Single-Position Lateral Lumbar Interbody Fusion in Prone: Single-Centric Case-Series

Rodrigo Amaral
Instituto de Patologia da Coluna
Gabriel Pokorny (ghpokorny@gmail.com)
Instituto de Patologia da Coluna
Fernando Marcelino
Instituto de Patologia da Coluna
Jullyene Pokorny
Instituto de Patologia da Coluna
Rafael Moriguchi
Instituto de Patologia da Coluna
Igor Barreira
Instituto de Patologia da Coluna
Daniel Arnoni
Instituto de Patologia da Coluna
Weby Mizael
Instituto de Patologia da Coluna
Luiz Pimenta
Instituto de Patologia da Coluna

Research Article

Keywords: Spine, Minimally Invasive Surgery, Case Series, Prone Transpsoas Technique, Lateral Lumbar Interbody Fusion

Posted Date: July 25th, 2023

DOI: https://doi.org/10.21203/rs.3.rs-3189559/v1

Abstract

Background

The main difference between prone and lateral surgery is that the patient's position is changed from lateral decubitus to prone, which may work around the three principal difficulties of the standard lateral approach. The prone transpsoas (PTP) technique enables single-position surgery with more familiar patient positioning, which improves lumbar lordosis and lengthens the psoas muscle, pushing it posteriorly. Therefore, this study aimed to examine the clinical and surgical outcomes of the prone transpsoas procedure.

Methods

This was a retrospective case series in which patients with up to two levels of lateral lumbar interbody fusion in the prone decubitus position for degenerative diseases were included. The outcomes of interest were classified as surgical or clinical. According to the variable distribution, Kruskal-Wallis or one-way ANOVA was used to assess variance across all groups, and the t-test or Wilcoxon test was used to examine intragroup variances. The statistical significance level was set at $p < 0.05$.

Results

Thirty-nine patients participated in the trial. The average operating time was 166 min (± 79 min) and the average blood loss was 182 mL (± 151 mL). The median length of hospital stay was one day, with an interquartile range of 1.25 days. All clinical outcomes significantly improved at 1–3, 6–12, and 24–36 months compared to baseline. There was one intraoperative (2,5%) and two postoperative complications (5,1%).

Conclusion

According to the authors’ case experience, PTP is a safe, practical, and reproducible procedure capable of treating a wide spectrum of degenerative disorders.

Level of Evidence: III

Introduction

The creation and popularization of the lateral lumbar interbody fusion (LLIF) technique pioneered by Luiz Pimenta was a fundamental push for a better level of complexity in lateral spine surgery [1]. The LLIF approach offers surgeons an orthogonal plane that allows bilateral annulus fibrosus release. This minimally invasive procedure allows for indirect decompression, disc height restoration, and foraminal space restoration, while avoiding the pitfalls associated with open and posterior techniques [2, 3].

The procedure created a corridor wide enough for indirect decompression by positioning a huge cage on the apophyseal ring, restoring natural segmental lordosis, and disc height. Since then, advancements in technology have fueled the progress of lateral spine surgery, which has expanded the literature to the point where the original LLIF technique article was the most cited minimally invasive reference in 2017 [4].

Although the procedure has proven to be a safe and highly adaptable approach for treating problems ranging from minor degenerative disorders to complicated deformities, it has some limitations. The patients' initial positioning was unfamiliar and difficult, and there was concern about potential neurological consequences from psoas muscle manipulation and the adequacy of sagittal alignment correction. These challenges have led to attempts to create a single-position lateral access technique; however, it has never been made universal because of its complexity [5].

The fundamental change proposed by prone lateral surgery is to change the position of the patient from lateral decubitus to prone, as this change might work over the three fundamental issues of the traditional lateral technique. The prone transpsoas (PTP) allows single-position surgery with a more familiar patient positioning that enhances lumbar lordosis and lengthens the psoas muscle, shifting it posteriorly. Furthermore, this innovative approach relies on procedure-specific enabling technologies, including a patient positioner, a redesigned retractor, and actionable SSEP neuromonitoring of femoral nerve health [6].

Therefore, the current work aimed to investigate the feasibility and applicability of the PTP procedure through a series of consecutive cases in a single-center experience.

Methods

This was a single-center, retrospective, non-comparative, observational study. The study cohort included patients from a single institution in Brazil who underwent at least one lateral lumbar interbody fusion level in the prone decubitus position between 2019 and 2023. Data were retrieved from an online database (Banco de Dados de Cirurgia da Coluna do Brazilian Spine Study Group) [7, 8].

Inclusion & Exclusion criteria

All patients who underwent prone transpsoas surgery (PTP), the technical details of which have been thoroughly detailed in other publications [6] from 2019 to 2023 at the institution, were included in the study.

The exclusion criteria were as follows:1) patients who did not have sufficient information about the surgical procedure (Zero cases) and 2) patients who had more than two-level surgeries (16 cases).

Outcomes

The number of operating levels, expected blood loss (EBL), surgical time, transpsoas time, length of (hospitalization) stay (LoS), and intensive care stay (UCI) were all recorded and retrieved from the database.

Clinical outcomes included the Oswestry Disability Index (ODI) in both percentage (ODI %) and absolute numerical form (ODI points), Euro-Qol quality of life measure (Eq. 5D3L), and numeric rating scale (NRS) for back pain.

Intraoperative and postoperative complications were recorded and analyzed.

Data were collected at baseline, seven–14 days, one–three months, six–12 months, and twenty-four to thirty-six months.

Statistical Analysis

R 4.2 was used for data analysis and summary statistics (CRAN, Vienna)[9]. The tidyverse program was used to construct all descriptive statistics and tables.[10]. ANOVA or the Kruskal-Wallis test, depending on the variable distribution, was used to compare the mean variance between time points, with the pairwise t-test or Wilcoxon test employed to investigate intragroup differences with Benjamini-Hochberg p-value correction, depending on the variable distribution. P was set to 0.05.

Results

Demographics

Thirty-nine patients were included in the study. The mean patient age was 54 years. The sample was composed of twenty-two females (one counted twice due to different surgeries where she received PTP) and 17 males, with the most common pathology being degenerative disc disease (30%) (Table 1).

Thirty-seven patients underwent one PTP procedure, whereas one patient received two procedures. Thirty-one patients had one-level PTP, whereas eight patients received two-level PTP. The most frequent PTP level was L4L5 (21), followed by L3L4, L2L3, and L3L5 (5). Concurrently, one patient underwent ALIF at the L5-S1 level (Table 1).

Table 1 **– Demographic data**

Table 1
Description of sample demographics. ALIF: Anterior lumbar interbody fusion; PTP: Prone transpsoas approach.

Item	Frequency	Percentage (%)
Biologic Sex		
Male	17	43,2
Female	22	56,8
Total Levels Receiving PTP (per Patients)		
1	31	79,4
2	8	20,6
Primary Pathology		
Degenerative Disc Disease	11	29,7
Adjacent Level Disease	8	21,6
Disc Herniation	7	18,9
Spondylolisthesis	7	18,9
Central Stenosis	4	10,8
Arthroplasty Failure	2	5,41
Operated Levels (Patients)		
L4-L5	21	56,7
L3-L4	5	13,5
L2-L3	5	13,5
L3-L5	5	13,5
L4-S1	2	5,4
L2-L4	1	2,7
Other Intersomatics		
ALIF	1	2,7

Surgery Data

The mean operative time was 166 min (± 79 min), and the mean blood loss was 182 ml (± 151 mL). The median length of hospital stay was one day, with an interquartile range of 1.25 days. The median length of ICU stay was 0 days (IQR, 0 days) (Table 2). Table 2 shows the surgical data grouped by the number of operated levels.

Table 2
Surgical outcomes of prone transpsoas (PTP) surgery are shown in the table below. NA, not applicable; EBL, estimated blood loss; ICU, intensive care unit; IQR, interquartile range; LoS, length of stay; SD, standard deviation.

Op. Levels	**N**	**Surgery Time (minutes)**	**TP Time (minutes)**	**EBL (milliliter)**	**LoS (days)**	**ICU (days)**
#	Count	Mean (SD) {Range}	Mean (SD) {Range}	Mean (SD) {Range}	Median (IQR) {Range}	Median (IQR) {Range}
//////////	39	166.85 (79.08) {60–360}	29.40 (17.9) {10–67}	182.34 (151.06) {15–600}	182.34 (151.06) {15–600}	182.34 (151.06) {15–600}
Breakdown by Level						
1	31	152.03 (77.57) {60–360}	32.5 (18.3) {14–67}	138.64 (104.76) {15–400}	1 (1) {1–14}	0 (0) {0–9}
2	8	224.25 (58.48) {139–300}	24.5 (17.6) {10–57}	357.14 (188.03) {150–600}	3 (2.5) {1–8}	0 (0) {0–1}

Clinical Outcomes

The patients' quality-of-life assessments deteriorated as expected during the early postoperative follow-up (7–14 days), although the difference was not statistically significant. Patients showed significant improvement in every evaluated quality of life score at the 1-to-3-month, 6-12-month, and 24-36-month follow-ups, and the effect sizes of all analyzed clinical outcomes were deemed large (Table 3).

Table 3
The evolution of clinical outcomes. FUP indicates Follow-up; IQR stands for Interquartile Range; NRS stands for Numerical Rating Scale; ODI stands for Oswestry Disability Index. SD is for Standard Deviation; pts stands for Points Score; and percent stands for Percentage Score. The results in bold are significant ($p < 0.05$) when compared to the baseline values.

FUP	ODI (%)	ODI (pts)	EQ-5D-3L	Back (NRS)
	Mean(SD) {Range}	Mean(SD) {Range}	Mean(SD) {Range}	Median (IQR) {Range}
Baseline	47.06(19.2) {14–92}	23.53(15.5) {7–46}	0.46(0.18) {-0.07-0.8}	8(2) {3–10}
PosOp (7–14 days)	50.47(24.3) {4–92}	25.23(16.5) {2–46}	0.48(0.26) {-0.13-1}	6.5(5) {0–9}
1–3 months	**29.67(18.44) {4–68}**	**14.83(15.62) {2–34}**	**0.67(0.2) {0.32-1}**	**4(4.75) {0–8}**
6–12 months	**29.13(21.26) {0–70}**	**14.57(17.5) {0–35}**	**0.57(0.26) {0.22-1}**	**4(4.75) {0-9.5}**
24–36 months	**24.29(24.47) {0–72}**	**12.15(19.5) {0–36}**	**0.73(0.29) {0.17-1}**	**2(7) {0–10}**

The ODI scores decreased from 47 to 24 over a 24-36-month period (Fig. 1).

Moreover, the numerical rating scale values for back pain decreased from 8 to 2 over the same period (Fig. 2).

Finally, EQ-5D-3L scores improved from 0.46 at baseline to 0.76 (Fig. 3) at the final follow-up.

Complications

One intraoperative complication (2,5%) occurred, with one case of cage breakage. One psoas hematoma and one adjacent-level disease were detected postoperatively (5.1%). Furthermore, two patients developed new neurological symptoms (both resolved at the 6-month visit).

Discussion

Several authors have attempted instrumented lateral surgery in a single (lateral) position [5, 11]. Although these procedures reduce time, they do not address other concerns such as lumbar lordosis in the lateral position and the difficulty of performing posterior surgery with the patient in lateral decubitus [11].

Pimenta et al. published an article in 2021 outlining the prone transpsoas technique (PTP) and its capacity for anterior/posterior column access in a single position in an attempt to address some of the shortcomings of the standard lateral approach [12]. Others have published about prone and lateral surgery but have encountered problems when attempting to use known methods for lateral surgery [13, 14]. The PTP was developed from early experience (beginning in early 2019) with similar challenges and has changed the landscape with procedure-specific access systems that make surgery more reproducible [6].

Prone transpsoas and Intra/Perioperative outcomes

One of the most significant benefits of single-position surgery is that it saves operative time compared to traditional LLIF [15, 16]. Ziino et al. (2018) showed that single-position lateral surgery had a 44 min shorter duration than dual-position surgery, similar to that reported by Hiayama et al. (2019), who showed a 31 min reduction when performing single-position lateral surgery [17, 18]. Finally, Berjano et al. showed in 2019 that the prone decubitus lateral technique reduced the surgical duration compared to typical lateral surgery [13].

Overall, the prone transpsoas technique appears to alleviate the drawbacks of the traditional LLIF approach without increasing the surgical risk. A convenient prone patient position enables posterior surgical treatments, such as posterior fixation or direct decompression, as well as lateral access to the disc space, while also improving both lumbar and segmental lordosis. Newly released research has shown that the PTP technique is safe, with only one (3%) complication in 32 cases [19]. Similarly, an initial 120 multicentric case series analysis revealed seven intraoperative problems after the PTP approach [20].

Furthermore, Pimenta et al. demonstrated that only three of thirty-two patients who underwent PTP at the L4-5-disc level experienced new neurological symptoms postoperatively, two of which were sensory deficits and one of which was a slight motor deficit, all of which resolved within the follow-up visit.[19]. Similarly, Morgan et al. (2022) reported that femoral nerve injuries were rare after a prone lateral approach, with only one of twenty-nine patients suffering from motor disability due to nerve injury (recovered at the 3-month visit) [21]. Furthermore, only eight individuals experienced the onset of neurological symptoms in the initial 120 multicentric case series involving the application of the PTP approach [20].

The findings of Amaral et al.(2021) may explain the apparent reduction in the rate of postoperative neurological complications. The authors revealed that the psoas muscle retracts significantly in the prone position, resulting in reduced muscular mobilization and a lower risk of plexus damage [22]. Furthermore, recent plexus position investigations using tractography and fluoroscopy support the hypothesis that prone positioning promotes mobilization in the psoas muscle-lumbar plexus complex, which may facilitate femoral nerve retraction to more posterior positions [23].

Prone transpsoas and quality of life outcomes

Only three articles studied the impact of the PTP technique on the improvement in the quality of life of patients. One study compared the technique with the standard lateral approach, showing that the PTP approach led to a higher reduction in the ODI and SF-12 physical scores than the LLIF [24]. Furthermore, in a second article, PTP was compared with transforaminal lumbar interbody fusion (TLIF) with equivalent results, where the PTP technique showed a significantly greater improvement in the ODI score than the TLIF technique[25]. The results aligned with those presented in this article, which showed a significant improvement in the ODI score compared with the baseline. Finally, in a cohort published in early 2023, Wellington et al. (2023) showed that prone transpsoas could significantly improve several health-related QoL scores for up to 3 months[26]. These results are very similar to those presented in this study.

Limitations

The limitations of the current study are that it is a retrospective case series that could induce bias in the analysis and that not every patient reached the final follow-up. Two methods were used to reduce bias associated with retrospective studies. First, all the data were prospectively collected. Second, clear guidelines were implemented for data collection and analysis.

Conclusion

The authors' consecutive case experience shows that PTP is a safe, feasible, and reproducible technique capable of treating a wide range of degenerative pathologies. Moreover, the present work demonstrates that PTP yields short operative times, low blood loss volume, and reduced hospitalization duration while significantly improving the patient's quality of life.

Declarations

An ethics committee approved the work, and all patients consented to have their data collected.

Diclosures

Dr. Luiz Pimenta and Dr. R odrigo Amaral receives consultancy fees form ATEC.

The other authors have no disclosures to declare.

References

1. Ozgur BM, Aryan HE, Pimenta L, Taylor WR: Extreme Lateral Interbody Fusion (XLIF): a novel surgical technique for anterior lumbar interbody fusion. Spine Journal. 2006, 6:435–43. 10.1016/j.spinee.2005.08.012
2. Mobbs RJ, Phan K, Malham G, Seex K, Rao PJ: Lumbar interbody fusion: techniques, indications and comparison of interbody fusion options including PLIF, TLIF, MI-TLIF, OLIF/ATP, LLIF and ALIF. J Spine Surg. 2015, 1:2–18. 10.3978/j.issn.2414-469X.2015.10.05
3. Pimenta L, Tohmeh A, Jones D, et al.: Rational decision making in a wide scenario of different minimally invasive lumbar interbody fusion approaches and devices. Journal of Spine Surgery. 2018, 4:142–55. 10.21037/jss.2018.03.09

4. Virk SS, Yu E: The Top 50 Articles on Minimally Invasive Spine Surgery. Spine (Phila Pa 1976). 2017, 42:513–9. 10.1097/BRS.0000000000001797
5. Blizzard DJ, Thomas JA: MIS Single-position Lateral and Oblique Lateral Lumbar Interbody Fusion and Bilateral Pedicle Screw Fixation. Spine (Phila Pa 1976). 2018, 43:440–6. 10.1097/BRS.0000000000002330
6. Pimenta L, Amaral R, Taylor W, et al.: The prone transpsoas technique: preliminary radiographic results of a multicenter experience. European Spine Journal. Published Online First: 2020. 10.1007/s00586-020-06471-y
7. Harris PA, Taylor R, Minor BL, et al.: The REDCap consortium: Building an international community of software platform partners. J Biomed Inform. 2019, 95:103208. 10.1016/j.jbi.2019.103208
8. Pokorny G, Amaral R, Pratali R, et al.: PRESENTATION OF THE MULTICENTRIC COLLECTION SPINE SURGERY DATABASE. Coluna/Columna. 2022, 21:. 10.1590/S1808-185120222104261485
9. R Core Development Team: R: a language and environment for statistical computing, 3.2.1. Document freely available on the internet at: http://www r-project org. Published Online First: 2015.
10. Wickham H, Averick M, Bryan J, et al.: Welcome to the Tidyverse. J Open Source Softw. 2019, 4:1686. 10.21105/joss.01686
11. Hiyama A, Katoh H, Sakai D, Tanaka M, Sato M, Watanabe M: Facet joint violation after single-position versus dual-position lateral interbody fusion and percutaneous pedicle screw fixation: A comparison of two techniques. Journal of Clinical Neuroscience. 2020, 78:47–52. 10.1016/j.jocn.2020.06.016
12. Pimenta L, Taylor WR, Stone LE, Wali AR, Santiago-Dieppa DR: Prone transpsoas technique for simultaneous single position access to the anterior and posterior spine. Oper Neurosurg . 2020.
13. Lamartina C, Berjano P: Prone single-position extreme lateral interbody fusion (Pro-XLIF): preliminary results. European Spine Journal. 2020, 29:6–13. 10.1007/s00586-020-06303-z
14. Martirosyan NL, Uribe JS, Randolph BM, Buchanan RI: Prone Lateral Lumbar Interbody Fusion: Case Report and Technical Note. World Neurosurg. 2020, 144:170–7. 10.1016/j.wneu.2020.08.172
15. Drazin D, Kim TT, Johnson JP: Simultaneous Lateral Interbody Fusion and Posterior Percutaneous Instrumentation: Early Experience and Technical Considerations. Biomed Res Int. 2015, 2015:. 10.1155/2015/458284
16. Tohmeh AG, Watson B, Tohmeh M, Zielinski XJ: Allograft cellular bone matrix in extreme lateral interbody fusion: Preliminary radiographic and clinical outcomes. The Scientific World Journal. 2012, 2012:. 10.1100/2012/263637
17. Hiyama A, Katoh H, Sakai D, Sato M, Tanaka M, Watanabe M: Comparison of radiological changes after single- position versus dual- position for lateral interbody fusion and pedicle screw fixation. BMC Musculoskelet Disord. 2019, 20:. 10.1186/s12891-019-2992-3
18. Ziino C, Konopka JA, Ajiboye RM, Ledesma JB, Koltsov JCB, Cheng I: Single position versus lateral-then-prone positioning for lateral interbody fusion and pedicle screw fixation. Journal of Spine Surgery. 2018, 4:717–24. 10.21037/jss.2018.12.03

19. Pimenta L, Pokorny G, Amaral R, et al.: Single-Position Prone Transpsoas Lateral Interbody Fusion Including L4L5: Early Postoperative Outcomes. World Neurosurg. 2021, 149:. 10.1016/j.wneu.2021.01.118
20. Smith TG, Joseph SA, Ditty B, Amaral R, Tohmeh A, Taylor WR, Pimenta L: Initial multi-centre clinical experience with prone transpsoas lateral interbody fusion: Feasibility, perioperative outcomes, and lessons learned. North American Spine Society Journal (NASSJ). 2021, 6:100056. 10.1016/j.xnsj.2021.100056
21. Morgan CD, Katsevman GA, Godzik J, Catapano JS, Hemphill C, Turner JD, Uribe JS: Outpatient outcomes of patients with femoral nerve neurapraxia after prone lateral lumbar interbody fusion at L4-5. J Neurosurg Spine. 2022, 1–4. 10.3171/2021.11.SPINE211289
22. Amaral R, Daher MT, Pratali R, et al.: THE EFFECT OF PATIENT POSITION ON PSOAS MORPHOLOGY AND IN LUMBAR LORDOSIS. World Neurosurg. Published Online First: June 2021. 10.1016/j.wneu.2021.06.067
23. Alluri R, Clark N, Sheha E, et al.: Location of the Femoral Nerve in the Lateral Decubitus Versus Prone Position: https://doi.org/101177/21925682211049170. 2021, 0:219256822110491. 10.1177/21925682211049170
24. Soliman MAR, Aguirre AO, Ruggiero N, et al.: Comparison of prone transpsoas lateral lumbar interbody fusion and transforaminal lumbar interbody fusion for degenerative lumbar spine disease: A retrospective radiographic propensity score-matched analysis. Clin Neurol Neurosurg. 2022, 213:107105. 10.1016/J.CLINEURO.2021.107105
25. Soliman MAR, Aguirre AO, Ruggiero N, et al.: Comparison of prone transpsoas lateral lumbar interbody fusion and transforaminal lumbar interbody fusion for degenerative lumbar spine disease: A retrospective radiographic propensity score-matched analysis. Clin Neurol Neurosurg. 2022, 213:107105. 10.1016/J.CLINEURO.2021.107105
26. Wellington IJ, Antonacci CL, Chaudhary C, et al.: Early Clinical Outcomes of the Prone Transpsoas Lumbar Interbody Fusion Technique. Int J Spine Surg. 2023, 17:112. 10.14444/8390

Figures

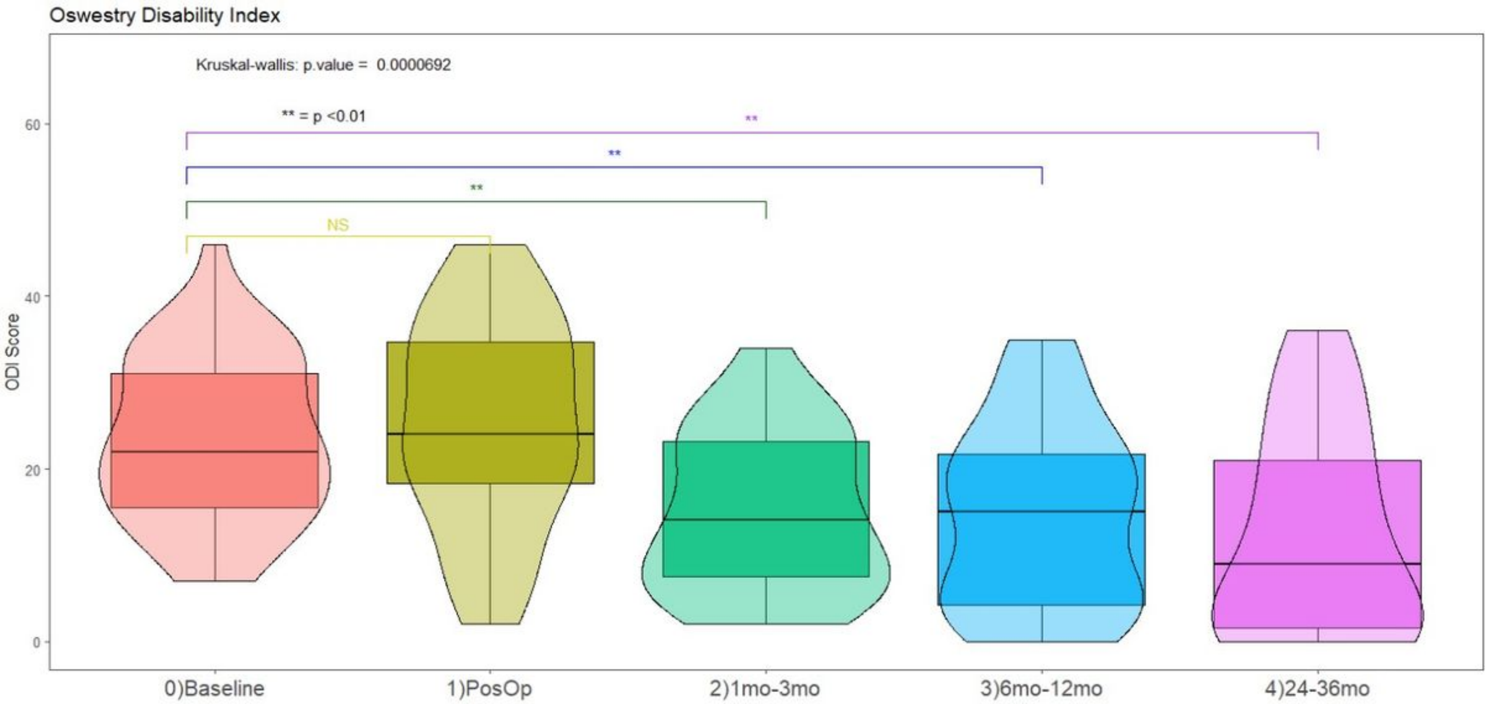

Figure 1

Evolution of ODI score percentages. ** p < 0.01.

Violin and Box-plot graph plot showing both the density and the distribution of the quality-of-life scores across the follow-ups. * represent p < 0.05, ** p < 0.01, *** p < 0.001

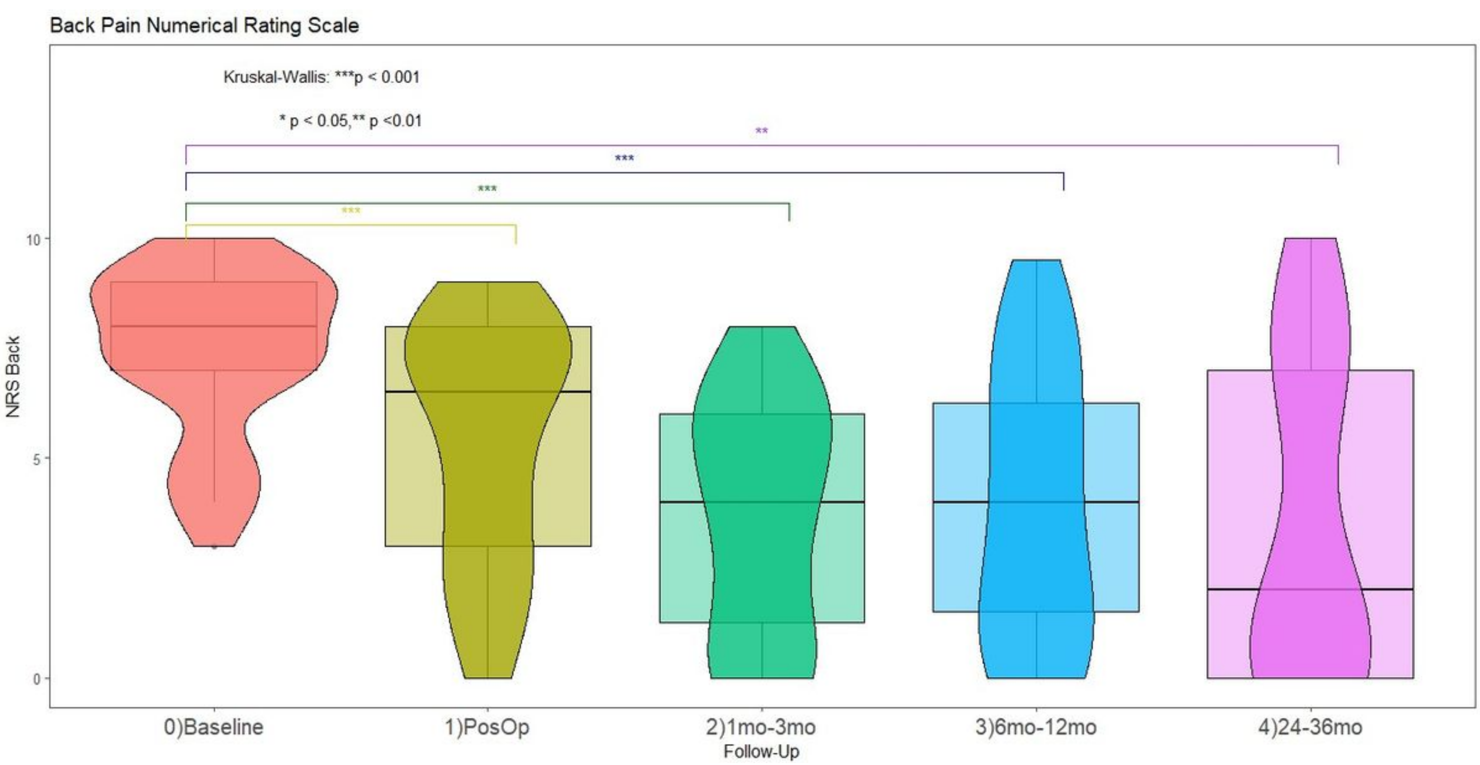

Figure 2

Evolution of the back pain score. *** p < 0.01. 1–3 months: one–to–three months follow-up. 6mo–12mo: six–to–12-month follow-up. 24mo–36mo: 24-to–36-month follow-up.

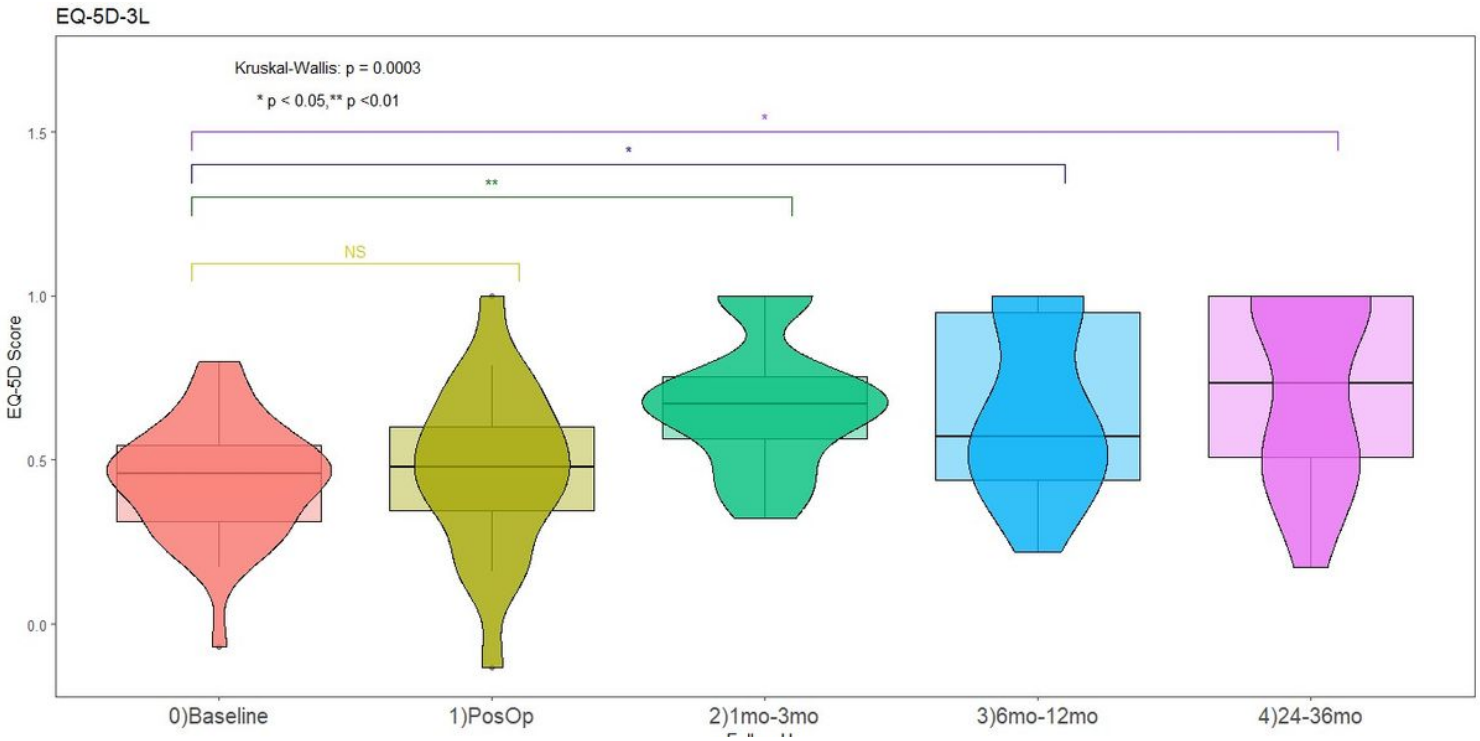

Figure 3

Evolution of EQ-5D-3L scores. *** p < 0.01. 1–3 months: one–to–three months follow-up. 6mo–12mo: six–to–12-month follow-up. 24mo–36mo: 24-to–36-month follow-up.