EVALUATION OF SPINO-PELVIC PARAMETERS ACCORDING TO INTRAOPERATIVE POSITION IN LUMBOSACRAL SPINE ARTHRODESIS

AVALIAÇÃO DOS PARÂMETROS ESPINOPÉLVICOS PELO POSICIONAMENTO INTRA-OPERATÓRIO NA ARTRODESE DE COLUNA LOMBO-SACRA

EVALUACIÓN DE LOS PARÁMETROS ESPINOPÉLVICOS POR EL POSICIONAMIENTO INTRAOPERATORIO EN LA ARTRODESIS DE COLUMNA LUMBOSACRA

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ABSTRACT

Objective: To evaluate the relationship between spino-pelvic preoperative, intraoperative, and postoperative parameters and the influence of surgical positioning with these values. Methods: This retrospective study evaluates radiographs pre-, intra-and postoperative patients who underwent arthrodesis of the lumbosacral spine. Results: Of the 16 patients evaluated a decreased sacral slope between the pre-and postoperative was observed, with a direct influence on the values of lumbar lordosis, with a consequent angular reduction. Conclusion: There is a variation in sacral inclination as a function of position on the operating table, mainly between the pre-and intraoperative position, during fusion surgery of the lumbosacral spine, and the sacral slope is directly responsible for the change in lumbar lordosis.

Keywords: Arthrodesis; Spine; Lordosis; Pelvis/surgery; Patient positioning.

RESUMO

Objetivo: Avaliar a relação dos parâmetros espinopélvicos pré-operatório, intra-operatório, pós-operatório e a influência do posicionamento cirúrgico com esses valores. Métodos: Estudo retrospectivo, avaliando imagens radiográficas pré, intra e pós-operatória de pacientes que foram submetidos a artrodese de coluna lombossacral. Resultados: Dos 16 pacientes avaliados observou-se que houve uma diminuição da inclinação sacral entre os momentos pré e pós-operatórios com uma influência direta sobre os valores da lordose lombar, com a consequente redução angular. Conclusão: Existe variação da inclinação sacral em função do posicionamento na mesa de cirurgia, principalmente entre o momento pré e intra-operatório posicionado, durante a cirurgia de fusão da coluna lombossacra e a inclinação sacral é responsável diretamente pela variação da lordose lombar

Descritores: Artrodese; Coluna vertebral; Lordose; Pelve/cirurgia; Posicionamento do paciente.

RESUMEN

Objetivo: Evaluar la relación de los parámetros espinopélvicos preoperatorio, intraoperatorio, posoperatorio, y la influencia del posicionamiento quirúrgico con esos valores. Métodos: Estudio retrospectivo que evaluó radiografías pre, intra y posoperatorias de pacientes que se sometieron a la artrodesis de la columna lumbosacra. Resultados: De los 16 pacientes evaluados se observó que hubo una pendiente menor del sacro entre el pre y el posoperatorio con una influencia directa en los valores de la lordosis lumbar, con la consecuente reducción angular. Conclusión: Existe una variación en la inclinación del sacro en función de la posición en la mesa de operaciones, principalmente entre el momento pre e intraoperatorio colocado, durante la cirugía de fusión de la columna lumbosacra, y la inclinación del sacro es directamente responsable por el cambio en la lordosis lumbar.

Descriptores: Artrodesis; Columna vertebral; Lordosis; Pelvis/cirugía; Posicionamiento del paciente.

INTRODUCTION

The human being is the only species of the animal kingdom to adopt a bipedal posture alone. This evolution in physical posture required some structural changes in the spine, being fundamental the development of the lumbar lordosis, which is not found in any other animal species.[1]

With the emergence of bipedalism in the animal kingdom, the sacrum has assumed a key role as a cornerstone for the distribution of load as we walk.[2] The high mobility of the hip joint affects pelvic positioning, so that, with bipedalism, the sacral plateau began to act as a base to support the weight of the spine.

Degenerative diseases of the spine are influenced by its spatial positioning during the lifetime of the individual. With aging, it requires a greater amount of invasive treatments in the lumbosacral region.[3]

Currently, there is concern about analyzing the sagittal alignment of the spine. It is now known that sagittal alignment directly influences an individual's energy expenditure.[4] The C7-sacrum plumb line, thoracic kyphosis, and lumbar lordosis serve as parameters for evaluating sagittal alignment. The shape of the pelvis and the sacral slope influence the lumbar lordosis of each individual.[5] There are some parameters that are used as references for the evaluation of pelvic alignment.

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The pelvic incidence (PI) is defined as the angle between a line perpendicular to the midpoint of the sacral plateau and a line from this point to the center of the femoral head.[4,6-8] (Figure 1) This angle most reliably represents the transmission of load by the sacral plateau. The average value of the angle of incidence is 55° ± 10°.[9] The incidence angle is a fundamental characteristic of the pelvis: it is an anatomical feature that is unique to each individual, which is set at the end of growth. This is a fixed angle that can be quickly calculated. The angle of incidence has a direct relationship to the balance of the spinal column, which rests on the sacral plateau.[6,9]

Two other parameters of importance are the pelvic tilt and sacral slope. Pelvic tilt (PT) is the angle formed between a line drawn from the midpoint of the sacral plateau with the center of the femoral head and a line vertical to the ground. (Figure 2) With the person standing, the mean value of the pelvic tilt is 13° ± 6°.[9]

The sacral slope (SS) is the angle between the horizontal line and the sacral plateau. (Figure 3) The degree of sacral slope determines the position of the lumbar spinal column, since the sacral plateau constitutes the base of the spine.[6,10] The pelvic incidence angle is the sum of the angles of pelvic tilt with the sacral slope (PI = PT + SS).[8]

Lumbar lordosis varies by individual, and is measured between the upper plateau of the L1 vertebral body and the upper plateau of the sacrum (S1).[6,11]

The procedures that secure the bony structures of the spine may in some ways alter the angular morphology of the spine, with a direct influence on the global positioning of these vertebrae.

It is possible to evaluate these spino-pelvic parameters through simple x-rays.

The aim of the study was to evaluate the angular values of the pelvic incidence, pelvic tilt, sacral slope, and lumbar lordosis before surgery, after positioning in the prone position with a pad for the surgical procedure, and after spinal fusion.

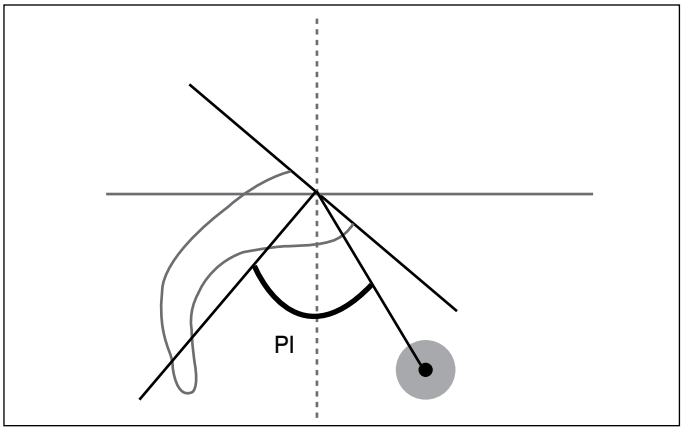

Figure 1. Pelvic incidence.

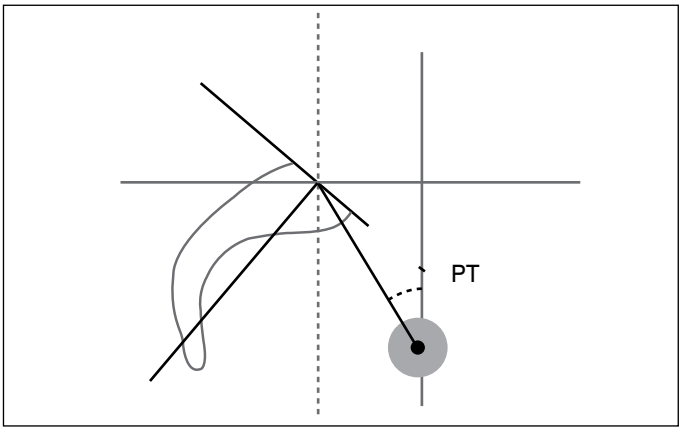

Figure 2. Pelvic tilt.

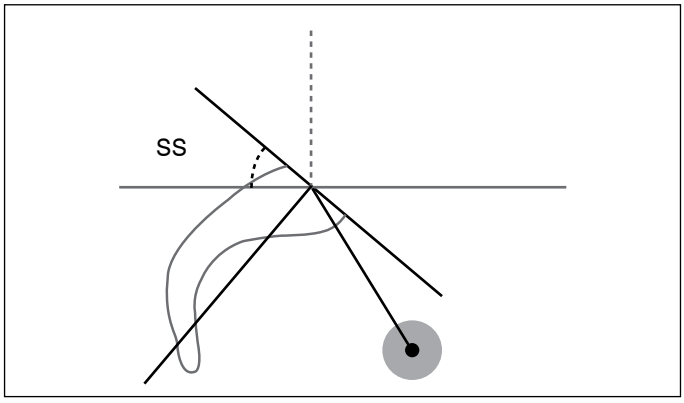

Figure 3. Sacral slope.

MATERIALS AND METHODS

Lateral radiographs were retrospectively analyzed in 16 patients with degenerative spine disease undergoing lumbosacral arthrodesis. The pre- and postoperative images were obtained in the standing position and intraoperative images were obtained by radioscopy to check the placement of the pedicle screws. A standardized pad was used for all patients in the prone decubitus to obtain 40° hip flexion and 30° knee flexion, both measured with an angle ruler.

The following measurements were taken from the radiographs: pelvic incidence (PI), sacral slope (SS); pelvic tilt (PT), lumbar lordosis (LL).

All parameters were measured by two orthopedic surgeons, members of the Brazilian Society of Orthopedics and Traumatology.

The statistical calculation was obtained by Pearson's method, ANOVA (analysis of variance), and Bonferroni and SPSS 15.0 software was used.

RESULTS

Of the 16 patients, 10 were female and six were male. The average age was 45.1 years (SD 11 years). Among the patients, 14 underwent spinal arthrodesis (AVP) with fusion of L4-S1 (88 %). One patient underwent AVP at L3-L5 and one patient at L4-L5.

Measures of sagittal balance and lumbar lordosis were described according to the times of assessment with the use of summary measures (mean, standard deviation, median, minimum, and maximum) and compared between the times using analysis of variance (ANOVA) for repeated measures,[12] followed by the Bonferroni[12] test for multiple comparisons to compare pairs of moments if differences were detected between them.

We calculated Pearson correlations between lumbar lordosis and sagittal balance parameters at each time point to determine the presence of a correlation between them.

The tests were performed with a significance level of 5%.

The results for the pelvic parameter values are shown in Table 1.

We conducted a comparison between pairs of moments for Sacral slope (SS) in order to compare the preoperative (AO), intraoperative (IO) and postoperative (PO) values. (Table 2)

Analyzing the lumbar lordosis with each specific pelvic parameter using the method of Pearson correlations[12] yielded the following results. (Table 3)

DISCUSSION

A relatively high prevalence of impaired lumbosacral region, requiring AVP at L4-S1 (88%) can be observed in the results. It is believed that this increased incidence of pathologies is associated with increased mobility in that region of the spine, therefore with more instability.[2,13]

The pelvic incidence averaged 50.3°, within the average of the general population as reported in the beginning of this study.[9,14]

The sacral slope showed large variations between the pre-, intra-,

Table 1. Description of the parameters of sagittal balance and lumbar lordosis according to moments of evaluation and results of comparisons between the moments.

Variable	Moment	Average	SD	Median	Minimum	Maximum	N	P
Lumbar lordosis	Pre	45.0	17.0	44	6	72	16	0.212
	Intra	40.8	10.8	40	20	58	16	
	Post	42.8	12.0	43	20	62	16	
Sacral slope	Pre	34.1	11.7	32	14	56	16	0.028
	Intra	29.0	8.2	30	16	48	16	
	Post	30.5	9.2	31	14	46	16	
Pelvic tilt	Pre	16.1	7.6	17	4	34	16	0.051
	Intra	20.6	9.0	20	6	34	16	
	Post	19.8	9.3	19	6	38	16	
Pelvic incidence		50.3	12.2	47	30	76	16	#

Results of ANOVA with repeated measures. # Constant values.

Table 2. Results of comparisons between pairs of moments for sacral slope.

Comparison		Mean difference	Standard error	p	CI (95%)	
					Inferior	Superior
AO	IO	5.13	1.79	0.035	0.31	9.94
AO	PO	3.63	1.72	0.155	-0.99	8.24
IO	PO	-1.50	2.05	>0.999	-7.03	4.03

Results of Bonferroni multiple comparisons.

Table 3. Evaluation of lumbar lordosis with specific parameters.

Variable	Pre		Intra		Post		N
	Correlation	P	Correlation	p	Correlation	P	
SS	0.823	<0.001	0.808	<0.001	0.858	<0.001	16
PI	0.698	0.003	0.732	0.001	0.599	0.014	16
PT	-0.144	0.595	0.224	0.404	-0.062	0.818	16

and postoperative periods, and is highly indicative of its relationship to the positioning on the operating table. These values are statistically significant ($p < 0.05$).

When analyzing the sacral slope alone according to the phases of the study, we observed a decrease of 5.13° from the pre- to the intraoperative period ($p = 0.035$), but among the other times there were no statistically significant average variations of the SS ($p > 0.05$). But there is a compensation of this variation in postoperative measurements, probably due to the instrumentation of the spine, blocking additional compensation. Figure 4 below helps in understanding this analysis:

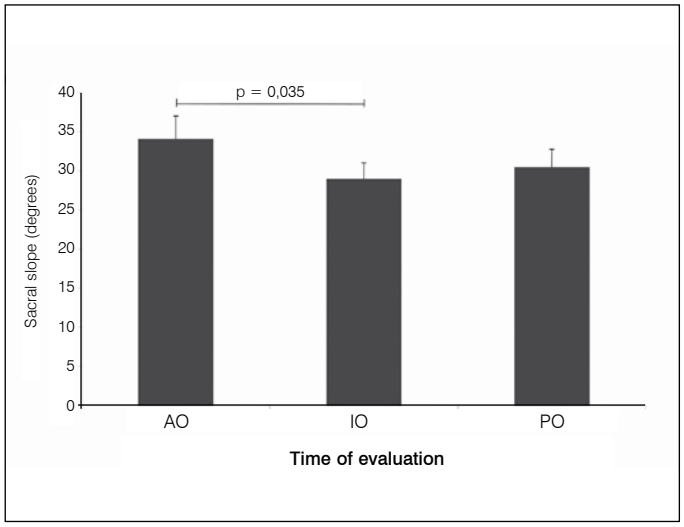

Figure 4. Mean values and standard errors of the sacral slope according to the time of evaluation.

This change in the sacral slope, showing decreased values, negatively influences the clinical pain of the patients.[15] The decreased sacral slope, referring to the sacral standard similar to when we are seated, causes more pain post-surgery.[16] Therefore, we should be concerned with maintaining the sacral parameters within appropriate values. When shaping posterior fixation rods, we can compensate for the sacral slope values with increased lordosis.[14]

Upon analyzing lumbar lordosis according to each pelvic parameter, sacral slope is the parameter most strongly correlated with the degree of lumbar lordosis (correlation > 0.8), but pelvic incidence also shows a statistically significant direct correlation with the degree of lumbar lordosis. That is, the higher the lumbar lordosis, the greater are the values of PI and SS and vice versa.[5] It is known clinically that patients who develop increased lordosis postoperatively have a tendency to preserve the adjacent segments without degeneration. A study published by Izumi et al.[14] demonstrated that the degeneration of segments adjacent to the fused segment is accompanied by a loss in the degree of lumbar lordosis. On average, there is a 10° reduction in the total lordosis.[13] This demonstrates the compensation potential of the spine in the mobile segments adjacent to the fused segment.

The loss of lumbar lordosis not only influences the degeneration of adjacent levels, but also causes a direct change in the spine--pelvic alignment of patients. Jackson et al.[17,18] have shown that this causes a displacement of the C7 plumb line anterior to the sacrum S1, changing the sagittal balance.

There is a great variability between the sagittal alignment of individuals. The great difficulty is to be able to delineate the degree of change that the individual's spine already has in the preoperative period and which values are specific to the individual, since in the course of aging there is compensation in adjacent levels of the spine and in the spino-pelvic parameters. There is a reciprocal relationship between the sacral slope, pelvic incidence

and lumbar lordosis, as demonstrated by the results presented above. Understanding the variation in the sagittal alignment for each individual helps in finding the association between sagittal balance and degeneration.[19]

The molding of rods, along with the fixation of the spine, influences the pelvic parameters.[15] Another factor that can influence the pelvic parameters is the angle resulting from the positioning of the pelvis with the surgical pads, since the pelvic values are directly influenced by the positioning of the hip (center of the femoral head).[1]

CONCLUSION

There is variation in the sacral slope due to the positioning on the operating table, mainly between the pre- and intraoperative positioning, during fusion surgery of the lumbosacral spine, and the sacral slope is directly responsible for changes in lumbar lordosis.

All authors declare no potential conflict of interest concerning this article.

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