ISSN: 2755-015X

Journal of Surgery & Anesthesia Research

SCIENTIFIC Research and Community

Research Article

Open Access

Health Related Quality of Life and Spinopelvic Parameters in Sagittal Imbalance Patients: A Comparison of Multilevel Smith-Petersen Osteotomy (SPO) and Pedicle Subtraction Osteotomy (PSO)

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ABSTRACT

Study Design: A multicenter, retrospective review of surgical patients with sagittal imbalance.

Objective: Determine if the use of one type of osteotomy is justified instead of the other by basing on improvements in the quality of life and radiographical parameters after sagittal imbalance correction.

Summary of Background Data: ASD includes broad ranges of clinical and radiographical conditions that could be associated with a decrease in quality of life of patients. SPO and PSO are the techniques most commonly used to correct sagittal imbalance.

Methods: Retrospective study with patients from two hospitals who suffered from sagittal imbalance and underwent PSO/SPO with a minimum one-year follow-up. Radiographic parameters measured were Thoracic Kyphosis (TK), Lumbar Lordosis (LL), Coob Angle (Cobb), pelvic incidence (PI), pelvic tilt (PT), and sacral slope (SS). Health Related Quality of Life was obtained by ODI, SRS-22, and VAS. Two analyses: (1) Pre-/postoperative data comparison of each technique (paired sample t-test). (2) Magnitude of change comparison between SPO and PSO (independent samples t-test).

Results: 65 patients with a mean age of 67.7 (±9.59) years, 70.8% female. Two groups: SPO (48 cases with a mean of 2.13 osteotomies), PSO (17, one PSO in each). In the SPO group significant improvements were seen TK (Pre: 31.38 ± 16.92; Post: 41.37 ± 11.67, $p < 0.001$), LL (Pre: 31.20 ± 15.69; Post: 38.63 ± 9.62, $p < 0.001$), and Cobb (Pre: 25.42 ± 15.84; Post: 9.49 ± 8.60, $p < 0.001$), as well as in the quality of life questionnaires. In the PSO group significant improvements were determined in TK (Pre: 32.26 ± 19.48; Post: 42.51 ± 16.23, $p = 0.003$), LL (Pre: 20.71 ± 12.50; Post: 38.54 ± 8.62, $p < 0.001$), and SVA (Pre: 156.00 ± 37.79; Post: 98.65 ± 38.72, $p < 0.001$) and in total SRS-22 (Pre: 2.13 ± 0.42; Post: 3.10 ± 0.87, $p < 0.001$) and self- image subdomain (Pre: 2.06 ± 0.54; Post: 2.99 ± 0.77, $p = 0.002$), mental health (Pre: 2.06 ± 0.54; Post: 3.59 ± 1.08, $p < 0.001$), and function (Pre: 2.31 ± 0.43; Post: 2.96 ± 0.92, $p = 0.010$). The comparison between SPO/PSO revealed no significant improvements in both techniques. Regarding quality of life, significant better scoring was obtained in VAS-PSO group (-3.29 ± 5.77) in comparison with SPO-group (-2.73 ± 3.49), $p = 0.009$. However, as a whole, quality of life improves more in both osteotomies groups.

Conclusions: Significant quality of life improvements are seen in patients with sagittal imbalance after being treated with SPO and PSO techniques. Differences between both techniques were not found.

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Received: January 13, 2022; **Accepted:** January 21, 2022; **Published:** February 15, 2022

Introduction

Adult spine deformity may occur as a result of a number of conditions that include idiopathic scoliosis, de novo and/or degenerative curves, each of which leads to imbalance of the structural support of the spinal column [1, 2]. To assume a standing position with a minimal energy expenditure is the result of ideal spinal alignment, normally this is reached through a complex relationship between the physiologic curvatures of the spine, the morphology of the pelvis, and the musculature of the axial skeleton [3, 4]. The cone of economy concept was first proposed by Dubousset which refers to a stable region of standing posture and is generally designed to assessing balance in spinal deformity patients. Concept of optimal spinal balance is not clearly defined, nevertheless several radiographical parameters have been used as a guide of sagittal alignment [5,6].

To analyze regional alignement it is normally used values of thoracic kyphosis (TK) by Cobb measurements (Cobb) and lumbar lordosis (LL); more recently, pelvic parameters have also been examined to improve the evaluation of sagittal plane balance being most used one the plumb of C7 defined as sagittal vertical axis (SVA) which is a radiographical parameter which measures the distance between the plumb C7 and the posterior superior corner of S1 in the sagittal plane [7-10]. In order to obtain a beneficial global spinal realignement SVA should be attempted to be less than 50 mm. In this way it gets physiologic standing posture and level gaze [4,11]. This term is our principal indication of sagittal imbalance.

In many cases the osteotomies, which are complex reconstructive procedures, are indicated to correct and restore global balance. Authors suggest the major factors to choose the type of osteotomy are bone density, stiffness, surgeon`s experience, type of deformity, magnitude of the curve and the condition of the spine (spinoplevic juntion and global spinal balance) [11-13].

SPO (Smith-Petersen osteotomy) and PSO (pedicle subtraction osteotomy) are the most common choices of the osteotomies in the literature [14-16]. Main difference between these two types of osteotomies is the degree of correction per spinal level, SPO provides appromimately 10° and PSO allows for a segmental correction of 30-40°; however, there are other distinctions such as, SPO procedure maintains a reduction in operative time, blood loss and a risk of neurological complications when compared with other techniques; nevertheless, it has disadvantages for instance less amount of sagittal plane correction carrying an increased risk of coronal decompensation. On the other hand, PSO procedure is generally used for the treatment of idiopathic and/or iatrogenic flatback deformity either fixed sagittal imbalance or both sagittal and coronal imbalance, but these techniques are fraught with complications [16-20].

Health Related Quality of Life (HRQOL) measurements are used to assess the outcomes of a different treatment of ASD in general and in particular, concerning this study, sagittal imbalance 2. Authors report that there is an important connection between sagittal imbalance and unsatisfactory HRQOL outcomes; in fact, pain and disability are recognized as effect of sagittal plane malalignment [21-24]. However, after correction imbalance surgery, HRQOL questionnaires such as ODI and SRS22 get an improvement in their outcomes [25-27].

The aim of this study is to compare two techniques of osteotomies (SPO and PSO) based on an improvement in HRQOL and a restoration of radiographical parameters after spinal realignment surgery.

Material and Methods

Database

Retrospective analysis of prospectively collected data from multicenter database of sagittal imbalance patients.

Inclusion/Exclusion Criteria

Inclusion criteria for the whole database were: over 18 years old and the presence of spinal deformity, scoliosis Cobb angle of 20° or greater, pelvic tilt (PT) of 25° or greater, and/or thoracic kyphosis (TK) of 60° or more. The minimum of instrumented vertebra were 4. The present study included patients only with completed and 2 year follow-up.

Patients who suffered from ankylosing spondylitis, neuromuscular diseases, history or clinical signs of hip, pelvic or lower limbs, previous spine surgery, spinal compression fractures, metabolic bone disease, infection or tumor were excluded.

Data Collection

Demographic and Surgical Data

The demographic and clinical data were obtained for each patient: age, sex, body mass index (BMI), instrumented levels, time of surgery and bleeding. The presence of rigid sagittal deformity, which could not be corrected without the use of osteotomies, was the main indication for surgery.

Health-Related Quality of Life (HRQOL)

Standardized HRQOL measures included Visual Analogue Scale (VAS) back, Oswestry Disability Index (ODI), Scoliosis Research Society-22 (SRS-22), and were collected at baseline and at the end of follow-up.

Radiographical Analysis

The horizontal distance between C7PL and S1 SVA greater than 50 mm is considered to be sagittal imbalance [28]. In this study, we define the distance greater than 50 mm previously mencioned as sagittal imbalance.

Radiographic evaluation mainly included standard digital standing lateral and anterior–posterior radiographs of the entire spine and pelvis which were obtained before surgery and the latest clinical follow-up. Standing AP radiographs were obtained with the knees and hips fully extended. Standing lateral radiographs were taken with fingers on the clavicles of forward elevation, and knees and hips fully extended [28-30]. The measurements were obtained in base on descriptions of Spinal Deformity Study Group (SDSG) [31].

Statistical Analysis

Statistical analysis was performed by using SPSS v21 (IBM). First a paired sample t-test was carry out for the comparison of each technique and second independent samples t-test were made on the magnitude of change by comparing SPO and PSO.

Results

Demographic characteristics

65 patients with a 2 year follow-up, whom have undergone vertebral column osteotomies (48 SPOs and 17 PSOs) and were followed for at least one year, were included and then evaluated in this study. Within this population, 70.8% (n = 46) were female, mean age of the cohort was 67.7 ± 9.59 years, the average number of levels fused was 8 ± 2.36, with an operative time of 372 ± 90.54 minutes, 356.50 ± 89.12 mL of estimated blood loss and BMI was 27.73 ± 3.42.

Before surgery, the patients included in this study had undergone traditional conservative measures which were not successful; examples of these types of treatments are: Use of nonsteroidal medications, physical therapy and modification of lifestyle prior to surgery for more than 3 months.

Radiographical Outcomes

In SPO group resulted in correction of TK from 31.38 ± 16.92° to 41.37 ± 11.67° ($p < 0.001$), LL from 31.20 ± 15.69° to 38.63

± 6.92° ($p < 0.001$), Cobb from 25.42 ± 15.84° to 9.49 ± 8.60° ($p < 0.001$) there are no statistically significant changes in other radiographical parameters (Table 1).

Table 1: Health-Related Quality of Life Scores in patients pre-surgery before complication and at one year postoperation

Radiological Measurements	Pre-Surgery	Post-Surgery	P-value**
TK (°)	31.38 ± 16.92	41.37 ± 11.67	<0.001
LL (°)	31.20 ± 15.69	38.63 ± 9.62	<0.001
COBB (°)	25.42 ± 15.84	9.49 ± 8.60	<0.001
SVA (mm)	114.59 ± 66.99	92.05 ± 48.74	ns***
PT (°)	28.25 ± 8.06	27.05 ± 8.41	ns***
PI (°)	57.01 ± 10.64	59.37 ± 10.33	ns***
SS (°)	27.65 ± 11.06	29.90 ± 7.79	ns***

Mean ± standard deviation is presented. ** Statistically significant values were considered $p < 0.05$. *** ns = not significant. TK thoracic kyphosis, LL lumbar lordosis, COBB Cobb angle, PT pelvic tilt, PI pelvic incidence, SS sacral slope.

Statistically significant differences in spinopelvic parameters were not found in PSO group (Table 2), however changes were reported in TK being 32.26 ± 19.48° before surgery and 42.51 ± 16.23° after surgery ($p = 0.003$) and likewise with LL pre-surgery 20.71 ± 12.50° and post-surgery 38.54 ± 8.62°. It should be pointed out that SVA had a highly value before surgery (156 ± 37.79 mm) and it would be improved after the procedure (98.65 ± 38.72 mm) ($p < 0.001$).

Table 2: Pre and post surgery radiographic parameters of patients who underwent pedicle subtraction osteotomy (PSO) for adult spinal deformity

Radiological Measurements	Pre-Surgery	Post-Surgery	P-value**
TK (°)	32.26 ± 19.48	42.51 ± 16.23	.003
LL (°)	20.71 ± 12.5	38.54 ± 8.62	<0.001
COBB (°)	19.10 ± 16.98	10.20 ± 10.98	ns***
SVA (mm)	156 ± 37.79	98.65 ± 38.72	<0.001
PT (°)	28.83 ± 9.47	28.35 ± 11.01	ns***
PI (°)	57.66 ± 11.65	55.22 ±11.65	ns***
SS (°)	28.53 ± 7.35	26.93 ± 7.35	ns***

Mean ± standard deviation is presented. ** Statistically significant values were considered $p < 0.05$. *** ns = not significant. TK thoracic kyphosis, LL lumbar lordosis, COBB Cobb angle, PT pelvic tilt, PI pelvic incidence, SS sacral slope.

Health-Related Quality of Life

Regarding HRQOL we found statistically significant improvement in SPO patients in all questionnaires (Table 3). In PSO group, after surgery, SRS22 function, self-image, mental health and total subdomains significantly increased (improved HRQOL) from 2.31 ± 0.43 to 2.96 ± 0.90 ($p = 0.010$), 2.06 ± 0.54 to 2.99 ± 0.77 ($p = 0.002$), 2.06 ± 0.54 to 3.59 ± 1.08 ($p < 0.001$) and 2.13 ± 0.42 to 3.10 ± 0.87 ($p < 0.001$) respectively and curiously, we did not find significant differences in VAS questionnaire, even though there was a clear improvement (Table 3), this is probably due to the great variability of the sample.

Table 3: Outcomes of Health related quality of life (HRQOL) questionnaires in smith-petersen osteotomy (SPO) and pedicle subtraction osteotomy (PSO) patients for adult spinal deformity

HRQOL questionnaires	Smith-petersen osteotomy (SPO)			pedicle subtraction osteotomy (PSO)		
	Pre-Surgery	Post- Surgery	P- value**	Pre-Surgery	Post- Surgery	P- value**
VAS back	7.93 ± 2.05	5.20 ± 3.36	<0.001	8.13± 3.07	4.87 ± 3.38	ns***
ODI	65.16±18.07	47.61 ± 21	<0.001	53.42±21.40	42.62±21.08	ns***
SRS22-Function	2.21 ± 0.41	2.67 ± 0.76	0.003	2.31 ± 0.43	2.96 ± 0.90	0.010
SRS22-Pain	1.86±0.65	2.81±1.06	<0.001	1.91 ± 0.847	2.88 ± 1.28	ns***
SRS22-Selfimage	1.98 ± 0.53	3.03 ± 0.80	<0.001	2.06 ± 0.54	2.99 ± 0.77	0.002
SRS22-Mental health	2.14 ± 0.69	3.39 ± 0.84	<0.001	2.06 ± 0.54	3.59 ± 1.08	<0.001
SRS22-Total	2.08 ± 0.44	2.98 ± 0.73	<0.001	2.13 ± 0.42	3.10 ± 0.87	<0.001

Mean ± standard deviation is presented. ** Statistically significant values were considered $p < 0.05$ *** ns = not significant

Analysis of the Difference Pre-Post in Radiographical Parameters and Quality of Life at Follow-Up

Finally, we wanted to verify if one technique provided more benefits, both radiographical and quality of life compared to the other, therefore, an analysis about pre-post differences in the two groups of osteotomies was carried out, both in radiographical parameters and in HRQOL, no statistically significant differences were found between both techniques. However, we can see that there is a greater correction of LL with the PSO (17.83 ± 13.86°) with respect to the SPO (7.43 ± 14.38°) (p = 0.830), on the contrary, it occurs with an angle of Cobb (-8.9 ± 13.60°) in PSO and (-15.93 ± 12.95°) in SPO (p = 0.987), additionally PSO provides a great SVA correction (-57.35 ± 43.70) in relation to SPO (-22.54 ± 62.80) (p = 0.224) (Table 4). In respect of HRQOL, a negative value indicates that the pre value is greater than the post value, in questionnaires such as the VAS or the ODI, having a lower score means getting an improvement, in contrast to what happens with SRS22, high values of the questionnaire mean better quality of life; therefore, the differences in the SRS22 subdomains are positive (Table 5).

Table 4: Outcomes of the difference pre-post surgery of radiological parameters in smith- petersen osteotomy (SPO) and pedicle subtraction osteotomy (PSO)

	Type of osteotomy	Values	P-value
TK_dif (°)	PSO	10.25 ± 11.99	.221
	SPO	9.99 ± 16.85	
LL_dif (°)	PSO	17.83 ± 13.86	.830
	SPO	7.43 ± 14.38	
COBB_dif (°)	PSO	-8.9 ± 13.60	.987
	SPO	-15.93 ± 12.95	
SVA_dif (mm)	PSO	-57.35 ± 43.70	.224
	SPO	-22.54 ± 62.80	
PT_dif (°)	PSO	-0.48 ± 6.81	.118
	SPO	-1.20 ± 9.24	
PI_dif (°)	PSO	-2.44 ± 10.77	.958
	SPO	2.36 ± 10.19	
SS_dif (°)	PSO	-1.60 ± 7.94	.364
	SPO	3.25 ± 10.45	

Mean ± standard deviation is presented. ** Statistically significant values were considered p <0.05. TK thoracic kyphosis, LL lumbar lordosis, COBB Cobb angle, PT pelvic tilt, PI pelvic incidence, SS sacral slope.\

Table 5. Outcomes of the difference pre-post surgery of quality of life in smith-petersen osteotomy (SPO) and pedicle subtraction osteotomy (PSO)

		Type of osteotomy	Values	P-value
VAS back_dif		PSO	-3,29 ± 5,77	,009
		SPO	-2,73 ± 3,49	
ODI_dif		PSO	-14,14 ± 26,08	,834
		SPO	-17,34 ± 25,50	
SRS22	Function_dif	PSO	0,66 ± 0,82	,318
		SPO	0,47 ± 0,74	
	Pain_dif	PSO	0,96 ± 1,49	,182
		SPO	0,95 ± 1,08	
	Selfimage_dif	PSO	0,89 ± 0,87	,790
		SPO	1,04 ± 0,87	
	Mental health_dif	PSO	1,60 ± 1,10	,615
		SPO	1,25 ± 1,01	
	Total_dif	PSO	0,98 ± 0,87	,224
		SPO	0,91 ± 0,74	

Mean ± standard deviation is presented. ** Statistically significant values were considered p <0.05

Discussion

The main purpose of the current study was to compare two types of principal osteotomies to restore the sagittal plane. On the assumption that the indication is different in these osteotomies. As for SPO is used for mild to moderate deformity with mobile intervertebral discs and it offers up to 10 correction grades per osteotomy so it could be performed in any level in the thoracolumbar spine [32]. This procedure is easier and safer than the PSO; in addition, it reduces the surgery time, blood loss and neurological complications. Nevertheless, this osteotomy carries some disadvantages, such as less sagittal plane correction and more risks of coronal decompensation [13]. Regarding PSO, a closing wegde osteotomy is generally used for the fixed deformity and it obtains 30-40 grades of segmental correction and more lordosis, so, when possible, it is recommended making it in L2 or L3 with the purpose of decreasing the neurological risk associated 33. This osteotomy has an elevated number of complications despite of the fact that it achieves a greater sagittal plane correction [34, 35].

It is important to obtain a suitable correction of sagittal malalignment in order to balance the head over the sacrum. Many authors have postulated that patients are more predisposed to develop loss of correction and pseudoarthosis if the sagittal imbalance is not restored at time of the osteotomy, in addition PSO could restore malalignment more satisfactorily [32, 34-37]. The final data showed that the postoperative SVA correction was 57.35 (± 43.70) mm and 22.54 ± (62.809) mm, for PSO and SPO respectively; therefore, the correction of SVA was consistent, although comparison between groups of osteotomies was not statistically significant. In fact, no statistical differences were found in all radiological measurements analyzed to contrast both techniques [13, 16].

In the literature, no many articles have investigated the comparison between PSO and SPO in relation with HRQOL, this could be an innovative line of research. However, it is known that poor HRQOL outcomes are associated with sagittal imbalance [21-24]. Kim and coworkers reported that, in spite of improvement, there were no differences between pre-post in ODI and SRS-22 questionnaires at 2 year follow-up like our study shows [25]. In the same way these questionnaires are favorable after realignment surgery [26, 27]. specially when global realignment is totally recuperated (SVA<50 mm) [4].

In our study, with both techniques, an improvement in radiographical measurements and HRQOL were achieved when they were analyzed individually. However, we cannot state which technique is better as statistically significant differences have not been found in the parameters previously described.

This study has certain limitations, information must be taken with caution since sample size is low and we are aware of the fact that indications are different for both techniques. However, the importance of HRQOL in decision making should be taken in to account. In future studies, it will be necessary to make a thorough analysis including variables which could influence our outcomes like the complications associated to these procedures.

Conclusion

Adult spinal deformity often requires major reconstructive procedures such as spinal osteotomy techniques, which include valuable tools like SPO and PSO. The correction of the sagittal profile can be achieved by performing these procedures. Sagittal plane imbalance is normally associated with poor HRQOL scores and these techniques may improve these results. Despite good clinical and radiographic outcomes, we can not claim which technique is better. That is why, future studies like the one we have here should be carry out in order to provide more information with new variables which can bring benefits in decision making.

Acknowledgments

We are grateful for support from the Complejo Asistencial Universitario de León.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

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