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LUMBAR ARTHRODESIS IN LATERAL SINGLE POSITION: CONCEPTS, RATIONAL AND CLINICAL-FUNCTIONAL RESULTS OF 100 CONSECUTIVE CASES

ARTRODESE LOMBAR EM DECÚBITO LATERAL ÚNICO: CONCEITOS, JUSTIFICATIVAS E RESULTADOS CLÍNICO-FUNCIONAIS DE 100 CASOS CONSECUTIVOS

ARTRODESIS LUMBAR EN POSICIÓN LATERAL ÚNICA: CONCEPTOS, JUSTIFICACIONES Y RESULTADOS CLÍNICO-FUNCIONALES DE 100 CASOS CONSECUTIVOS

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ABSTRACT

Objective: Arthrodesis techniques such as anterior lumbar interbody fusion (ALIF) and lateral lumbar interbody fusion (LLIF) aim to reestablish physiological lordosis and minimize tissue damage to the paravertebral musculature. Supplementation with percutaneous pedicle screws is indicated in most cases, therefore, intraoperative changes in decubitus are necessary, generating costs and risks for the patient. This study aims to present concepts and results of a series of 100 cases of patients undergoing 360° fusion in lateral single position surgery (LSPS). Methods: retrospective analysis of databases collected between 2016 and 2021. Patients who underwent 360° fusion of the lumbar spine in single lateral decubitus to treat degenerative and infectious diseases were included. Cases with arthrodesis greater than 3 levels were excluded. Data collected include demographics, body mass index (BMI) and scores such as visual analog scale (VAS), EuroQOL 5D (EQ5D) and Oswestry disability index (ODI). Results: 100 patients were included in the study, submitted to LLIF and/or ALIF associated with percutaneous pedicle fixation. The lumbar VAS improved from 6.75 to 2.1 after 12 months, while the sciatica VAS started from 4.55 and reached 0.81 after one year. The EQ5D improved from 66.1 to 81.6 after the first year, while the ODI ranged from 28.54 to 14.18 in the same period. Conclusions: the clinical-functional results of the LSPS procedures are favorable and place the LSPS as an option to be studied, developed and practiced by spine surgery teams. ***Level of evidence: IV. Case series.***

Keywords: Minimally Invasive Surgical Procedures; Pedicle Screws; Surgical Procedures, Operative.

RESUMO

Objetivo: Técnicas de artrodese como anterior lumbar interbody fusion (ALIF) e lateral lumbar interbody fusion (LLIF) tem como objetivos o reestabelecimento da lordose fisiológica e a mínima lesão tecidual da musculatura paravertebral. A suplementação com parafusos pediculares por via percutânea é indicada na maioria dos casos, sendo, portanto, necessárias mudanças de decúbito intraoperatórias, gerando custos e riscos para o paciente. Este estudo tem como objetivo apresentar conceitos e resultados de uma série de 100 casos de pacientes submetidos a fusão 360° em lateral single position surgery (LSPS). Métodos: análise retrospectiva de banco de dados coletados entre 2016 e 2021. Foram incluídos pacientes submetidos a fusão 360° da coluna lombar em decúbito lateral único para tratamento doenças degenerativas e infecciosas. Foram excluídos casos com artrodeses maiores que 3 níveis. Os dados coletados incluem demografia, índice de massa corpórea (IMC) e scores como visual analog scale (VAS), EuroQOL 5D (EQ5D) e Oswestry disability index (ODI). Resultados: 100 pacientes foram incluídos no estudo, submetidos a LLIF e/ ou ALIF associados a fixação pedicular percutânea. O VAS lombar apresentou melhora de 6,75 para 2,1 após 12 meses, já o VAS ciatalgia partiu de 4,55 e atingiu 0,81 após um ano. O EQ5D apresentou melhora de 66,1 para 81,6 após o primeiro ano, enquanto o ODI variou de 28,54 para 14,18 no mesmo período. Conclusões: os resultados clínico-funcionais dos procedimentos em LSPS se mostram favoráveis e a colocam o LSPS como uma opção a ser estudada, desenvolvida e praticada pelas equipes de cirurgia de coluna. ***Nível de evidência: IV. Série de casos.***

Descritores: *Procedimentos Cirúrgicos Minimamente Invasivos; Parafusos Pediculares; Procedimentos Cirúrgicos Operatórios.*

RESUMEN

Objetivo: Las técnicas de artrodesis como la fusión intersomática lumbar anterior (ALIF) y la fusión intersomática lumbar lateral (LLIF) tienen como objetivo restablecer la lordosis fisiológica. La suplementación con tornillos pediculares percutáneos está indicada en la mayoría de los casos, por lo que son necesarios cambios en decúbito intraoperatorios, generando costos y riesgos para el paciente. Este estudio

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tiene como objetivo presentar conceptos y resultados de una serie de 100 casos de pacientes sometidos a fusión de 360° en cirugía de posición única lateral (LSPS). Métodos: análisis retrospectivo de bases de datos recolectadas entre 2016 y 2021. Se incluyeron pacientes que se sometieron a fusión de columna lumbar 360° en decúbito lateral y se excluyeron los casos con artrodesis mayores de 3 niveles. Los datos recopilados incluyen datos demográficos, índice de masa corporal (IMC) y puntajes como la escala analógica visual (VAS), EuroQOL 5D (EQ5D) y el índice de discapacidad de Oswestry (ODI). Resultados: 100 pacientes fueron incluidos en el estudio, sometidos a LLIF y/o ALIF asociados a fijación pedicular percutánea. La EVA lumbar mejoró de 6,75 a 2,1 a los 12 meses, mientras que la EVA de ciática partió de 4,55 y llegó a 0,81 al año. El EQ5D mejoró 66,1 a 81,6 después del primer año, mientras que el ODI varió 28,54 a 14,18 en el mismo período. Conclusiones: los resultados clínico-funcionales de los procedimientos de LSPS son favorables y a sitúan como una opción a ser estudiada, desarrollada y practicada por los equipos de cirugía de columna. ***Nivel de evidencia: IV. Series de casos.***

Descriptores: *Procedimientos Quirúrgicos Mínimamente Invasivos; Tornillos Pediculares; Procedimientos Quirúrgicos Operativos.*

INTRODUCTION

The LLIF *(lateral lumbar interbody fusion*) is an established surgical technique for lateral transpsoas lumbar arthrodesis, developed and widely used since the 2000s, peer-reviewed, and supported by extensive scientific literature.[1-6] The procedure classically uses positioning the patient in the right or left lateral decubitus position and laterally accesses a retroperitoneal safety corridor, reaching the psoas muscle. Then, the disc space is visualized through the opening of the psoas fibers. Its advantages include (1) wide discectomy and ability to implant larger cages compared to TLIF and PLIF, (2) lower subsidence rate, (3) preservation of posterior musculature, (4) restoration of disc height and segmental lordosis, (5) possibility of releasing the anterior longitudinal ligament (ALL) for greater lordosis gain, and (6) indirect decompression of neural elements.[7-10] Among its limitations, it is worth noting the difficulty of approaching the L5-S1 level due to the iliac crest and the neurovascular anatomy.

In turn, the ALIF *(anterior lumbar interbody fusion*) is a worldwide spread lumbar arthrodesis technique, capable of performing *interbody* fusion through the anterior retroperitoneal or transperitoneal access. The procedure is classically done through a midline approach with the patient positioned in dorsal decubitus. Alternatively, there is also the modified anterolateral access, used for ALIF in the lateral decubitus position.[11,12] Both similarly reach the anterior region of the lumbar spine and the lumbosacral transition. ALIF can implant cages with a large contact surface with the plateaus, restore segmental lordosis, disc, and foraminal height, and improve the patient's spinopelvic parameters. It is currently considered the gold standard for performing arthrodesis in the L5-S1 segment,[13,14] where it approaches the disc space below the bifurcation of the great vessels. It, therefore, does not require much manipulation and removal of these vessels. Thus, it works synergistically with LLIF, enabling anterior and lateral inter-somatic arthrodesis throughout the lumbosacral spine. This association becomes even more logical when the choice is made to use lateral decubitus for ALIF, which allows the concept of single-lateral decubitus to be applied.

After implanting a *cage* in the disc space, supplemental posterior fixation with percutaneous pedicle screws (PPP) is necessary, with *stand-alone* procedures reserved for exceptional situations.[15] The goal of fixation is to increase the stiffness and stability of the construct and restore lordosis. Among the available options, pedicle screws are the most indicated to perform this role.[16,17] The screws are inserted through a percutaneous technique, using small skin accesses and fluoroscopy or neuronavigation as a guide. In this way, tissue injury is minimized, and the paravertebral musculature is preserved.

The need for intraoperative decubitus change is a major difficulty in joining the ALIF, LLIF, and posterior fixation techniques in a single-surgical time. In 360° reconstruction procedures, up to two repositionings may be required during the operation, from dorsal decubitus in ALIF to lateral in LLIF, and then to ventral decubitus for posterior fixation. Intraoperative repositioning increases surgical and anesthetic time, the cost of disposable materials, and the risks of perioperative complications.

To solve these problems and increase surgical efficiency while preserving the benefits of anterior and posterior circumferential fusion of the spine, techniques have been developed to perform the procedures in *lateral single-position surgery (LSPS*). Thus, ALIF, LLIF, and fixation with PPP can be performed with a single-positioning, allowing for shorter surgical procedures, fewer perioperative complications, and, consequently, shorter hospital stays.[18]

This study aims to describe the LSPS technique, present its concepts and rationale for its implementation, and present clinical and functional results from 100 consecutive cases using this concept.

MATERIALS AND METHODS

The study performs a retrospective analysis of a prospectively collected database from a single center between 2016 and 2021. The data was collected by signing an informed consent form, protecting the patient's privacy. The creation of the *Registry* database was previously submitted for approval by an ethics committee, under CAAE number 69683917.5.0000.5126.

One hundred patients were involved in the study and underwent clinical and functional data collection. All had diagnoses of degenerative diseases of the lumbar spine (e.g., spondylolisthesis, degenerative disc disease, canal stenosis) or infection and were treated surgically using LLIF and/or ALIF, always associated with percutaneous pedicle fixation in single-lateral decubitus. To standardize the sample, only patients treated at up to three levels at the same surgical time were included.

The clinical and functional results were evaluated using questionnaires uniformly applied in the pre- and postoperative periods at three, six, and 12 months. Demographic, socio-occupational, BMI, and medical history data were collected, and the EuroQOL-5D, ODI, and VAS questionnaires were applied.

The perioperative complications identified by the team are reported in the *complications form* and classified according to severity, immediate and definitive clinical repercussion (Table 1). Adverse events requiring specific treatment, surgical or clinical, and new motor or sensory deficits were defined as complications.

Patients with incomplete data collection, *follow-ups of* less than 12 months, lumbar arthrodesis greater than three levels,

Table 1. Classification of postoperative complications.

Grade	Description
1	Required simple or minimally invasive treatment (e.g., Foley catheter, nasogastric tube) but has no long-term effect.
2	Required invasive (e.g., surgery) or complex treatment (e.g., bedside monitoring) and is likely to have temporary (<6 months) adverse effects.
3	Required invasive (e.g., surgery) or complex treatment (e.g., bedside monitoring) and are likely to have prolonged adverse effects* (>6 months).
4	Significant neurological injury (one or more grades of deterioration on the ASIA scale) or life or limb-threatening event (sentinel event**).
5	Results in death

* Any complication with functional significance (patient-reported) and likely prolonged adverse effect (>6 months), regardless of whether it required treatment, should be classified as grade 4. ** Sentinel event is an unexpected event that threatens the patient's life or limb and requires investigation and review to determine the cause.

degenerative scoliosis, or procedures with a change in decubitus were excluded.

The data collected was submitted for statistical analysis by one of the study team members using Wizard Pro® *software* and organized into graphs to illustrate the evolution of *scores* over the follow-up period.

RESULTS

One hundred patients were included in this study, all of whom underwent lumbar arthrodesis surgical procedures of one to three levels using LSPS techniques. A single surgeon performed the procedures in Belo Horizonte, Brazil. The gender distribution was 56 women and 44 men, with a mean age of 60.03 years at the time of the procedure and a mean BMI of 28.37. The primary diagnoses were degenerative disc disease (41%), spondylolisthesis (29%), canal stenosis (17%), pseudoarthrosis (9%), infection (3%), post-laminectomy syndrome (1%), as illustrated in Table 2.

The mean VAS for axial low back pain started from 6.75 preoperatively, reaching 2.1 at 12 months postoperatively. In turn, the VAS for pain radiating to the lower limbs went from 4.55 before surgery to 0.81 one year after the procedure, as illustrated in Figure 1.

The average in the preoperative ODI was 28.54, presenting a descending curve until six months postoperatively when it reached a value of 9.77. After 12 months, there was a small increase to 14.18, illustrated in Figure 2.

The patients' average perception of quality of life was measured using the EuroQOL 5D scoring scale. The values found were 66.1 preoperatively, reached a peak of 82.9 in 6 months, and regressed a little to reach 81.6 in 12 months postoperatively, as shown in Figure 3.

Ten surgical complications were identified among the operated cases, six being intraoperative complications and another four, postoperative complications. Type I intraoperative complications was: one intraoperative subsidence with no need for treatment. We also had five type II complications, these being: (1) an implant malposition requiring surgical revision, (2) a dural injury requiring repair, (3) a ruptured anterior longitudinal ligament treated with screw cage fixation, (4) an infection noted intraoperatively during decompression treated with antibiotic therapy, and (5) a residual root compression requiring foraminotomy. All complications were resolved in less than six months without leaving any major sequelae.

We also identified four postoperative complications, one type I (paralytic ileus), two type II: (1) deep surgical wound infection requiring surgical debridement and (2) subsidence requiring surgical revision, and one type III: neurological deterioration with hypoesthesia and nerve root paresis.

Table 2. Primary diagnoses of the patients operated on.

Diagnosis	Number of patients
Primary degenerative disc disease	21
Adjacent level disease	14
Isthmic spondylolisthesis	5
Degenerative spondylolisthesis	25
Central canal stenosis	12
Canal stenosis - lateral recess	4
Pseudoarthrosis	9
Infection	3
Post laminectomy syndrome	1
Total	100

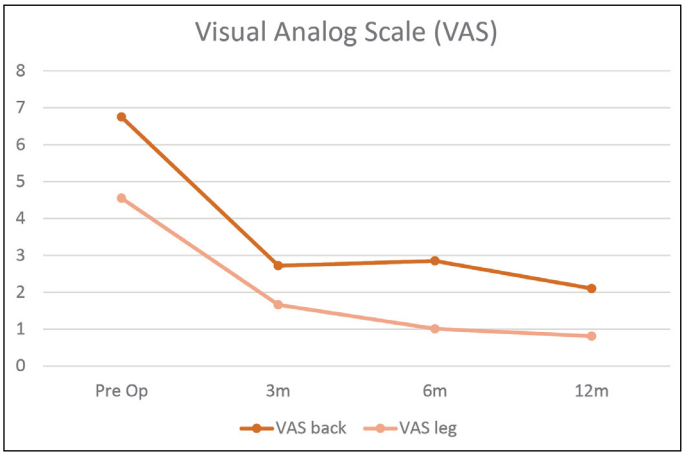

Figure 1. Mean back VAS (low back pain) and leg VAS (sciatica) preoperatively, 3, 6, and 12 months after the surgical procedure (p<0,05).

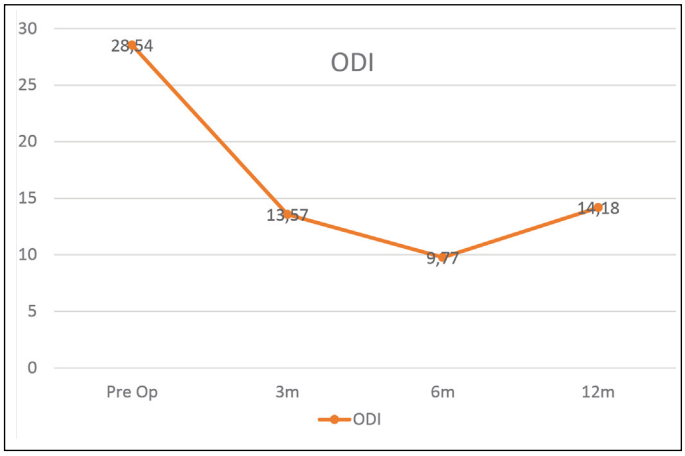

Figure 2. Evolution of the average Oswestry Disability Index (ODI) of the study population (p<0,05).

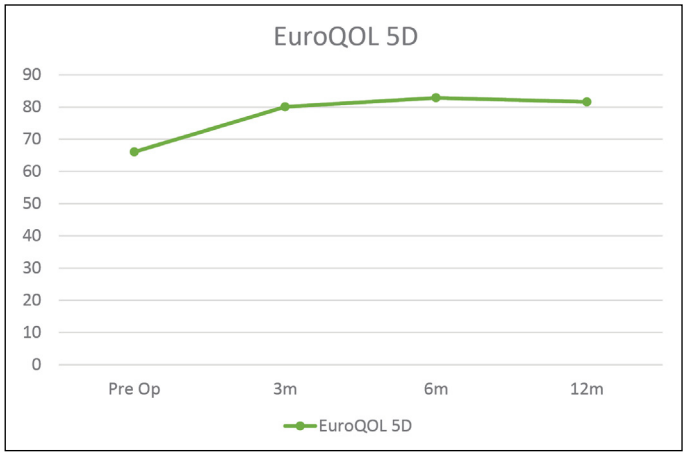

Figure 3. EuroQOL 5D score (p<0,05).

DISCUSSION

The constant search for improvements in the efficiency and safety of spine surgical procedures led to the development of the LSPS surgical technique. This concept has been expanded and popularized over the last few years. Its main argument in favor is the reduction in operative time while maintaining the same principles and objectives as the anterior and lateral approaches with decubitus change: preservation of the posterior musculature, restoration of physiological lordosis, indirect decompression of the nerve roots, extensive inter somatic fusion surfaces, and low complication rates.[19-21]

Although it is a recent technique, with little literature about it, studies have shown shorter operative time and hospitalization in LSPS procedures compared to lateral procedures followed by prone decubitus change.[22] Several studies published by the *American College of Surgeons National Surgical Quality Improvement Program (NSQUIP)* correlate prolonged operative time in lumbar arthrodesis

surgeries with a higher rate of perioperative and postoperative complications.[23-26] More scientific support is still needed to prove a lower complication rate for LSPS; however, the shorter duration of the procedure is a strong argument in its favor.

We can also mention that LSPS is an option that uses disposable resources such as sterile fields, gowns, and gloves more rationally and economically. The increased efficiency reduces operating room time and decreases the use of drugs for the anesthetic procedure, representing a financial saving.

It is important to note that LSPS, being a new technique, presents challenges and requires the development of specific skills by the surgeon and his team. The positioning of the patient in lateral decubitus must be accompanied by adequate protection of bony prominences with padding, and control of table rotation for the correct visualization of the spine in AP and profile through fluoroscopy. Access for lateral ALIF requires minor modifications, such as the entry point, which is more lateral than the supine ALIF. The surgeon also goes through a learning curve for percutaneous screw placement in the lateral decubitus position.

Another challenging situation is minimally invasive direct decompression via tubing in the lateral decubitus position. In some cases, indirect decompression through ligamentous re-tensioning is insufficient, and a subsequent, direct approach is needed to release the neural elements. Thomas JA et al. studied the failure rate of indirect decompression in LSPS. They concluded that the low failure rate should be considered when deciding on direct decompression, the risks involved in laminectomy, and the increased surgical time.[27] In our team's experience, direct decompression is indicated in cases with facet cyst, extruded disc herniation, and Schizas grade D central canal stenosis.[28]

As an alternative to LSPS, in 2020, another SPS solution was described by Lamartina C et al, the LLIF in prone decubitus.[29] The procedure adopts the ventral positioning of the patient and allows the execution of LLIF and supplemental posterior fixation without decubitus change. In his favor, the author cites that most spine surgeons have in their arsenal of skills, the ability to perform posterior percutaneous fixation in ventral decubitus, as well as prone positioning would favor the gain of lumbar lordosis. However, the possible solutions for the L5-S1 level in prone decubitus are TLIF and PLIF, which limits the ability to gain disc and foraminal height, and segmental lordosis, as well as the size of the inter somatic spacer, to be implanted.

CONCLUSION

The LSPS concept is seen as the next stage in the evolution of spine surgery, allowing for greater efficiency associated with minimal invasion. To optimize the execution and the results of the procedures, the dissemination of knowledge on minimal invasion and single decubitus is necessary. This study demonstrated through clinical and functional data collected during a 1-year *follow-up* a significant improvement in parameters such as low back pain and sciatica, as well as a gain in perceived quality of life. This, together with the gain in time and safety provided by the technique, places LSPS as an option to be considered, studied, and practiced by spine surgeons.

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