NATURAL HISTORY OF LUMBAR CANAL STENOSIS: CLINICAL ASPECTS AND SAGITTAL BALANCE

HISTÓRIA NATURAL DA ESTENOSE DO CANAL LOMBAR: ASPECTOS CLÍNICOS E DO EQUILÍBRIO SAGITAL

HISTORIA NATURAL DE LA ESTENOSIS DEL CANAL LUMBAR: ASPECTOS CLÍNICOS Y DEL EQUILIBRIO SAGITAL

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ABSTRACT

Objective: To compare the sagittal alignment (SA) parameters in individuals with LCS and surgical indication with a control group and to study the correlations between SA parameters and ODI, VAS and EQ-5D in individuals with LCS and surgical indication. Methods: In this multicenter cross-sectional case-control study, the individuals were allocated as follows. A stenosis group (SG) composed by patients with LCS confirmed by magnetic resonance imaging with surgical indication, treated between July 2010 and August 2016 and a control group (CG), without LCS. All subjects underwent anamnesis, completed the Health-related Quality of Life (HRQoL) and total spine radiographs were taken. Clinical data, HRQoL and radiographic parameters were correlated. Results: Sixty-four individuals formed the SG and 14 the CG. The SG had higher values of mean age, coronal imbalance, sagittal vertical axis (SVA), pelvic tilt (PT), sacrofemoral distance (SFD), overhang (OH), PI-LL mismatch, Oswestry Disability Index (ODI) and Visual Analog Scale (VAS) for pain and smaller thoracic kyphosis (TK), total (TLPL) and regional lumbopelvic lordosis (RLPL) in all vertebrae, sagittal offset (SO) in all evaluated vertebrae and EuroQol-5D (EQ-5D) with $p < 0.05$. In the SG, the only significant correlations ($p < 0.05$) were between TK and ODI and EQ-5D; all the other sagittal parameters did not correlated with VAS, ODI or EQ-5D. Conclusion: SG had SA parameters altered in relation to CG. There was a direct correlation between decrease in TK and worsening of ODI and EQ-5D in SG. ***Level of evidence: III; Case Control Study.***

Keywords: Spine; Quality of Life; Radiography; Spinal Stenosis; Natural History.

RESUMO

Objetivo: Comparar parâmetros do AS em indivíduos portadores de EDL com indicação cirúrgica aos de uma população controle; estudar a correlação entre os questionários ODI, VAS e EQ-5D a parâmetros do AS nos portadores de EDL com indicação cirúrgica. Métodos: Estudo transversal multicêntrico tipo caso-controle. Grupo estenose (GE) composto por portadores de EDL, confirmada por Ressonância Nuclear Magnética, com indicação cirúrgica, atendidos entre Julho de 2010 a agosto de 2016. Grupo controle (GC) sem EDL. Todos os indivíduos realizaram anamnese, responderam questionários de qualidade de vida e realizaram radiografias de coluna total. Dados clínicos, questionários e parâmetros radiográficos foram correlacionados. Resultados: 64 indivíduos formaram o GE e 14 o GC. GE apresentou valores maiores de idade média, desequilíbrio coronal, sagital vertical index (SVA), pelvic tilt (PT), sacrofemoral distance (SFD), overhang (OH), missmatch PI - LL, Owestry Disability Index (ODI), Visual Analogic Scale (VAS) e valores menores de cifose torácica, lordose lombopélvica total e regional em todas as vértebras, offset sagital em todas as vértebras avaliadas e EuroQol-5D (EQ-5D), com $p < 0,05$. No GE, houve correlações significativas ($p < 0,05$) apenas entre TK e ODI e EQ-5D, sendo que todos os outros parâmetros sagitais não apresentaram correlação significativa com os questionários de qualidade de vida. Conclusão: GE apresentou perda dos parâmetros de AS em relação ao GC. Houve correlação direta entre diminuição da TK e piora do ODI e EQ-5D no GE. ***Nível de Evidência III; Estudo de Caso Controle.***

Descritores: *Coluna Vertebral; Qualidade de Vida; Radiografia; Estenose Espinal; História Natural.*

RESUMEN

Objetivo: Comparar los parámetros del alineamiento sagital (AS) en individuos con ECL e indicación quirúrgica con un grupo control y estudiar las correlaciones entre los parámetros de SA y ODI, EVA y EQ-5D en pacientes con ECL e indicación quirúrgica. Métodos: En este estudio multicéntrico de casos y controles, los individuos fueron asignados como sigue. Un grupo estenosis (GE) compuesto por pacientes con ECL confirmada por imágenes de resonancia magnética con indicación quirúrgica, tratados entre julio de 2010 y agosto de 2016 y un grupo control (GC) sin ECL. Todos los individuos se sometieron a una anamnesis, respondieron el cuestionario de Calidad de Vida Relacionada con la Salud (HRQoL) y se tomaran radiografías totales de la columna. Se relacionaron datos clínicos, HRQoL y parámetros radiográficos. Resultados: Sesenta y cuatro individuos formaron el GE y 14 el GC. El GE tenía valores más altos de edad promedio, desequilibrio coronal, eje sagital vertical (ESV), inclinación pélvica (IP), distancia sacrofemoral (DSF), protuberancia (P), falta de emparejamiento IP –LL, Índice

Study conducted at the Hospital das Clínicas da Universidade Estadual de Campinas – UNICAMP, Campinas, SP, Brasil, and the Instituto de Patologia da Coluna, São Paulo, SP, Brazil.
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de Discapacidad de Oswestry (ODI), Escala Visual Analógica (VAS) para el dolor y menos cifosis torácica (CT), lordosis lumbopélvica total (LLPT) y regional (LLPR) en todas las vértebras, offset sagital (OS) en todas las vértebras evaluadas y EuroQol-5D (EQ-5D), con p < 0,05. En el GE, las únicas correlaciones significativas (p < 0,05) fueron entre TC y ODI y EQ-5D; todos los demás parámetros sagitales no se correlacionaron con EVA, ODI o EQ-5D. Conclusión: El GE tuvo parámetros de AS alterados en relación con el GC. Hubo correlación directa entre la disminución de TC y el agravamiento del ODI y EQ-5D en el GE. **Nivel de evidencia III; Estudio de Caso Controle.**

Descriptores: *Columna Vertebral; Calidad de Vida; Radiografía; Estenosis Espinal; Historia Natural.*

INTRODUCTION

Degenerative lumbar stenosis (DLS) is a narrowing of the lumbar spinal canal and/or the vertebral foramens, characterized by low back pain, radicular pain, and/or claudication. It is a common clinical condition, affecting more than 200,000 people in the USA,[1] being the main reason for indications of spinal surgery in patients above 65 years of age and affecting 1 in every 1000 people per year in this age group.[2] The increasing prevalence of disease, considered an exacerbation of the degenerative physiological process of aging, is expected as the life expectancy of the population continues to rise.[3,4]

Disc degeneration is often associated with DLS,[3] usually occurring at the lowest lumbar levels[5] and causing loss of disc height from dehydration. Consequently, there is an overload on the facet joints, with arthritis and facet joint hypertrophy, thus causing a loss of lumbar lordosis (LL).[6] There is also a dynamic component, since the canal space decreases with extension and increase with the flexion-distraction of the trunk.[7] Flexion of the trunk increases the area of the lumbar foramens by 12% and in extension there is a reduction of 15% of their sectional area.[8]

There is an association between structural changes of the spine and antalgic position,[9] which culminates in a posture of anteriorization of the trunk. Compensatory mechanisms, such as an increase in pelvic tilt (PT), are activated in an attempt to reduce the loss of sagittal alignment (SA).[10]

Extensive literature supports the importance of SA and the recognition of its compensatory mechanisms in the treatment of degenerative lumbar spine diseases in cases where surgery is indicated. This becomes even more important when intraoperative sagittal correction with instrumentation and vertebral fusion is necessary.[11-14]

The objectives of this study were to evaluate whether there were any changes in the SA parameters in DLS patients indicated for surgical treatment as compared to a control population and to study the correlation of the SA parameters with the Visual Analog Scale (VAS),[15] Oswestry Disability Index (ODI),[16] and EuroQol - 5 Dimensions (EQ-5D)[17] in DLS patients with an indication of surgical treatment.

METHODS

Study and sample design: This was an original cross-sectional multicentric case-control study.

The Stenosis Group (SG) was comprised of patients with DLS confirmed by Magnetic Resonance Imaging with indication of surgical treatment (refractory symptoms after at least 4 months of the best conservative treatment). The Control Group (CG) included healthy individuals without any diagnosed spinal diseases. Data collection took place during the period from 07/03/2010 to 08/12/2016.

Individuals who refused to participate in the study, those with a history of spinal surgery, previously known disease of the hips and/or pelvis, and individuals with a prior diagnosis of neuropathy were excluded from the study.

Clinical data such as data of evaluation, age, weight, height, tobacco use, and comorbidities were collected, in addition to VAS, ODI, and EQ-5D scores.

This study was approved by the Institutional Review Board (protocol number 50833515.3.0000.5404) and the data were collected after the study participants had signed the Informed Consent Form.

Digitalized frontal and lateral full spinal radiographs were taken of the study subjects in a standing position with hips and knees in extension. In the frontal radiographs, the subjects let their arms hang down close to the body and in the lateral radiographs the arms were flexed at 45 degrees in relation to the plane of the body. We used 30 x 90 cm film and the radiographs were centered on T12 during inhalation, with a distance between the film and the focus of 230 cm. The images were digitalized and the parameters were measured and reviewed by an orthopedist familiar with the indices described, using the *Arya PACS Aurora* v.1.9.19 program (São Bernardo do Campo, Brazil).

Vertebral and spinopelvic parameters measured are shown in Figure 1 and described in Chart 1.

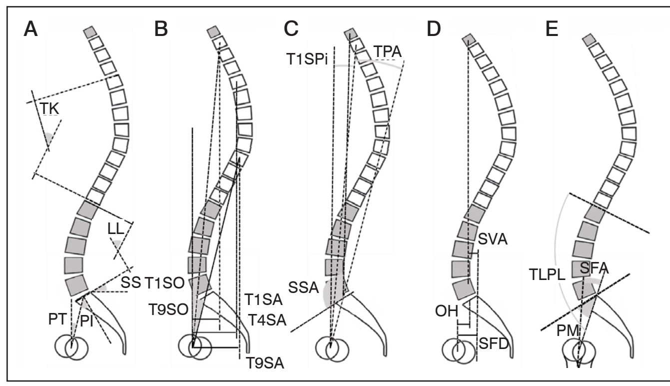

Figure 1. Radiological parameters used in this study.

Chart 1. Radiological parameters used in this study.

A	TK (thoracic kyphosis): angle between T4 ptp and T12 dtp
	LL (lumbar lordosis): angle between L1 and ptp S1
	SS (sacral slope): angle between S1 ptp and hl
	PT (pelvic tilt): angle between line that joins chr to the midpoint of the S1 ptp and vl
	PI (pelvic incidence): angle between line that touches the chr and midpoint of the S1 ptp and the line orthogonal to the S1 ptp
B	T1SO and T9SO (sagittal offset in T1 and T9): angle between vl and the line that connects chr to the respective vc
	T1SA, T4SA, and T9SA (sagittal axis): horizontal distance between chr and the respective vc
C	SSA (spinal-sacral angle): angle between line that touches C7 vc and midpoint of S1 ptp and line tangent to S1 ptp
	T1SPi (T1 spinopelvic inclination): angle between vl and line that touches chr and T1 vc
	TPA (T1 Pelvic Angle): sum of T1SPi and PT
D	SVA (sagittal vertical axis: dh between C7 vc and psIS1
	OH (overhang): dh between chr and midpoint of S1 ptp
	SFD (sacrofemoral distance): dh between chr and splS1
	C7PL/SFD (Barrey Ratio): SVA over SFD
E	TLPL (total lumbopelvic lordosis): angle between T12 dtp and the pelvic radius
	RLPL (regional lumbopelvic lordosis): angle between the ptp of each lumbar vertebra and the pelvic radius
	PM (pelvic morphology): angle between the pelvic radius (line between chr and splS1) and S1 ptp
	SFA (sacrofemoral angle): between the axis of the femoral diaphysis and S1 ptp

Key: ptp – proximal terminal plate, dtp – distal terminal plate, chr – center of hip rotation, vl – vertical line, hl – horizontal line, vc vertebral centroid, splS1 – superior posterior limit of S1.

Statistical analysis

The radiographic measurements and personal characteristics of the CG and SG were described as mean and standard deviation (SD) or median, minimum, and maximum and compared using the Student's T-test or Mann-Whitney test. For the comparison of qualitative measurements, the Fisher's exact test was used. To check the correlation between the radiographic measurements and the questionnaires evaluated for each group, the Spearman correlation was calculated.[18] The analyses were conducted with the use of IBM-SPSS v. 20.0 software (Chicago, USA) and tabulated using Microsoft-Excel 2003 v. 11.0 software (Redmond, USA). All tests were performed with a level of significance of 5% ($p < 0.05$).

RESULTS

During the study period, 64 individuals were included in the SG and 14 in the CG. In the SG there were 33 men and 31 women, ranging in age from 34 to 82 years (mean of 60 years). In the CG there were 4 men and 10 women, ranging in age from 25 to 62 years (mean of 49.1 years). Table 1 summarizes the differences in personal characteristics between the two groups and we observed that the only statistically relevant variable was age, lower in the CG.

Table 2 shows that patients in the SG had statistically higher values for coronal imbalance, SVA, PT, SFD, OH, PI-LL mismatch, ODI, and VAS and lower values for TK, TLPL, RLPL in all vertebrae, T1SO, T9SO, and EQ-5D ($p < 0.05$).

Table 3 correlates the clinical and SA parameters with the quality of life questionnaires in the CG. The ODI had no correlation with any of the radiographic parameters evaluated. The VAS presented a correlation with the LLR of L4 ($r = -0.662$ and $p = 0.014$), L5 ($r = -0.624$ and $p = 0.023$), T1 SA ($r = -0.6$ and $p = 0.039$), T9 SA ($r = -0.607$ and $p = 0.036$), and PI-LL mismatch ($r = -0.599$ and $p = 0.024$). EQ-5D had a positive correlation with the PI-LL mismatch ($r = 0.608$ and $p = 0.021$).

Table 4 correlates the radiographic parameters measured to the VAS, ODI, and EQ-5D questionnaires in the SG. It shows that TK presented an inverse correlation with the ODI ($r = -0.273$, $p=0.038$) and a direct correlation with the EQ-5D ($r = 0.428$, $p=0.001$), while there was no relationship observed between parameters such as SVA, SSA, TPA, and PI-LL and the questionnaires in the SG.

It was not possible to visualize the proximal terminal plate of T4, and therefore not possible to measure TK, in 6 out of the 64 individuals participating in the study. Of the 58 individuals had TK T4-T12 measured, 4 were hypokyphotic, 47 had normal kyphosis, and 7 were hyperkyphotic, considering normal to be between 20 and 40.[19] Table 5 shows the mean TK, ODI, VAS, and EQ-5D by TK classification group.

DISCUSSION

Today there is extensive discussion about the real importance of the SA parameters and whether they are able to predict quality of life in the patient with DLS.[20-22]

The data found in our study are in agreement with those reported by Cavali et al. in terms of the loss of SA in the SG as compared to the CG. The same authors also found that the population of DLS patients was older than the randomly selected control group.[19]

Several studies argue that an increase in SVA is associated with a poorer quality of life and an increase in axial pain.[23-25] In 2013, Schwab concluded that serious clinical disability (ODI > 40) is associated with an increase in SVA, PI-LL mismatch, and PT.[26] Lafage also concluded that an increase in PT is correlated to a poorer quality of life and that T1SPi is more highly correlated to the quality of life questionnaires than the SVA.[27]

In the literature it is also noted that abnormal TPA values are associated with a worse quality of life in adults with degenerative scoliosis[28,29] and that an increase in C7PL/SFD is related to a worse quality of life in degenerative lumbar disease.[30]

Nevertheless, most studies that report a correlation between the SA parameters and preoperative quality of life use univariate analysis or multivariate analysis adjusted only for age,[23-25,31] which creates a strong confusion bias.

Takemoto compared SA parameters with the ODI in 204 cases of adult spinal deformity pre- and postoperatively to deformity correction surgery. In the multivariate analysis, the SA parameters were not significantly correlated with the preoperative ODI. However, he observed that the postoperative improvement in SA resulted in a better ODI. He concluded, therefore, that in surgical cases, reestablishing the SA should be sought with the goal of achieving an improved postoperative ODI, although changes in the SA should not be decisive in a surgical indication.[32]

The lack of a correlation observed between the SA parameters and quality of life in the above-mentioned study is compatible with the data obtained in our study. This raises questions about the reproducibility of the results reported in studies that claim that the SA parameters are predictors of quality of life in individuals with DSL.

Besides the debatable value of using SA parameters to predict quality of life in DSL patients, said parameters are not correlated to non-specific[33]

Table 1. Study demographic data.

	Control		Stenosis		P
	mean ± SD	N	mean ± SD	N	
Age (years)	49.1 ± 11.1	14	60 ± 10.7	64	0.001
Weight (Kg)	75 ± 16.1	14	78.1 ± 13.5	58	0.456
Height (m)	1.7 ± 0.1	14	1.7 ± 0.1	58	0.282
BMI (Kg/m^2)	25.6 ± 3.9	14	27.5 ± 3.4	58	0.066
Sex (male)	4	14	33	64	0.119*

Student's T-test; *Chi Square

Table 2. Study radiographic parameters.

	Control		Stenosis		p
	median (min; max)	N	median (min; max)	n	
Coronal imbalance	0 (0; 15)	14	12 (0; 89)	60	0.001
TK	40.5 (25; 59)	14	39.5 (7; 67)	62	0.629
LL	59 (48; 81)	14	49 (20; 82)	62	0.016
SVA	-10 (-35; 50)	14	28.5 (-100; 134)	58	0.001
PT	13.5 (5; 22)	14	20 (3; 42)	62	0.006
SS	41 (26; 60)	14	35.5 (13; 60)	62	0.102
PI	52.5 (34; 82)	14	57 (29; 89)	62	0.477
Cobb coronal angle	0 (0; 10)	14	1 (0; 54)	61	0.069
TLPL	92 (76; 102)	13	81 (40; 104)	61	0.001
RLPL L1	93 (88; 103)	13	80 (50; 103)	61	<0.001
RLPL L2	92 (85; 98)	13	77 (23; 108)	61	<0.001
RLPL L3	88 (74; 111)	13	71 (25; 110)	60	<0.001
RLPL L4	75 (65; 118)	13	62 (28; 126)	59	0.001
RLPL L5	60 (50; 132)	13	51 (27; 140)	59	0.002
PM	42 (14; 150)	13	31 (6; 175)	61	0.017
T1 SA	-41 (-86; 70)	12	-21 (-91; 105)	51	0.294
T4 SA	-58.5 (-115; 80)	12	-56 (-112; 75)	56	0.748
T9 SA	-63.5 (-117; 79)	12	-66 (-130; 54)	58	0.726
T1 SO	7.5 (0; 10)	12	0.5 (-16; 87)	52	0.001
T9 SO	13 (9; 21)	12	-8 (-50; 18)	61	<0.001
SFA	42 (10; 90)	12	50 (15; 78)	48	0.136
SFD	10 (-32; 21)	12	22 (-30; 60)	58	0.005
OH	20 (2; 47)	13	35 (-40; 73)	58	0.005
PI-LL Mismatch	-8 (-25; 19)	14	8 (-19; 41)	62	0.002
ODI	6 (0; 26)	14	46 (2; 68)	60	<0.001
VAS	0.5 (0; 6)	14	7 (0; 10)	60	<0.001
EQ-5D	0.9 (0.5; 1)	14	0.5 (0.1; 1)	59	<0.001

Mann-Whitney test

Table 3. Correlation between demographic/radiographic parameters and clinical findings in the CG

		ODI	VAS	EQ-5D
Age	r	0.201	0.182	-0.073
	p	0.491	0.533	0.804
BMI	r	-0.042	-0.369	0.316
	p	0.886	0.194	0.270
Tobacco use	r	-0.189	-0.444	0.434
	p	0.517	0.112	0.121
Coronal imbalance	r	-0.104	-0.192	0.159
	p	0.723	0.511	0.587
TK	r	0.284	0.275	-0.460
	p	0.326	0.340	0.098
LL	r	0.264	0.485	-0.470
	p	0.362	0.079	0.090
SVA	r	0.072	0.052	-0.010
	p	0.807	0.859	0.973
PT	r	-0.050	-0.166	0.433
	p	0.864	0.571	0.122
SS	r	0.049	0.007	-0.104
	p	0.867	0.981	0.723
PI	r	0.094	0.007	0.027
	p	0.749	0.981	0.928
Cobb coronal angle	r	-0.155	0.198	0.089
	p	0.597	0.497	0.762
TLPL	r	0.051	0.250	-0.081
	p	0.870	0.410	0.793
RLPL L1	r	-0.038	0.142	0.062
	p	0.902	0.644	0.840
RLPL L2	r	-0.221	-0.430	0.287
	p	0.468	0.143	0.343
RLPL L3	r	-0.071	-0.312	0.233
	p	0.817	0.299	0.444
RLPL L4	r	-0.464	-0.662	0.468
	p	0.111	**0.014**	0.107
RLPL L5	r	-0.235	-0.624	0.492
	p	0.440	**0.023**	0.088
PM	r	-0.204	-0.407	0.451
	p	0.503	0.168	0.122
SA T1	r	-0.283	-0.600	0.051
	p	0.372	**0.039**	0.875
SA T4	r	-0.188	-0.495	-0.021
	p	0.559	0.102	0.948
SA T9	r	-0.261	-0.607	0.098
	p	0.413	**0.036**	0.761
SO T1	r	0.005	0.134	-0.011
	p	0.987	0.679	0.974
SO T9	r	0.451	0.196	-0.262
	p	0.141	0.541	0.411
SFA	r	-0.280	-0.227	0.461
	p	0.379	0.478	0.131
SFD	r	-0.040	-0.110	0.293
	p	0.903	0.733	0.355
OH	r	0.079	0.014	0.078
	p	0.799	0.965	0.801
PI-LL Mismatch	r	-0.368	-0.599	0.608
	p	0.196	0.024	0.021

Spearman correlation

Table 4. Correlation between radiographic parameters and quality of life in the Stenosis Group.

		ODI	**VAS**	**EQ-5D**
Coronal Imbalance	r	0.144	0.229	0.089
	p	0.285	0.086	0.510
TK	r	-0.273	-0.232	-0,290
	p	0.038	0.079	0.001
LL	r	-0.191	-0.065	0.031
	p	0.151	0.630	0.820
SVA	r	-0.132	-0.106	0.223
	p	0.338	0.441	0.102
PT	r	-0.021	0.149	0.075
	p	0.874	0.265	0.581
SS	r	-0.248	-0.021	0.126
	p	0.060	0.876	0.349
PI	r	-0.179	0.031	0.182
	p	0.180	0.820	0.176
Cobb coronal angle	r	0.113	0.115	0.081
	p	0.402	0.394	0.552
TLPL	r	-0.157	-0.185	0.058
	p	0.243	0.169	0.670
RLPL L1	r	-0.149	-0.209	0.038
	p	0.269	0.119	0.780
RLPL L2	r	-0.156	-0.228	0.047
	p	0.247	0.088	0.730
RLPL L3	r	-0.092	-0.255	0.004
	p	0.500	0.058	0.980
RLPL L4	r	0.085	-0.221	-0.089
	p	0.537	0.105	0.521
RLPL L5	r	0.126	-0.224	-0.119
	p	0.358	0.101	0.390
PM	r	0.180	-0.122	-0.226
	p	0.180	0.365	0.094
SA T1	r	-0.062	0.067	0.039
	p	0.675	0.653	0.793
SA T4	r	-0.024	0.010	0.000
	p	0.867	0.945	0.998
SA T9	r	-0.060	0.055	-0.047
	p	0.665	0.690	0.731
SO T1	r	-0.212	-0.161	0.126
	p	0.148	0.275	0.393
SO T9	r	-0.250	-0.213	0.007
	p	0.061	0.112	0.961
SFA	r	0.142	0.086	-0.014
	p	0.346	0.572	0.929
SFD	r	-0.093	0.156	-0.017
	p	0.499	0.256	0.902
OH	r	-0.067	0.076	0.063
	p	0.625	0.580	0.648
PI – LL mismatch	r	0.108	0.103	0.083
	p	0.420	0.443	0.538
SSA	r	-0.099	0.047	0.067
	p	0.528	0.763	0.671
T1SPi	r	0.031	0.126	-0.026
	p	0.857	0.464	0.879
TPA	r	-0.219	0.005	0.161
	p	0.200	0.978	0.348
C7PL/SFD	r	-0.018	-0.069	0.123
	p	0.909	0.660	0.431

Spearman correlation

Table 5. Mean values of TK, ODI, VAS, and EQ-5D according to the kyphosis groups of the SG.

	TK	ODI	VAS	EQ-5D	n
Hypokyphosis	13	37	7.5	0.558	4
Normal kyphosis	37	44	6.3	0.476	47
Hyperkpyphosis	48	33	5.9	0.732	7

low back and are not useful as a tool for screening this condition.[34]

We did not find a study that correlated TK and quality of life in DSL. A recent descriptive analytical study evaluated 34 women with osteoporosis and observed that a decrease in TK had an inverse correlation to gait performance and to the SF-36,[35] results similar to those found in our study.

One limitation of our study was comparing a population of DSL patients with surgical indication to a control group with a lower mean age.

CONCLUSION

This study showed a significant loss in SA parameter values in patients with DSL indicated for surgery as compared to a control population. It also revealed a direct correlation between a decrease in TK and a worsening of the ODI and EQ-5D quality of life indicators in these patients.

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

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