the pre-pandemic and pandemic cohorts are a limiting factor of this study. The pandemic cohort had a much smaller sample size which could impact the clinical insight provided by the data. In addition, multiple fusion procedures were included, with discrepancies in the proportion of patients receiving one LIF approach versus another, which may carry their own differences that could confound our results. With this being a longitudinal study, loss to follow-up, especially by the 1-year timepoint, may have contributed selection bias to our results. Finally, as most patients were non-smokers, non-diabetics, non-obese, and without hypertensive disorder, our study evaluates outcomes among most individuals who may be less at risk for acquisition of the COVID-19 infection. Future studies focusing on patients with greater comorbidities may thus provide further insight on this topic. Future multicenter studies with a greater number of subjects are necessary to verify the trends presented in our analysis and increase the statistical power of the results.

CONCLUSION

The introduction of the COVID-19 pandemic led to a considerable decrease in surgical output, with more than a two-fold decrease in the number of LIF cases performed within the same time period. Demographic and perioperative characteristics (i.e., estimated blood loss, duration of operation) were similar whether patients received LIF prior to or during the pandemic. While pre-pandemic patients improved for almost all PROMs at almost all timepoints, pandemic patients demonstrated limited improvements from preoperative to postoperative timepoints (i.e., depression only improved from pre- to postoperative at 6 months). Nevertheless, postoperative mean PROM scores and MCID achievement rates for pain, disability, physical function, and mental health were comparable pre-pandemic and post-pandemic declaration. This suggests that lumbar spinal fusion procedures are safe and allow for similar outcomes and clinically meaningful improvements. Still, to enhance recovery during the pandemic, spine surgeons are encouraged to promote continued suggested exercise and rehabilitation efforts. A multicenter study with a larger sample size is required to confirm trends presented in this analysis and to provide further insight on this topic.

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REFERENCES

- Anjum, Samiaa, Rooh Ullah, Muhammad Suleman Rana, Hamid Ali Khan, Fawad Shabir Memon, Yasin Ahmed, Sadia Jabeen, and Rani Faryal. 2020. "COVID-19 Pandemic: A Serious Threat for Public Mental Health Globally." *Psychiatria Danubina* 32 (2): 245–50. <https://doi.org/10.24869/psyd.2020.245>.
- Cohen, Abigail, Ruud W. Selles, Willemijn A. De Ridder, Marloes H. P. Ter Stege, J. Sebastiaan Souer, and Robbert M. Wouters. 2021. "What Is the Impact of the COVID-19 Pandemic on Quality of Life and Other Patient-Reported Outcomes? An Analysis of the Hand-Wrist Study Cohort." *Clinical Orthopaedics & Related Research* 479 (2): 335–45. <https://doi.org/10.1097/corr.0000000000001514>.
- Cucinotta, D., and M. Vanelli. 2020. "WHO Declares COVID-19 a Pandemic." *Acta Biomedica* 91 (1): 157–60.
- Cushnie, Duncan, Kenneth Thomas, W. Bradley Jacobs, Roger K.H. Cho, Alex Soroceanu, Henry Ahn, Najmedden Attabib, et al. 2019. "Effect of Preoperative Symptom Duration on Outcome in Lumbar Spinal Stenosis: A Canadian Spine Outcomes and Research Network Registry Study." *The Spine Journal* 19 (9): 1470–77. <https://doi.org/10.1016/j.spinee.2019.05.008>.
- Fornari, Maurizio, Scott C. Robertson, Paulo Pereira, Mehmet Zileli, Carla D. Anania, Ana Ferreira, Silvano Ferrari, Roberto Gatti, and Francesco Costa. 2020. "Conservative Treatment and Percutaneous Pain Relief Techniques in Patients with Lumbar Spinal Stenosis: WFNS Spine Committee Recommendations." *World Neurosurgery*: X 7 (July):100079. <https://doi.org/10.1016/j.wnsx.2020.100079>.
- Jain, Nickul S., Ram K. Alluri, Steven S. Schopler, Raymond Hah, and Jeffrey C. Wang. 2020. "COVID-19 and Spine Surgery: A Review and Evolving Recommendations." *Global Spine Journal* 10 (5): 528–33. <https://doi.org/10.1177/2192568220923655>.
- Lee, Thomas J., Alexander A. Thomas, Nikhil R. Grandhi, Matthew S. Galetta, Dhruv K.C. Goyal, Taolin Fang, Gregory D. Schroeder, Christopher K. Kepler, and Alexander R. Vaccaro. 2020. "Cost-Effectiveness Applications of Patient-Reported Outcome Measures (PROMs) in Spine Surgery." *Clinical Spine Surgery: A Spine Publication* 33 (4): 140–45. <https://doi.org/10.1097/bsd.0000000000000982>.
- Mobbs, R.J., K. Phan, G. Malham, K. Seex, and P.J. Rao. 2015. "Lumbar Interbody Fusion: Techniques, Indications and Comparison of Interbody Fusion Options Including PLIF, TLIF, MI-TLIF, OLIF/ATP, LLIF and ALIF." *Journal of Spine Surgery* 1 (1): 2–18.
- Öztürk Çopur, Ebru, and Fatma Karasu. 2021. "The Impact of the COVID-19 Pandemic on the Quality of Life and Depression, Anxiety, and Stress Levels of Individuals above the Age of Eighteen." *Perspectives in Psychiatric Care* 57 (4): 1645–55. <https://doi.org/10.1111/ppc.12730>.
- Ravindra, Vijay M., Steven S. Senglaub, Abbas Rattani, Michael C. Dewan, Roger Härtl, Erica Bisson, Kee B. Park, and Mark G. Shrinne. 2018. "Degenerative Lumbar Spine Disease: Estimating Global Incidence and Worldwide Volume." *Global Spine Journal* 8 (8): 784–94. <https://doi.org/10.1177/2192568218770769>.
- Rizkalla, James M., William Hotchkiss, Andrew Clavenna, Andrew Dossett, and Ishaq Y. Syed. 2020. "Triaging Spine Surgery and Treatment during the COVID-19 Pandemic." *Journal of Orthopaedics* 20 (July):380–85. <https://doi.org/10.1016/j.jor.2020.06.015>.
- Terai, Hidetomi, Masayoshi Iwamae, Koji Tamai, Shinji Takahashi, Yusuke Hori, Shoichiro Ohyama, Akito Yabu, Masatoshi Hoshino, and Hiroaki Nakamura. 2021. "Reductions in the Frequency of Going Out Due to the COVID-19 Pandemic Negatively Affect Patients with Spinal Disorders." *Spine Surgery and Related Research* 5 (6): 365–74. <https://doi.org/10.22603/ssrr.2021-0088>.
- Verma, Virendra, Manoj Nagar, Vaibhav Jain, John A. Santoshi, Manish Dwivedi, Prateek Behera, Rajkumar Selvanayagam, Dharm Pal, and Kuldeep Singh. 2020. "Adapting Policy Guidelines for Spine Surgeries During COVID-19 Pandemic in View of Evolving Evidences: An Early Experience From a Tertiary Care Teaching Hospital." *Cureus* 12 (7). <https://doi.org/10.7759/cureus.9147>.
- Weiner, Joseph A., Peter R. Swiatek, Daniel J. Johnson, Philip K. Louie, Garrett K. Harada, Michael H. McCarthy, Niccole Germscheid, et al. 2020. "Spine Surgery and COVID-19: The Influence of Practice Type on Preparedness, Response, and Economic Impact." *Global Spine Journal* 12 (2): 249–62. <https://doi.org/10.1177/2192568220949183>.
- Wilson, Lauren A., Haoyan Zhong, Jashvant Poeran, Jiabin Liu, and Stavros G. Memtsoudis. 2020. "Recommendations for Resuming Elective Spine Surgery in the COVID-19 Era." *British Journal of Anaesthesia* 125 (3): e339–41. <https://doi.org/10.1016/j.bja.2020.06.022>.
- Xiong, Jiaqi, Orly Lipsitz, Flora Nasri, Leanna M.W. Lui, Hartej Gill, Lee Phan, David Chen-Li, et al. 2020. "Impact of COVID-19 Pandemic on Mental Health in the General Population: A Systematic Review." *Journal of Affective Disorders* 277 (December):55–64. <https://doi.org/10.1016/j.jad.2020.08.001>.
- Yoo, Joon S., Nadia M. Hrynewycz, Thomas S. Brundage, Francesca A. Mogilevsky, Holly C. Shah, Nasima Mehraban, and Kern Singh. 2020. "The Influence of Preoperative Mental Health on PROMIS Physical Function Outcomes Following Minimally Invasive Transforaminal Lumbar Interbody Fusion." *Spine* 45 (4): E236–43. <https://doi.org/10.1097/brs.0000000000003236>.