Original Article

Analyzing results of cervical sagittal parameters in patients operated with polyetheretherketone cages without plate

ABSTRACT

Study Design: This was a retrospective longitudinal observational study.

Purpose: The purpose of this study was to analyze the results of cervical sagittal parameters on preoperative and postoperative lateral radiographs in anterior cervical discectomy and fusion (ACDF). ACDF is believed to change craniocervical parameters and thus cervical curvature using polyetheretherketone (PEEK) or titanium cages with or without self-locking as well as an anterior plate, the latter of which has not been shown to provide better clinical or radiological results.

Overview of Literature: Cervical spondylotic myelopathy (CSM) is a common degenerative pathology that can affect one or more levels and treatment has varied over time trying to maintain sagittal parameters within acceptable values where the ACDF is the main treatment.

Materials and Methods: The study was performed in patients with CSM who underwent anterior cervical discectomy, and their pre- and postoperative radiographs were analyzed using Surgimap software a few days before and 3 months after surgery.

Results: Fifteen files were included in the study. Statistically significant sagittal balance variables were observed in cervical lordosis (CL) with an increase of 4.73 ($P = 0.019$) and T1 slope (T1S)-CL with a decrease of –5.93 ($P = 0.007$).

Conclusions: CL and T1S-CL showed favorably modified values when performing ACDF using stand-alone PEEK cages without the need for self-blocking or an anterior plate.

Keywords: Cervical lordosis, cervical sagittal parameters, cervical spine, myelopathy, polyetheretherketone, T1 slope

INTRODUCTION

Cervical spondylotic myelopathy (CSM) is a common degenerative pathology that can affect one or more levels. The term cervical spondylosis or CSM refers to degenerative changes in the cervical spine that may involve compression of the spinal cord (myelopathy) and/or nerve roots (radiculopathy).[1] Multilevel CSM refers to the disc involvement of three or more contiguous or noncontiguous levels.[2] Treatment has varied over time, including posterior approaches with laminoplasty. Nevertheless, anterior decompression and fusion is currently a globally accepted surgical practice that has provided satisfactory results.[3-5]

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Anterior cervical discectomy and fusion (ACDF) can lead to changes in the cervical curvature and modify craniocervical parameters.[6] The use of polyetheretherketone (PEEK) or titanium cages with or without locking helps to accomplish such changes. Employing an anterior plate is also a common practice; however, none of these has demonstrated a compelling superiority over the other in terms of clinical and radiographic results.[3,7-9]

One of the objectives of surgery is to maintain sagittal parameters within acceptable values, since these have been associated with a lower likelihood of developing adjacent segment disease, better clinical results, and are important for maintaining global balance.[10-14] Several regional sagittal parameters have been used to assess cervical alignment, including the cervical sagittal vertical axis (cSVA), T1 slope (T1S), C2-C7 cervical lordosis (CL), and T1S-CL. The latter (T1S-CL) is one of the most reliable measures for assessing cervical sagittal alignment.[11,15]

Anterior discectomy with stand-alone cage can be performed at up to four levels, considering that the fewer levels are operated, the lower the risk of complications.[16-18] Different anterior techniques for treating CSM, the anterior cervical approach including placement of stand-alone PEEK cages, have shown good clinical and radiographic results, with a risk of subsidence or other complications same as using titanium cages, with locking, with the use of an anterior plate, or a combination of them.[7,8,11,19-22] Assuming proper decompression and the correct cage placement technique are used, the results are similar.[23] According to some studies, there are no significant differences in postoperative results when using stand-alone PEEK cages in comparison with PEEK cages + anterior plate, while others claim that using an anterior plate provides better sagittal measurements than stand-alone cages, although this does not relate to clinical results.[24] Complications may occur with any technique used.[2-4,8,11,14,25,26] Dysphagia due to anterior cervical plate placement may be reduced when the plate is not placed, which is also the case in adjacent segment disease.[20,21,27,28] Cage subsidence has been reported in these various techniques with the literature showing an increase in cage subsidence in unplated cages compared to plated cages. Other studies report no such increased complication. Migration of the screws with anterior cervical plate is another important complication that can be discarded when using stand-alone cages.[23,24,29]

The advantages of using stand-alone cages are less surgical time, less blood loss, a lower postoperative dysphagia rate, and lower hospital expenses. Since there are no significant differences compared to other techniques, some authors even consider stand-alone cage placement as the gold standard for anterior cervical surgery with discectomy.[23]

MATERIALS AND METHODS

A retrospective, longitudinal, observational study was

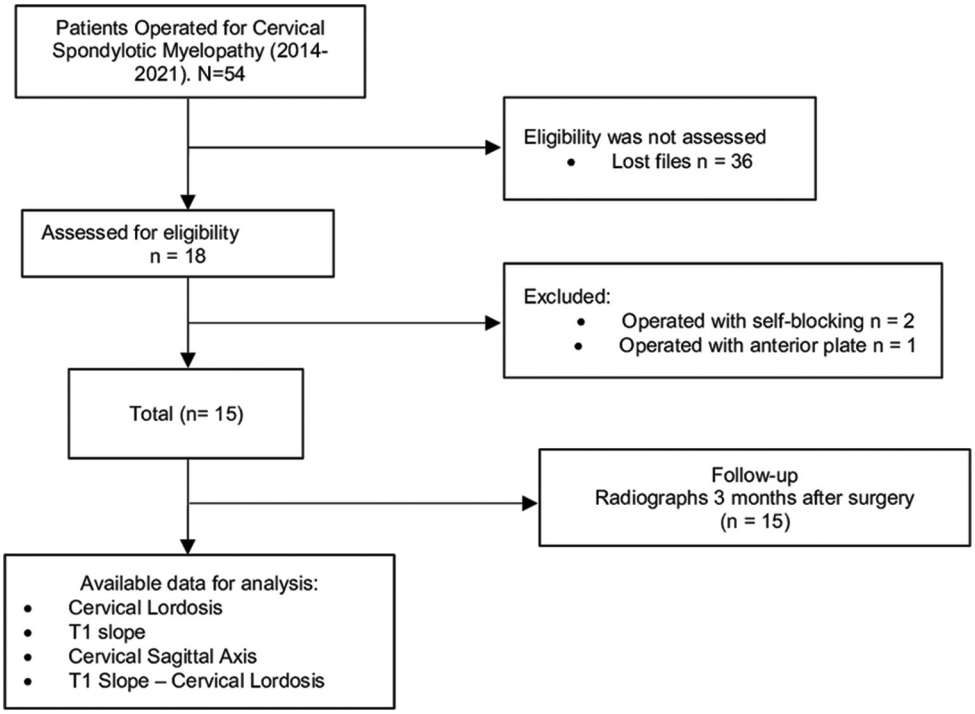

Figure 1: STROBE Diagram. The final sample number was 15, with preoperative and postoperative lateral cervical spine radiographs followed up three months after surgery

performed, screening records from Hospital Angeles de Pedregal in Mexico City, dated between 2014 and 2021. The diagnosis of the patients was CSM of one or more levels treated surgically by anterior approach with discectomy and fusion with zero-profile stand-alone PEEK cages. The inclusion criteria were: (1) patients who underwent ACDF with preoperative and postoperative X-ray studies (3 months later) in neutral lateral projections The exclusion criteria were: (1) patients who underwent with anterior plate placement, (2) the placement of self-blocking cages, (3) and patients whose files were incomplete such as lack of either anterior or posterior X-ray studies or lack of both [Figure 1 and Table 1].

Table 1: Population of our study by age, sex, and cervical levels operated on

Case	Sex	Age	Operated levels
1	1	83	2
2	2	40	2
3	2	72	4
4	1	79	3
5	2	54	4
6	2	56	3
7	1	34	1
8	1	62	3
9	2	68	1
10	2	69	1
11	1	75	4
12	2	63	2
13	2	63	3
14	1	72	3
15	2	61	3
Average	NA	63.40	NA
SD	NA	13.43	NA
Frequency	6 male/9 female	NA	3O/3T/6Th/3Fo

O - One-level; T - Two-level; Th - Three-level; Fo - Four-level; SD - Standard deviation; NA - Not available

Radiological evaluation

Cervical spine radiographs were taken in neutral lateral projections, before and after (3 months later) the surgery, and were analyzed and measured using Surgimap. The parameters included were T1S, CL, cSVA, and T1S-CL. T1S was defined as the angle between the upper endplate line of T1 and a horizontal line passing through the posterior corner of T1; CL was defined as the Cobb angle formed by the parallel lines of the lower C2 endplate and the lower C7 endplate; cSVA is the distance from the posterosuperior corner of C7 to the point where the vertical line connects from the centroid of C2–C7 ending (plumb line); and T1S-CL is the result of the difference between T1S and CL. The measurements were performed by medical specialists in spine surgery, in pre- and postsurgical studies.

Statistical analysis

Statistical analysis was performed using SPSS software version 25.0, (IBM Corp. 2017. IBM SPSS Statistics for

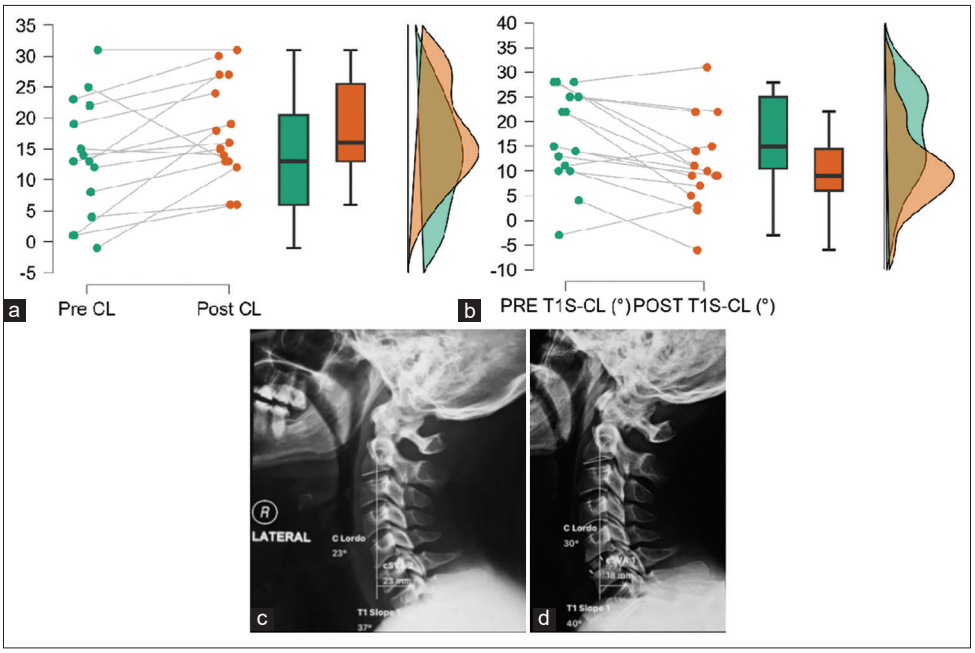

Figure 2: (a) Pre and postoperative (green dots and orange dots respectively) measurements of the C2-C7 Cervical Lordosis (CL) (upper left) estimation with the box-and-whisker distribution showing a statistically significant change with an increasing tendency. (b) We observe the estimated measurements of the arithmetic operation of T1 Slope – Cervical Lordosis (T1S-CL) which eliminates the overestimation in pre and post-surgery; there is a statistically significant change with a decreasing trend shown in the box-and-whisker plot and the distribution of the area under the curve, which means that eliminating CL overestimation yields a more accurate result that lies within clinically acceptable ranges. Finally, we show the measurement of our cervical sagittal parameter variables taking the preoperative (c) and postoperative (d) neutral lateral X-ray plate; these measurements were performed using Surgimap.

Table 2: Results of each of our cases with their mean, standard deviation, delta (pre- and postoperative difference), and statistics

Case/ variable	Pre-C2–C7 (CL) (°)	Post-C2–C7 (CL) (°)	Delta CL	Pre-T1 slope (°)	Post-T1 slope (°)	Delta T1 slope	Pre-T1S—CL (°)	Post-T1S—-CL (°)	Delta T1S—CL	Pre-cSVA (C2C7) (mm)	Post-cSVA (C2C7) (mm)	Delta cSVA
1	19	24	5	29	26	−3	10	2	−8	10	11	1
2	4	6	2	32	37	5	28	31	3	24	47	23
3	14	16	2	42	27	−15	28	11	−17	30	32	2
4	13	19	6	26	28	2	13	9	−4	37	29	−8
5	1	6	5	26	28	2	25	22	−3	30	33	3
6	1	18	17	23	23	0	22	5	−17	16	13	−3
7	23	30	7	37	40	3	14	10	−4	22	18	−4
8	25	13	−12	36	28	−8	11	15	4	27	27	0
9	−1	12	13	27	26	−1	28	14	−14	15	12	−3
10	8	13	5	30	22	−8	22	9	−13	30	14	−16
11	13	27	14	23	34	11	10	7	−3	27	38	11
12	15	14	−1	30	25	−5	15	9	−6	12	21	9
13	31	31	0	28	34	6	−3	3	6	−2	24	26
14	12	15	3	37	37	0	25	22	−3	33	36	3
15	22	27	5	26	21	−5	4	−6	−10	14	4	−10
Average	13.33	18.07	4.73	30.13	29.07	−1.07	16.80	10.87	−5.93	21.67	23.93	2.27
SD	9.56	8.08	6.89	5.62	5.91	6.52	9.53	9.13	7.25	10.55	12.03	11.36
P	N/A	N/A	*P*=0.019	N/A	N/A	*P*=0.536	N/A	N/A	*P*=0.007	*t*=−0.773	N/A	*P*=0.453

CL had a trend to increase from preoperative to postoperative status of 4.73° with a standard deviation of 6.89 (*t*-student=−2.660, *P*=0.019). As for T1S-CL, the change consisted of a decreasing trend from pre- to postoperative status of −5.93° with a standard deviation of 7.2 (*t*-student=−3.172, *P*=0.007). The remaining two variables had an insignificant change. T1S had an average delta of −1.07 and cSVA with an average delta of 2.27. SD - Standard deviation; NA - Not available; CL - Cervical lordosis; cSVA - Cervical sagittal vertical axis; T1S—CL - T1 Slope (minus, −) CL

Windows, Armonk, NY, USA), where Student's t-test was used prior to corroboration of normality with Shapiro–Wilk test, which was corroborated using JASP 0.17.2.1 software (JASP Team BibTex 2023, Amsterdam, Netherlands. University of Amsterdam) and its graphs. Continuous variables are reported as the mean ± standard deviation (SD). Our statistically significant "*P*" had a value of < 0.05 with an SD of 95%.

RESULTS

Our search began with 54 files, of which 15 were subjects of the study. The levels operated were as follows: one-level: three patients; two-level: three patients; three-level: six patients; and four-level: three patients [Figure 1]. Demographic features are shown in Table 1.

Regarding CL, we obtained a preoperative (mean ± SD) of 13.33° ± 9.55°, and a postoperative of 18.06° ± 8.08°. T1S was 30.13° ± 5.61 preoperatively; the postoperative was 29.06° ± 5.90°. In relation to T1S-CL, we obtained a mean of 16.8° ± 9.53° preoperatively, while the postoperative decreased to 10.86° ± 9.12°. For the last variable cSVA, our preoperative results showed 21.66 mm ± 10.55; and the postoperative measure was 23.93 ± 12.03, as shown in Table 2.

Our CL variable was statistically significant, with a mean delta between postsurgery and presurgery of 4.73° and an SD of 6.89, with $P = 0.019$ and $t = -2.660$. Another statistically significant variable was the elimination of CL overestimation (T1S-CL) with a mean delta of –5.93°, $P = 0.07$, and $t = 3.172$, both with 14° of freedom [Figure 2].

The Shapiro–Wilk normality test was not statistically significant. Therefore, our results tended to normality, confirming the statistical test performed with paired Student's *t*-test.

DISCUSSION

Regional sagittal parameters have been regarded as a reference for predicting the clinical evolution of patients who have undergone spine surgery. In the cervical region, globally accepted parameters are part of the global balance, which is affected by the changes produced in each region but modification on cervical spine parameters have a little impact on others, such as T1S and pelvic parameters.

In this study, we observed that T1S did not have significant changes because it is a generally fixed measurement in each patient, bearing in mind that it corresponds to the first thoracic vertebra, is directly related to the rib cage, and is difficult to modify.[5,14]

In relation to cSVA, no significant changes were observed either. This can be explained by the fact that C2 and C7 are proximal and distal fixed points and depends on the global sagittal alignment parameters, and therefore, the regional measurements may not be affected by the procedure performed. Other parameters that may have changes following the placement of PEEK cages are the craniocervical parameters, which were not the subject of study in this article. Therefore, the change in the cSVA was not affected, whether the curvature increased or decreased.[5]

CL is a parameter whose changes have greater significance, and preoperative and postoperative measurements have been shown to improve in various studies with regard to less symptomatology and better postoperative results.[17] These changes can also be observed when analyzing the T1S-CL results. This is due to several factors such as interbody distraction during surgery, location of the cages placed in the anterior and middle spine, and restitution of intersomatic height.

CL values and (T1S – CL) show a higher significance in the pre- and the post-surgery evaluation and could be more reliable to use as a guide to evaluate cervical sagittal balance than the other two parameters (T1S and cSVA). Nevertheless, these variables could reach statistical significance if the sample size had been larger. It is mandatory additional clinical trials and correlation test with the global sagittal parameters.

CONCLUSIONS

The assessment of cervical sagittal parameters in patients operated on for CSM with discectomy and placement of intersomatic cages alone showed that CL and T1–CL are the most modified measurements that can regionally show improvement or no improvement of the curvatures. The use of lordotic cages is likely to improve these measurements. T1S and cSVA were not significantly modified, at least regionally, although they should be considered for global balance assessment.

Limitations

The final sample size for our study was small compared with the initial sample size.

The sagittal values obtained were regional and no global sagittal values were measured for the purposes of this study.

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Conflicts of interest

There are no conflicts of interest.

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