

THE LAMARTINA SQUARE AND SEVERITY INDEX IN SURGERY FOR HIGH-GRADE LUMBAR LISTHESIS

O QUADRADO DE LAMARTINA E ÍNDICE DE SEVERIDADE NA CIRURGIA PARA LISTESE LOMBAR DE ALTO GRAU

EL LAMARTINA SQUARE Y ÍNDICE DE SEVERIDAD EN LA CIRURGÍA DE LA LISTESIS LUMBAR DE ALTO GRADO

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ABSTRACT

Objective: evaluate the correlation between main sacropelvic alignment measurements and pelvic retroversion reduction and assessing Lamartina Square effectiveness in choosing the proximal instrumentation level. **Methods:** sample comprising 21 patients with high-grade L5-S1 spondylolisthesis subjected to arthrodesis with instrumentation from January 2004 to December 2016. Patients' demographic data, surgery type, complications, sagittal alignment parameters, Severity Index and Lamartina Square were recorded before surgery and in the last follow-up. Data processed in SPSS 22.0, with different means were calculated through Student's t test, for paired data. Linear correlation analysis was performed based on Spearman's coefficient. $P < 0.05$ was statically significant. **Results:** there was significant improvement in the slip and Dubousset's lumbosacral kyphosis angles ($> 100^\circ$ in the last postoperative follow-up). There was significant reduction of slip rate (and in the L4 and L5 Severity Index, which highlighted strong correlation to pelvic tilt, mismatch and slip angle. Severity index also showed strong inverse correlation between Dubousset's lumbosacral kyphosis angle and sacral slope. **Conclusion:** L5 Severity Index and Lamartina Square are important variables for preoperative planning of patients with high-grade lumbar spondylolisthesis. **Level of Evidence IV; Case Series.**

Keywords: Spondylolisthesis; Severity Index; Trauma; Follow-Up Studies; Surgery.

RESUMO

Objetivo: avaliar a correlação entre as principais medidas do alinhamento sacropélvico com a retroversão pélvica e avaliar a efetividade do Lamartina Square na escolha do nível proximal de instrumentação. **Métodos:** amostra com 21 pacientes com espondilolistese de alto grau L5-S1, submetidos à artrodese com instrumentação, de 01/2004 a 12/2016. Os dados demográficos dos pacientes, tipos de cirurgias, complicações, parâmetros do alinhamento sagital, Severity Index e Lamartina Square foram registrados antes da cirurgia e no último acompanhamento. Dados processados no SPSS 22.0 com as diferenças das médias calculadas utilizando-se o teste t de Student para dados emparelhados. A análise da correlação linear foi realizada pelo coeficiente de Spearman. Significantes as análises com $p < 0,05$. **Resultados:** melhora significativa do ângulo de deslizamento e de cifose lumbosacral de Dubousset's ($> 100^\circ$ no ultimo seguimento pós-operatório). Redução significativa da porcentagem de deslizamento (e do severity index em L4 e L5. Este teve uma forte correlação direta com: tilt pélvico, mismatch, ângulo de deslizamento, porcentagem de deslizamento e uma forte inversa com: ângulo de cifose lumbosacral de Dubousset's e o slope sacral. **Conclusão:** O Severity Index de L5 e o Lamartina Square devem ser consideradas variáveis importantes no planejamento pré-operatório de pacientes com espondilolistese lombar de alto grau. **Nível de Evidência IV; Serie de Casos.**

Descritores: Espondilolistese; Índices de Gravidade do Trauma; Seguimentos; Cirurgia.

RESUMEN

Objetivo: evaluar la correlación entre las principales medidas de alineación sacropélvica y la reducción de la retroversión pélvica y evaluar la eficacia de Lamartina Square en la elección del nivel de instrumentación proximal. **Métodos:** muestra compuesta por 21 pacientes con espondilolistesis L5-S1 de alto grado sometidos a artrodese con instrumentación desde enero de 2004 hasta diciembre de 2016. Se registraron datos demográficos de los pacientes, tipo de cirugía, complicaciones, parámetros de alineación sagital, Índice de Severidad y Cuadrado de Lamartina antes de la cirugía y en el último seguimiento. Los datos procesados en SPSS 22.0, con diferentes medias, se calcularon mediante la prueba t de Student, para datos pareados. Se realizó un análisis de correlación lineal basado en el coeficiente de Spearman. $P < 0,05$ fue estadísticamente significativo. **Resultados:** hubo mejoría significativa en los ángulos de deslizamiento y cifosis lumbosacra de Dubousset ($> 100^\circ$ en el último control postoperatorio). Hubo una reducción significativa en la tasa de deslizamiento ($< 50\%$) y en el índice de gravedad L4 y L5, que destacó una fuerte correlación con la inclinación pélvica, la falta de coincidencia y el ángulo de

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deslizamiento. El índice de gravedad también mostró una fuerte correlación inversa entre el ángulo de cifosis lumbosacra de Dubousset y la pendiente sacra. Conclusión: L5 Severity Index y Lamartina Square son variables importantes para la planificación preoperatoria de pacientes con espondilolistesis lumbar de alto grado. **Nivel de Evidencia IV; Serie de Casos.**

Descriptor: Espondilolistesis; Índices de Gravedad del Trauma; Estudios de Seguimiento; Cirugía.

INTRODUCTION

High-grade local deformity in the lumbar spondylolisthesis can induce global spinal deformity. L5 anterior and posterior slip, in relation to the sacrum, push the center of gravity line forward (it brings along the trunk and head) and force the patient to have a positive sagittal imbalance.¹

Patients with high-grade spondylolisthesis (HGS) always lose alignment and force torque gets much higher in the lumbosacral unit. Gravitational force passing through L5-S1, counterbalances the ground reaction force passing through the center of femoral heads. The longer distance between these two forces results in a force torque. The Severity Index (SI) is applied to calculate the torque and, consequently, the pelvic retroversion.²

Surgery is the treatment of choice for high-grade spondylolisthesis; however, there is no consensus about the proximal level to the instrumentation must be extended to. Therefore, there is the description of an instability zone (Lamartina Square), according to which the vertebrae within it must be fused when the L5 reduction is performed.³

The current study aimed to evaluate the correlation between the main sacropelvic alignment measurements and pelvic retroversion reduction, and Lamartina Square's effectiveness in choosing the proximal instrumentation level.

METHOD

Case-series study with 22 patients who underwent surgery for high-grade lumbar spondylolisthesis was performed in a national reference center for spinal deformities from January 2004 to December 2016.

Inclusion criteria comprised patients from both sexes, who underwent high-grade lumbar spondylolisthesis (Meyerding grade >3) surgery between L5 and S1 in a single service; availability of only one standing lateral radiograph showing the spine, pelvis and proximal femurs before surgery and at the last follow-up. Exclusion criteria comprised previous spine, pelvic, or lower extremity surgery; absence of inferior extremity pathology, such as developmental dysplasia of the hip; ankylosing disease, such as ankylosing spondylitis and diffuse idiopathic skeletal hyperostosis or Forestier's disease and less than 2-years follow-up.

Eligible patients had their demographic data, surgical indications, operative details and complications registered based on medical records. Retrospective measurements of radiological parameters were performed in all patients and reviewed, in separate.

Spondylolisthesis was measured through radiographs, according to the technique recommended by Bourassa-Moreau⁴ and the Meyerding grade.⁵ In addition, the following parameters were assessed in the preoperative period and the last follow-up: lumbar lordosis from L1 to L5 and from L1 to S1; slip angle; Dubousset's lumbosacral kyphosis angle; slip percentage.

The sacropelvic sagittal alignment was characterized by the PI, SS, and PT values. The spondylolisthesis type was defined based on SDCG classification. Severity Index (SI) and instability zone were described through Lamartina. The British Medical Council scale (MOM5) was also used to grade strength in the pre and postoperative period of these patients. Software Surgimap (version 2.2.15.5 CE 0129) calculated all variables.

Software SPSS 22.0 for Windows, Inc., Chicago, IL, USA, license number 10101131007, was used to process data. Student t-test was used to compare differences of the means recorded for the variables in paired data. Linear correlation analysis between differences in the

variables was performed through Spearman coefficient. $P < 0.05$ was considered statically significant.

The Research Ethics Committee approved the current study under protocol 3.241.077. The use of a free consent form was not necessary since this is a retrospective study.

RESULTS

Based on the inclusion and exclusion criteria from a sample of 22 patients, there were 21 patients eligible for the study. Table 1 summarizes patients' and surgical procedure's features.

The assessment of preoperative and postoperative values recorded for sacropelvic alignment parameters showed improvement in both the slip angle and the Dubousset's lumbosacral kyphosis angle (above 1000 in the last follow-up). In addition, there was significant reduction in slip rate (and in Severity Index in L4 and L5. (Table 2)

The assessment of preoperative correlation between sacropelvic alignment variables showed that L5 Severity Index had a strong correlation to pelvic tilt, mismatch, slide angle, and slide rate, as well as a strong inverse correlation to Dubousset's lumbosacral kyphosis angle and sacral slope. (Table 3)

Patients reported the following postoperative complications: subfascial wound infection (3 patients, 35.5%); screw loosening (1 patient, 12.5%); pseudoarthrosis (1 patient, 12.5%); dural injury (1 patient, 12.5%); pain caused by iliac screw (1 patient, 12.5%) and grade M3 bilateral paresis in L5 myotome (1 patient, 12.5%).

Table 1. Clinical and radiological preoperative findings in patients with high-grade lumbar spondylolisthesis.

Parameter	
Gender	
Female	18 (85.7%)
Age at surgery (years)	45.11 ± 19.86
BMI (Kg/m ²)	26.20 ± 4.38
Etiology	
isthmic	16 (76.2%)
dysplastic	5 (23.8%)
Meyerding	
3	12 (57.1%)
4	3 (14.3%)
5	6 (28.6%)
SDCG	
4	6 (28.5%)
5a	4 (19%)
5b	3 (14.3%)
6	7 (33.3%)
Not classified	1 (4.9%)
Surgery	
PLIF	9 (42.85%)
Sacral Osteotomy + PLIF	9 (42.85%)
Gaines	2 (9.52%)
Bohlman	1 (4.78%)
Instrumented Level	
L3-S1	1 (4.8%)
L3-iliac	1 (4.8%)
L4-S1	1 (4.8%)
L4-iliac	7 (33.3%)
L5-S1	11 (52.4%)
follow-up (years)	3.97 ± 2.54

Table 2. Comparison between preoperative and last follow up sagittal parameters values.

	Preoperative	Last Follow up	p
LORDOSIS LUMBAR (L1-S1) (°)	-55.55 ± 16.51	-50.35 ± 20.76	0.384
LORDOSIS LUMBAR (L1-L5) (°)	-52.57 ± 10.87	-54.85 ± 11.40	0.434
SLIP ANGLE (°)	15.11 ± 23.78	1.53 ± 16.03	0.007*
DUBOUSSET'S LSA (°)	83.23 ± 29.37	102.04 ± 24.63	< 0.001*
% SLIP	72.57 ± 20.43	43.71 ± 18.47	< 0.001*
PI (°)	66.23 ± 11.03	-	
PT (°)	24.47 ± 11.17	22.42 ± 11.61	0.290
SS (°)	41.85 ± 11.33	44.00 ± 8.91	0.282
SVA (mm)	4.58 ± 4.95	5.49 ± 3.49	0.552
MM (°)	9.09 ± 16.44	11.19 ± 14.06	0.506
SI L4	32.03 ± 9.77	23.35 ± 7.89	0.013*
SI L5	42.99 ± 23.59	30.24 ± 18.45	< 0.001*

*P < 0.05. Dubouset's LSA (Dubouset's Lumbosacral kyphosis Angle); PI (Pelvic Incidence); PT (Pelvic Tilt); SS (Sacral Slope); SVA (Sagittal Vertical Axis); MM (Mismatch); SI (Severity Index).

Table 3. Correlation between sacropelvic alignment parameters.

		SS°	MM°	DUB°	SLIP°	% SLIP	SI L4	SI L5
PT°	r	-0.519*	0.799*	-0.564*	0.531*	0.452*	0.635	0.861*
	p	0.016	< 0.001	0.008	0.013	0.039	0.066	< 0.001
SS°	r		-0.356	0.459*	-0.421	-0.426	-0.700*	-0.570*
	p		0.113	0.036	0.058	0.054	0.036	0.021
MM	r			-0.386	0.326	0.346	0.559	0.630*
	p			0.84	0.149	0.125	0.118	0.009
DUB°	r				-0.584*	-0.719*	-0.589	-0.778*
	p				0.005	< 0.001	0.095	< 0.001
SLIP°	r					0.504*	0.492	0.551*
	p					0.020	0.179	0.027
% SLIP	r						0.013	0.656*
	p						0.974	0.006
SI L4	r							0.728*
	p							0.041

DISCUSSION

The Severity Index is a simple criterion to feature and assess the slip progression in spondylolisthesis because it is a direct measurement of pelvic retroversion. An increase in pelvic retroversion leads to anterior displacement of the femoral heads, which results in an increased Severity Index – it presents a value < 20% in regular individuals or the ones with spondylolisthesis, without increased pelvic retroversion.²

Patients in the current study reported Severity Index value > 20% in the postoperative period, regarding L5 and/or L4 vertebrae; they showed spondylolisthesis and increased pelvic retroversion. The assessment of the correlation between variables showed that L5 Severity Index was the variable most strongly correlated to pelvic tilt within the sacropelvic alignment.

L5 Severity Index reported a strong correlation to pelvic tilt and all other assessed variables within the sacropelvic alignment. It is important to highlight the strongly inverse correlation between L5 Severity Index and lumbosacral kyphosis, measured through Dubouset's angle. In the postoperative period, the increase in this angle showed significant reduction in the observed correlation.

Several authors have shown the lumbosacral deformity correction's importance in restoring the sagittal balance. Long-term outcomes appear to be better after a reduction event. Therefore, reducing lumbosacral kyphosis and restoring sagittal alignment are major concerns during surgery for high-grade spondylolisthesis.⁶

There was a significant reduction in L4 and L5 Severity Index values compared to the preoperative period. However, values remained > 20%, which shows the presence of pelvic retroversion. Improvement in other assessed variables confirm improvements in the sacropelvic alignment.

Achieving a solid fusion in high-grade spondylolisthesis is

difficult despite the strong vertebral fixations currently achieved with pedicle screws. In such a situation, the unstable spondylolisthesis zone must be identified and stabilized.⁴

Regarding the two patients in the current study who had the proximal level of the instrumentation determined by the Lamartina instability zone in L3, in the preoperative period, one had the proximal level of instrumentation in L3 and the other in L4, and both did not have any mechanical complications in the postoperative period. Five patients had a proximal level of instrumentation in L4: one of them had the level extended to L3, due to intraoperative loosening of the L4 screws; in another patient, the proximal level chosen was L5, the patient did not present mechanical complications. Remainder patients had a proximal level of instrumentation in L4, without mechanical problems in the postoperative period.

Several authors have used monosegmental fusion to treat high-grade spondylolisthesis. However, posterior fusion of L5/S1 has 17% non-union rate and 11% chances of presenting structural complications, even when combined with anterior column support. The recommendation, in such a situation, is to perform the fusion from L4 to S1, although the proximal fixation can be extended to L3.⁷

Extending the proximal fusion to L4 should be considered in HGS, mainly if the unstable zone includes segment L4-L5. The transverse processes of L5 are very small and have minimal area for the fusion mass; yet, in the presence of degenerative changes/stenosis in the L4-L5 level, they may contribute to patient's symptoms.⁸

L5 fusion to the sacrum in high-grade slip creates horizontally oriented fusion, under high shear stress and prone to failure. L4 inclusion improves the mechanical advantage by creating a vertical fusion. The anterior position of transverse L5 processes, concerning the sacral wing, which makes fusion technically challenging, is another difficulty in L5 fusion to the sacrum in a high-grade slip.⁸

Complications were managed as follows: three patients had postoperative subfascial infection, with surgical debridement, which was treated with intravenous and local antibiotic therapy. There was no need to remove the implants; one patient had dural injury, which was solved with patient restriction to bed, and headboard use at zero degrees (for 3-5 days); one patient had cut-out of L4 screw on the left and L5 screw pull-out on the left, during the intraoperative distraction maneuver, which required extending the proximal instrumentation to L3; one patient, had pseudarthrosis in L5-S1, and was subjected revision surgery to remove L5 screws and to extend the fusion with the L4 instrumentation. In addition, one patient with paresis (grade M3) in the bilateral L5 myotome, in the immediate postoperative period, was followed without revision surgery, and the patient presented full-strength recovery three months after surgery.

CONCLUSION

The current study presents the importance of the L5 Severity Index as variable to be taken into account for the preoperative planning of patients with high-grade lumbar spondylolisthesis. L5 Severity Index showed strong correlation to variables of sacropelvic alignment, namely: pelvic tilt and Dubouset's lumbosacral kyphosis angle.

The authors of the current study regarded Lamartina square as an important tool. However, it was not possible to establish the association between mechanical complications in patients who did not have the proximal level of fusion encompassed by Lamartina in preoperative planning. However, Lamartina square should not be the only tool used to determine the choice for the proximal fusion level.

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