

# LEFT OBLIQUE CORRIDOR FOR PRE-PSOAS APPROACH: IMAGE STUDY

*CORREDOR OBLIQUO ESQUERDO PARA A ABORDAGEM PRÉ-PSOAS: ESTUDO DE IMAGEM*

*CORREDOR OBLICUO IZQUIERDO PARA EL ABORDAJE PRE-PSOAS: ESTUDIO DE IMAGEN*

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## ABSTRACT

**Introduction:** This study describes the imaging characteristics and accessibility of the L4 / L5 left oblique corridor used in the OLIF spinal fusion approach and the dimensions of the left oblique corridor at L2/L3 and L3/L4. **Methods:** Observational, retrospective, and descriptive study, in which MRI is described for 330 patients. The length of the left OC L2/L3, L3/L4, and L4/L5 were measured and classified into four grades: 0 (not measurable), 1 ( $\leq 10$  mm), 2 (10–20 mm), and 3 ( $\geq 20$  mm). The psoas was measured at the level of the L4 / L5, and the modified Moro classification was used for the height of the psoas, considering high psoas from All to AIV. The data was processed in the SPSS 26.0 system. **Results:** The mean age was  $62.1 \pm 13.5$  years, the OC length in L2/L3, L3/L4 y L4/L5 were  $16.1 \pm 5.9$ ,  $16.2 \pm 6.7$  and  $14.7 \pm 8.8$  mm, respectively. 14.8% had high psoas. OC grade 0 (2.1%) was obtained in 7 patients, 87 with grade 1 (26.4%), 129 with grade 2 (39.1%), and 107 with grade 3 (32.4%). The length of the OC in males was 2.4 mm (MD, 95% CI: 0.4–4.5,  $p: 0.02$ ), more than in females. **Conclusion:** It was shown that 85.2% had an accessible psoas muscle for the left OLIF L4 / L5 approach, 71.5% had an accessible oblique corridor, and only 14.8% had high psoas. These parameters combined, 61.5% of MRI, were appropriate for this approach. **Level of evidence III; Retrospective study.**

**Keywords:** Spine; Spondylosis; Spinal Fusion; Magnetic Resonance Imaging; Psoas Muscles; Lumbar Vertebrae.

## RESUMO

**Introducción:** Este estudio describe las características imagenológicas y la accesibilidad del corredor oblicuo izquierdo L4/L5 utilizado para la fusión intersomática oblicua, así como las dimensiones del corredor oblicuo izquierdo en L2/L3 y L3/L4. **Métodos:** Estudio observacional, retrospectivo y descriptivo, que se describe la RM de 330 pacientes. Se midió la longitud del CO izquierdo L2/L3, L3/L4 y L4/L5 y se clasificó en cuatro grados: 0 (no medible), 1 ( $\leq 10$  mm), 2 (10–20 mm) y 3 ( $\geq 20$  mm). El psoas se midió a nivel de L4/L5, para la altura del psoas se utilizó la clasificación de Moro modificada; considerando psoas alto de All a AIV. Los datos fueron procesados en el sistema SPSS 26.0. **Resultados:** La edad media fue de  $62.1 \pm 13.5$  años, la longitud de CO en L2/L3, L3/L4 y L4/L5 fue de  $16.1 \pm 5.9$ ,  $16.2 \pm 6.7$  y  $14.7 \pm 8.8$  mm, respectivamente. El 14.8% tenía psoas alto. En 7 pacientes, se obtuvo CO grado 0 (2.1%), 87 con grado 1 (26.4%), 129 con grado 2 (39.1%) y 107 con grado 3 (32.4%). La longitud de la CO en hombres fue 2.4 mm (DM, IC 95%: 0.4-4.5,  $p: 0.02$ ) más que en las mujeres. **Conclusión:** Se demostró que el 85.2% tenía un psoas accesible para el abordaje OLIF L4/L5 izquierdo, el 71.5% tenía corredor oblicuo accesible y solo el 14.8% tenía psoas alto. Combinados estos parámetros, el 61.5% de las RM fueron apropiadas para este abordaje. **Nivel de evidencia III; estudio retrospectivo.**

**Descritores:** Columna vertebral; Espondilosis; Fusión Vertebral; Imagen por Resonancia Magnética; Músculos Psoas; Vértebras Lumbares.

## RESUMEN

**Introdução:** Este estudo descreve as características de imagem e acessibilidade do corredor oblíquo esquerdo L4/L5 usado para a fusão intersomática oblíqua, bem como as dimensões do corredor oblíquo esquerdo em L2/L3 e L3/L4. **Métodos:** Estudo observacional e descritivo, no qual é descrita a RM de 330 pacientes. O comprimento do OC esquerdo L2/L3, L3/L4 e L4/L5 foi medido e classificado em quatro graus: 0 (não mensurável), 1 ( $\leq 10$  mm), 2 (10–20 mm) e 3 ( $\geq 20$  mm). O psoas foi medido no nível de L4/L5 sendo utilizada a classificação de Moro modificada; considerando um psoas alto de All a AIV. Os dados foram processados no sistema SPSS 26.0. **Resultados:** A média de idade foi de  $62.1 \pm 13.5$  anos, o comprimento do CO em L2/L3, L3/L4 e L4/L5 foi de  $16.1 \pm 5.9$ ,  $16.2 \pm 6.7$  e  $14.7 \pm 8.8$  mm, respectivamente. 14.8% tinham psoas alto. Em 7 pacientes obteve-se CO grau 0 (2.1%), 87 com grau 1 (26.4%), 129 com grau 2 (39.1%) e 107 com grau 3 (32.4%). O comprimento do CO nos homens foi 2.4 mm (MD, IC 95%: 0.4-4.5,  $p: 0.02$ ) a mais do que nas mulheres. **Conclusão:** Evidenciou-se que 85.2% tinham psoas acessível para a abordagem OLIF L4/L5 esquerda, 71.5% tinham corredor oblíquo acessível e apenas 14.8% tinham psoas alto. Combinados esses parâmetros, 61.5% das RMs foram adequadas para essa abordagem. **Nível de evidência III; Estudo retrospectivo.**

**Descritores:** Coluna Vertebral; Espondilose; Fusão Vertebral; Imagem de Ressonância Magnética; Músculos Psoas; Vértebras Lombares.

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## INTRODUCTION

Lumbar interbody fusion has been performed as a surgical alternative for the treatment of degenerative disc disease and other related pathologies since 1932, with the objectives of stabilizing the painful segment to movement, providing direct/indirect decompression of the neural elements, restoring lordosis and correct the deformity.<sup>1-3</sup> Currently, there is a variety of minimally invasive approaches and technical variants to achieve it, each with its indications, contraindications, advantages, and limitations; the literature does not generally consider the superiority of one over the other, but there are differences depending on the objective to be achieved. We have the posterior approach techniques: PLIF (posterior lumbar interbody fusion), TLIF (transforaminal), and the anterior approach: ALIF (anterior), OLIF (Oblique), and LLIF or XLIF (Lateral) or Transpsoas. The spine surgeon must be familiar with all the techniques and use them individually according to the requirement of the treated disease.<sup>2,4-7</sup>

One of the limitations of the oblique approach for interbody fusion (OLIF) is the careful selection of the patient and the medium technical complexity due to the proximity of critical vascular structures such as the iliac vessels; these vessels, together with the morphology of the psoas muscle, are of particular interest in pre-surgical planning, especially in the L4/L5 intervertebral space, being less demanding in the upper lumbar levels,<sup>8-10</sup> the distance between these retroperitoneal structures (aortoiliac vessels and psoas muscle) is called the oblique corridor (OC).<sup>11</sup> Few studies evaluate these characteristics, most of them in Asian and European countries, none in our population, so it is necessary to know the oblique corridor's anatomical-imaging characteristics to consider the OLIF approach's choice.

## METHODS

### Study Type and Population

The study carried out was observational, retrospective, cross-sectional, and descriptive, having as the study population patients with lumbosacral magnetic resonance imaging (MRI) in our institution's PACS (Picture Archiving and Communication System) from January to June 2019. Patients older than 18 years were included without spinal surgery at the lumbosacral level.

### Variables

The left OC was defined as the shortest distance (in mm) between the psoas muscle and the left aortoiliac vessels at the axial midpoint of the L2/L3, L3/L4, and L4/L5 disc levels. The degree of the oblique corridor was categorized as 0 (not measurable), 1 ( $\leq 10$  mm), 2 (10–20 mm), and 3 ( $\geq 20$  mm),<sup>11</sup> considered as not accessible to grade 0, of difficult access to grade 1 and accessible to grades 2 and 3.

For psoas height at L4/L5 level, the modified Moro Classification was used, being considered high psoas and therefore not accessible to AII, AIII, and AIV, according to Ng.<sup>11-13</sup>

### Data collection and processing

The medical records were reviewed for epidemiological information to obtain data, and the PACS system records evaluated the lumbosacral spine's magnetic resonance imaging from January to June 2019. Then, both authors measured the axial slices potentiated in T2, and each author obtained a value for each quantitative variable; the average was the final value used. This study had institutional authorization through note No. 5090 - GRPA - ESSALUD - 2021.

The data processing of the variables was carried out in the SPSS edition 26.0 system, the categorical data are described in percentages, and the continuous data are expressed in percentiles and mean values with confidence intervals. An association was sought between sex and the other variables, as well as age with a cut-off point of 60 years, for which paired tables were used, and the p-value was calculated using Fisher's exact test. We also compared the means of the quantitative variables according to gender, using the student's t for statistical significance.

## RESULTS

Of the 330 MRIs analyzed, 171 (51.8%) belonged to women and 185 (56%) to those older than 60. The OC on the left side for the L2/L3, L3/L4, and L4/L5 levels were  $16.1 \pm 5.9$  mm,  $16.2 \pm 6.7$  mm, and  $14.7 \pm 8.8$  mm, respectively. The data of the continuous variables for the L4/L5 level are shown in Table 1, obtaining a psoas area at the level of the midpoint of the L4/L5 disc of 10 cm<sup>2</sup>. Moro's classification is shown in Table 2, 49 (14.8%) people had high psoas (grade AII, AIII, and AIV), which approaches described as difficult. Regarding the degree of OC of Ng at the L4/L5 level, 2.1% are inaccessible (grade 0), 26.4% accessible but with some technical difficulty (grade 1), and 71.5% are accessible (grades 2 and 3) (Figures 1 and 2). For the L2/L3 and L3/L4 levels, 14.2% and 14.5% had an OC grade of 0 or 1 ( $\leq 10$  mm).

No significant differences were found when analyzing age ( $\leq 60$  and  $> 60$  years) in cross tables with the other categorical variables. In the bivariate analysis between sex and accessibility according to the Moro classification, an OR of 1.2 (95% CI: 1.1 – 1.4  $p < 0.001$ ) was found in favor of the female sex. The differences in means according to sex are in Table 3.

## DISCUSSION

Michael Mayer first described the retroperitoneal oblique lumbar approach in 1977.<sup>2</sup> The term OLIF was used in 2012 by Silvestre et al.<sup>14</sup> The technique is described with the patient in lateral decubitus, accessing the spine between the vessel's iliac and the psoas muscle, first crossing the space between the external and internal oblique muscles, and the transverse to reaching the retroperitoneal space, without affecting the posterior articular, ligamentous or muscular components.<sup>3,4,15-17</sup> The OLIF technique is safe for the intervertebral spaces L2/L3, L3/L4, and L4/L5, being technically more laborious the levels L1/L2 and L5/S1 because we find the costal arch and the iliac crest respectively.<sup>5,18</sup> Like the other techniques, it has gained popularity due to the advantages of being a minimally invasive spinal approach, less surgical and muscular trauma, and better imaging results of spinal-pelvic parameters (correction of lumbar lordosis and deformity) compared to posterior approaches in addition to reducing the injury to the psoas muscle and the lumbar

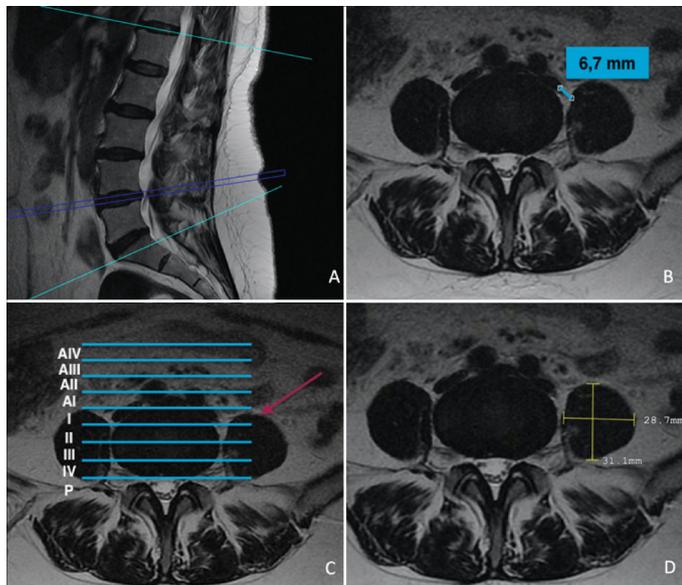
**Table 1.** Descriptive characteristics of the left oblique corridor in L4/L5 of 330 RM.

Characteristics at the L4/L5 level	Mean $\pm$ Dev.	(Min-Max)
Age	62.1 $\pm$ 13.5	(19 - 90)
Length of OC in mm	14.7 $\pm$ 8.8	(0 - 41.8)
Length AP of the psoas in mm	37.9 $\pm$ 6.9	(21.9 - 60)
Psoas length T in mm	33 $\pm$ 7.8	(15 - 50)
Psoas area at level L4/L5 in cm <sup>2</sup>	10 $\pm$ 3.6	(3.7 - 21.3)

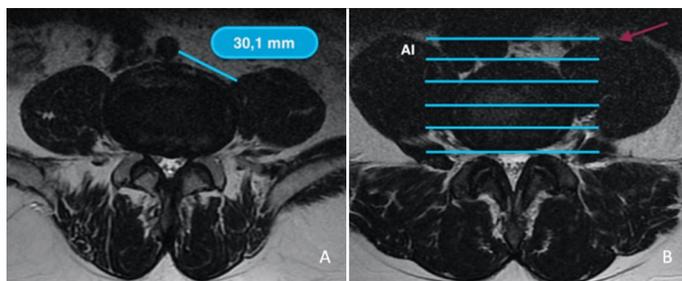
OC: oblique corridor, AP: anteroposterior, T: transverse.

**Table 2.** Absolute and relative frequency of the modified Moro classification and the Ng. Classification.

Modified Moro Classification			Ng classification of CO							
Left L4/L5 level					L2/L3	L3/L4		L4/L5		
P	0	0.0%	<b>G 0</b>	Not measurable	<b>0</b>	0%	<b>4</b>	1.2%	<b>7</b>	2.1%
IV	0	0.0%	<b>G 1</b>	$\leq 10$ mm	<b>47</b>	14.2%	<b>44</b>	13.3%	<b>87</b>	26.4%
III	2	0.6%	<b>G 2</b>	10 – 20 mm	<b>209</b>	63.3%	<b>204</b>	61.8%	<b>129</b>	39.1%
II	41	12.4%	<b>G 3</b>	$\geq 20$ mm	<b>74</b>	22.4%	<b>78</b>	23.6%	<b>107</b>	32.4%
I	147	44.5%								
AI	91	27.6%								
AII	37	11.2%								
AIII	10	3.0%								
AIV	2	0.6%								
	330	100%			330	100%	330	100%	330	100%



**Figure 1.** T2-weighted lumbar MRI of a 57-year-old woman. A. Sagittal showing the L4/L5 disc level where the measurements are made in the axial slices. B. Oblique corridor L4/L5 Grade 1. C. Left psoas height: I according to the modified Moro classification. D. Measurement of the psoas area at the L4/L5 level. Although this patient does not have “high psoas”, the oblique approach is technically difficult because she has <10 mm of the oblique corridor.



**Figure 2.** A, 47-year-old woman, T2 MRI at L4/L5 disc level, with grade 3 oblique corridor. B, 59-year-old man, T2 MRI at L4/L5 disc level, with modified Moro classification AI. Both patients have an oblique corridor accessible for the oblique lumbar approach.

**Table 3.** Quantitative variables according to sex at the L4/L5 level.

L4/L5 characteristic	Gender	Mean	MD	CI 95%	p-value
Left OC	M	15,7 mm	2,4 mm	0,4 – 4,5	0,02
	F	13,3 mm			
AP psoas	M	43,3 mm	10,3 mm	9,1 – 11,6	< 0,01
	F	33 mm			
T psoas	M	36,9 mm	7,4 mm	6,2 – 8,7	< 0,01
	F	29,4 mm			
Psoas area	M	12,6 cm <sup>2</sup>	5 cm <sup>2</sup>	4,4 – 5,6	< 0,01
	F	7,6 cm <sup>2</sup>			

nerve plexus when compared to the LLIF technique.<sup>8,11,16,19</sup> In addition to the advantages already mentioned, it has a lower risk of vascular injury than the ALIF technique.<sup>5</sup> Phan et al. in 2016, in a review of 16 articles, reported fusion rates between 84-100%,<sup>4</sup> most studies place it above 90%,<sup>17,19,20</sup> being on average higher than the other lumbar interbody fusion techniques.<sup>5,21</sup>

Complications of the OLIF technique occurs in two groups: intraoperative and postoperative. The first is vascular injury (0.3-2.4%), which represents the most severe complication, injury to the

vertebral end plate that can cause subsidence of the graft, vertebral fracture, and ureteral injuries, which are infrequent, although the risk increases when the L2/L3 intervertebral space is worked on. Among the postoperative, we have the displacement and sinking of the lumbar interbody cage, transient weakness of the psoas or quadriceps muscle (the most frequent 6-22%), root injury, sympathetic injury, and incomplete ileus.<sup>5,17,22,23</sup> Woods et al., in a sample of 137 patients undergoing the OLIF technique, the overall rate of complications was 11.7%, the most frequent being subsidence (4.4%), ileus (2.9%), and vascular injury (2.9%), considering these last two complications when performing the OLIF technique in the L5/S1 intervertebral space.<sup>21</sup>

**Oblique Corridor**

Boghani et al.,<sup>24</sup> in Texas, evaluated the left OC from L2 to S1 in 300 MRIs of patients; for the intervertebral spaces between L2 to L5, OC was defined as the distance between the medial aspect of the aorta and the most medial part of the psoas. The size of the retroperitoneal oblique corridor at L2/L3, L3/L4, and L4/L5 was, respectively, 17.3 ± 6.4 mm, 16.2 ± 6.3 mm, and 14.8 ± 7.8 mm, very similar to our results, it should be noted that for levels L2/L3 and L3/L4, we did not find differences in the mean lengths. Instead, the study of Julian Li et al.<sup>8</sup> in China, where they analyzed 200 MRIs of patients with degenerative spine disease, found that the mean length of the left OC in L2/L3 was 15.50 mm, at L3/L4 it was 12.75 mm and at L4/L5 it was 8.92 mm. In the publication by Boghani et al.,<sup>24</sup> the incidence of corridor size <10 mm at L2/3, L3/4, and L4/5 were 10.3%, 16.0%, 30.0%, respectively, in our study, the OC of the L4/L5 level ≤ 10 mm was 23.9%. We did not find a defined gradient from rostral to caudal as in the Boghani study. These differences in length and the percentage of OC ≤ 10 mm are probably due to the ethnographic variability of our population compared to North American and Asian countries.

**Oblique corridor L4/L5**

In our population, we obtained a mean of 14.7 mm in the length of the left OC L4/L5, a mean higher than that reported by Asian studies, for example, Julian Li et al.<sup>8</sup> in China in 2018 published an analysis of the morphology of the oblique corridor for all levels of lumbar intervertebral discs, using 200 MRIs of patients with degenerative disc disease. The average distances of the levels above the L4 vertebra were more than 12.7 mm (increasing according to the highest level) on the left side, 8.92 mm in the L4/L5 intervertebral space, being considerably less on the right side at all levels (right intervertebral space L4/L5 of 1.46mm), so the approach from the right side is not recommended. At the same time, Ng et al.<sup>11</sup> in Singapore, 2020, found a mean left L4/L5 OC measured in MRI of 12.1 mm, and Tao et al.<sup>25</sup> in China, 2019, conducted another study in MRI but with patients in lateral decubitus, found a mean OC of 10.36 mm for the L4/L5 level. Molinares et al.<sup>1</sup> in the USA also obtained a lower mean OC at L4/L5 (10.28 mm).

It is important to highlight two cadaveric studies; the study by Davis et al.,<sup>18</sup> in 20 specimens, described that the average left OC L4/L5 was 15 mm and that by slightly retracting the psoas muscle, the corridor increases by up to 58.97%, similar to the study by Wang et al.,<sup>26</sup> where at the same level he found a mean of 18.17 mm in 15 specimens and with slight retraction obtained a mean of 26.08 mm.

Regarding gender, we found a significant mean difference of 2.4 mm in favor of the male gender, unlike the study by Julián Li et al.,<sup>8</sup> where no significant differences were found, and Molinares et al.,<sup>1</sup> where they found the difference in favor of the female sex but without statistical significance.

Ng et al.<sup>11</sup> analyzed the MRIs of 449 patients for left L4/L5 OC, using a grading system of OC (0: not measurable, 1: <1 cm, 2: 1 to 2 cm, 3: > 2cm). 10.5% of their population had a non-measurable OC, 35% had a small OC (grade 1) while 54.5% had a grade 2 or 3 OC; taking its classification in our study, our population obtained a higher percentage (71.5%) of accessible OC (grade 2 and 3), with a lower frequency found of OC < 10 mm, (26.4%). In US studies,

there are two studies with very different values; Molinares et al.,<sup>1</sup> in California, in 133 MRIs, it was concluded that OC less than 10 mm is not suitable for this approach with a prevalence of 9% in its population, while Boghani et al.<sup>24</sup> in Texas, at 300 MRIs, 30% were less than 10 mm.

### Psoas Height and left muscle area at L4/L5 level

We consider “High Psoas” in the modified Moro classification to be All, AllI, AIV, that is, those that exceed anteriorly by more than ¼ the anteroposterior length of the L4/L5 disc in an axial section in the MRI.<sup>13</sup> Ng et al. found that 19.4% had high psoas considered unfeasible when combined with grade 0 OC.<sup>11</sup> In our study, 85.2% (281) were an accessible height for the oblique approach of the L4/L5 disc (Moro AI, I, II, III, and IV), and 14.8% high psoas, also considering that the seven patients with OC grade 0 had a Moro type AI or I classification, we find that 274 (83%) of the entire sample of images are potentially accessible for the OLIF approach.

Considering that the modified Moro classification combined with the OC classification can be used to predict the feasibility of oblique lumbar interbody fusion and help in patient selection,<sup>13</sup> in our

study of the 236 who had grade 2 or 3 of the OC according to Ng, 203 (61.5%) also had an accessible Moro staging, constituting the proportion of patients imaging ideal for this approach. Regarding sex, the muscle area at the CO L4/L5 level is smaller in women than in men.

### CONCLUSION

Of the sample of 330 MRIs in our population, 85.2% had accessible psoas for the left L4/L5 OLIF approach, and 71.5% had more than 10 mm of oblique corridor length at that level. Combining the two parameters, we conclude that 61.5% of patients are ideal in the resonance image for this approach. Age is not a determining factor for these characteristics, but the female sex has a significantly shorter OC length and smaller psoas area at this level compared to the male sex.

All authors declare no potential conflict of interest related to this article.

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