Original Article

# The effect of cage type on local and total cervical lordosis restoration and global spine alignment in single-level anterior cervical discectomy and fusion based on EOS® imaging: A comparison between standalone conventional interbody polyether ether ketone cage and integrated cage and plate (Perfect-C®)


## ABSTRACT

**Background:** There is a small level of evidence regarding the alterations in global spine alignment following the restoration of cervical lordosis using anterior cervical discectomy and fusion (ACDF). Different cage types are available to restore cervical lordosis through ACDF. In this study, we evaluate the impact of two types of these cages on local and global spine alignments.

**Patients and Methods:** Thirty-two patients with a mean age of 46 ± 10 who underwent ACDF for cervical disc herniation were included in this retrospective study. Patients were divided according to their cage type into two groups, 17 patients with standalone conventional polyether ether ketone cages and 15 patients with integrated cage and plate (ICP) (Perfect-C®). Cervical alignment and global spine alignment were evaluated on the pre- and post-operative EOS® images.

**Results:** Three months after the ACDF, total cervical lordosis correction was higher in patients with ICP ($P = 0.001$), while the local cervical lordosis correction was not significantly different between conventional cages and prefect-C cages ($P = 0.067$). Lumbar lordosis and pelvic tilt change were significantly higher among patients with Perfect-c cages ($P = 0.043$).

**Conclusion:** In patients undergoing ACDF, alignment of the global spine changes along with the restoration of the cervical spine. Cage type affects this association, mainly through the compensatory alteration of pelvic tilt.


**Keywords:** Anterior cervical discectomy and fusion, cervical disc herniation, cervical lordosis, fusion level, global spine alignment, pelvic tilt, Perfect-C cage (integrated cage and plate)

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## INTRODUCTION

Degenerative cervical disc disease is a common condition that can cause neck pain, radiculopathy, and myelopathy.[1] Anterior cervical discectomy and fusion (ACDF) is a widely used surgical treatment for this condition, which involves removing the affected disc and replacing it with a bone graft and a cage to maintain the disc height and promote fusion.[2]

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However, cage subsidence and loss of cervical lordosis are common complications of ACDF, which can lead to poor clinical outcomes and adjacent segment degeneration.[3] Recently, an integrated cage and plate (ICP) system has been developed to address these issues by providing additional stability and restoring cervical lordosis. In 2012, the Korean Ministry of Food and Drug Safety approved the Perfect-C® ICP device as an alternative to the standalone conventional interbody polyether ether ketone (PEEK) cage used in ACDF. The Perfect-C device combines the interbody spacer and front plate, protruding from the disk space similar to the front cervical plate.[4]

Alteration in the cervical curvature also adversely affects the alignment of the spine in other regions, including thoracolumbar angle and pelvic alignment, and vice versa.[5-7] However, the effect of cage type on cervical lordosis and global spine alignment is not well studied. To compare the effect of cage type on local and total cervical lordosis restoration and global spine alignment in patients undergoing ACDF this study was designed and performed.

## PATIENTS AND METHODS

Patients who underwent ACDF in our University Hospital between January 2017 and December 2022 were retrospectively reviewed. Patients were divided into two groups according to their cage type. Inclusion criteria were single-level cervical disc herniation who underwent ACDF indication with available pre- and post-operative EOS imaging. Patients with other indications for ACDF, such as trauma, tumor, or infection, patients with a history of any spinal surgery, tandem stenosis (concomitant stenosis of the cervical spine and thoracic or lumbar region) and patients who had other spinal pathologies besides cervical disc herniation, were excluded from the analysis. Finally, 32 patients who met the study criteria were included in the analysis. Seventeen patients had ACDF with conventional PEEK cage and 15 patients had ACDF with perfect-C cage. The demographic and surgical characteristics of the patients are demonstrated in Table 1. The patients were categorized based on cervical cage type.

**Table 1: Demographic and surgical characteristics of the patients who underwent anterior cervical discectomy and fusion for cervical disc herniation**

| Variable | Mean±SD or *n* (%) |
|---|---|
| Cage type | |
| Perfect C (Group A) | 15 (42.9) |
| Conventional (Group B) | 17 (53.1) |
| Sex | |
| Group A | |
| Male | 3 (9.3) |
| Female | 12 (37.5) |
| Group B | |
| Male | 5 (15.6) |
| Female | 12 (37.5) |
| Age | |
| Group A | 47.2±8 |
| Group B | 44.9±11 |

SD - Standard deviation

### Radiologic assessments

Radiographic assessments were performed on whole-spine EOS images that were obtained before the operation, 3 days after the operation, and 3 months after the operation. The assessments included the evaluation of local cervical alignment, whole-spine alignment, and spino-pelvic parameters. Whole-spine alignment was evaluated by the measurement of the cervical lordosis, thoracic kyphosis, lumbar lordosis, and spinal C7-S1 Sagittal vertical axis (SVA). Total cervical lordosis was measured by calculation of the Cobb angle between the caudal endplate of C2 and C7. Local cervical lordosis only included the lordosis of the involved cervical vertebrae. Spino-pelvic parameters were assessed by measuring pelvic tilt and sacral slope. Imaging evaluations are demonstrated in Figures 1 and 2.

### Statistical analysis

The data were analyzed by SPSS for Windows (version 16, SPSS Inc., Chicago, IL., USA). Descriptive data were demonstrated by the mean ± standard deviation or numbers and percentages for quantitative and qualitative variables, respectively. The normality of distribution was checked with a Kolmogorov–Smirnov test. A repeated measure ANOVA test or its nonparametric counterpart (Friedman test) was used to evaluate changes in radiographic measures over time, followed by a *post hoc* test to verify exactly which groups differ from each other. An independent *t*-test or its nonparametric counterpart (Mann–Whitney *U*-test) was used to compare mean values between two different groups. A $P < 0.05$ was considered statistically significant.

## RESULTS

Thirty-two patients with a mean age of 46 ± 10 were evaluated and divided into two groups Group A patients with ACDF using Perfect C cage and Group B patients with ACDF using a conventional PEEK cage. The mean age of patients in Group A was 47.2 ± 8 years and including 3 males and 12 females. Among patients in Group B, 5 patients were male and 12 patients were female with a mean age of 44.9 ± 11 years [Table 1].

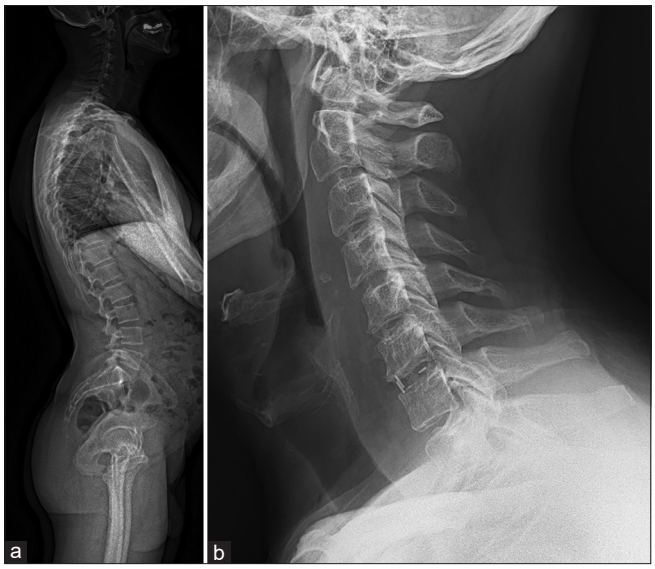


**Figure 1: Postoperative images of patient with conventional cage. (a) Standing lateral EOS. (b) Lateral cervical X-ray**

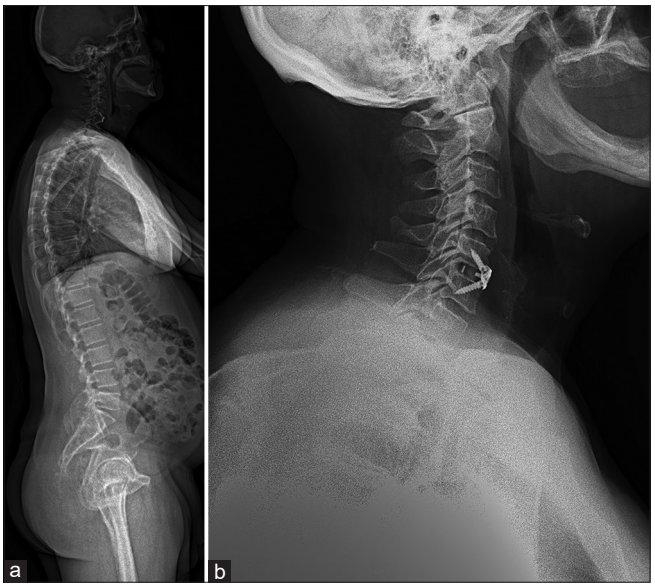


**Figure 2: Postoperative images of patient with Perfect-C cage. (a) Standing lateral EOS. (b) Lateral cervical X-ray**

Cervical alignment including C2-C7 lordosis and local cervical lordosis were improved in both groups. All other radiological measures as preoperative, 3 days' postoperative, and 3 months' postoperative are summarized in Table 2.

The instant effect of cage type on the local and global spine alignment was evaluated on 3 days' postoperative imaging. There was no significant differences between perfect-C and conventional cage groups in the correction of C2-C7 lordosis, local lordosis, lumbar lordosis, thoracic kyphosis, sacral slope, and pelvic tilt [Table 3].

The stable effect of cage type on the local and global spine alignment was evaluated on 3 months' postoperative imaging. Three months after the ACDF, correction of C2-C7 lordosis, lumbar lordosis, and pelvic tilt was significantly different between the two groups. The total cervical lordosis (C2-C7) correction was higher when the Perfect-C cage was used ($P < 0.001$), while the local cervical lordosis correction was not significantly different between the two groups ($P = 0.67$). The change in lumbar lordosis was significantly higher when the Perfect-C cage was used ($P = 0.029$). The change in pelvic tilt was also significantly higher when the Perfect-C cage (ICP) was used ($P = 0.049$). Change of other spinal measures, including cervical SVA, thoracic kyphosis, C7-S1 SVA, and the sacral slope, was not significantly different between patients of two groups [Table 4].

## DISCUSSION

The relationship between cervical alignment and global spine alignment is important in ACDF surgeries.[5] Cervical lordosis refers to the natural inward curvature of the cervical spine and plays a crucial role in maintaining proper balance and stability of the overall spine.[6,7] Loss of cervical lordosis, or cervical kyphosis, can lead to poor clinical outcomes and may contribute to adjacent segment degeneration.[8]

Different types of cages are used in ACDF surgeries. These cages serve to maintain disc height and promote fusion. Two commonly used cage types are the standalone cage and the ICP system.[9]

The material of these cages is composed of PEEK. Anterior cervical discectomy and interbody fusion using PEEK anatomical cervical cages can be considered a safe and effective technique to cure cervical disc herniation.[10]

Song *et al*. conducted the study on a total of 78 consecutive patients with cervical radiculopathy who underwent either 1- or 2-level ACDF-cage alone (CA) or ACDF-cage plate construct (CPC). The study compared the effectiveness of two surgical approaches for ACDF. The results showed that ACDF-CPC had a higher fusion rate, decreased segmental kyphosis, increased disc height, lower subsidence rate, and fewer complications compared to ACDF-CA. However, there was no significant difference in clinical outcomes between the two groups.[11]

Furthermore, Cheung *et al*. administered a systematic review and meta-analysis comparing clinical and radiographic outcomes of ACDF using a standalone interbody cage versus a conventional cage and anterior cervical plate technique. Nineteen studies met the inclusion criteria. The results

**Table 2: Preoperative, 3 days' and 3 months' postoperative spinal measures**

| Spinal measure | Perfect-C cage ($n$=15) | Conventional cage ($n$=17) | $P$ |
|---|---|---|---|
| C2–C7 lordosis change (°) | | | |
| Preoperative | 6.13±2.6 | 5.35±3.1 | 0.114 |
| 3-day postoperative | 13.04±3.8 | 12.03±3 | 0.073 |
| 3-month postoperative | 16.33±3.3 | 11.75±3.08 | 0.001 |
| Local cervical lordosis change (°) | | | |
| Preoperative | −2.13±6.4 | −2.82±5 | 0.001 |
| 3-day postoperative | 4.61±4.45 | 3.48±2.87 | 0.163 |
| 3-month postoperative | 4.57±4 | 3.35±2.9 | 0.241 |
| Lumbar lordosis (°) | | | |
| Preoperative | 45.8±4.7 | 47.18±8.6 | 0.556 |
| 3-day postoperative | 48±4 | 49.08±8.31 | 0.297 |
| 3-month postoperative | 48.01±4.6 | 48.38±7.3 | 0.198 |
| Thoracic kyphosis (°) | | | |
| Preoperative | 35.07±1.1 | 36.71±4.1 | 0.251 |
| 3-day postoperative | 36.27±1.22 | 37.62±4.32 | 0.335 |
| 3-month postoperative | 36.17±1.7 | 37.51±3.57 | 0.091 |
| C7-S1 SVA (mm) | | | |
| Preoperative | 14.07±13.6 | 15.71±15 | 0.835 |
| 3-day postoperative | 11.97±12.3 | 13.5±8.54 | 0.880 |
| 3-month postoperative | 12.17±10 | 13.41±6.68 | 0.719 |
| Sacral slope (°) | | | |
| Preoperative | 33.53±3 | 35.24±4.4 | 0.047 |
| 3-day postoperative | 35.54±2.97 | 37.54±4.63 | 0.049 |
| 3-month postoperative | 35.83±2.96 | 37.44±4.52 | 0.086 |
| Pelvic tilt (°) | | | |
| Preoperative | 15.13±2.42 | 15.94±3.15 | 0.292 |
| 3-day postoperative | 12.93±2.3 | 13.64±2.55 | 0.090 |
| 3-month postoperative | 12.63±2.9 | 14.64±2.6 | 0.045 |

Data are demonstrated with mean±SD; $P<0.05$ is considered statistically significant. SVA - Sagittal vertical axis; SD - Standard deviation

**Table 3: Effect of cage type on the alterations of spinal measures 3 days after anterior cervical discectomy and fusion**

| Spinal measure | Perfect-C cage ($n$=15) | Conventional cage ($n$=17) | $P$ |
|---|---|---|---|
| C2–C7 lordosis change (°) | 6.9±5.1 | 6.68±3.1 | 0.441 |
| Local cervical lordosis change (°) | 6.74±3.2 | 6.3±4.6 | 0.321 |
| Lumbar lordosis change (°) | 2.2±2.9 | 1.9±2.7 | 0.324 |
| Thoracic kyphosis change (°) | 1.2±1.1 | 0.9±2.4 | 0.377 |
| C7-S1 SVA change (mm) | −2.1±7 | −2.2±5.3 | 0.940 |
| Sacral slope change (°) | 2±2.9 | 2.3±1 | 0.124 |
| Pelvic tilt change (°) | −2.2±1.6 | −2.3±1.8 | 0.219 |

Data are demonstrated with mean±SD; $P<0.05$ is considered statistically significant. SVA - Sagittal vertical axis; SD - Standard deviation

showed that ACDF with a standalone cage had lower rates of postoperative dysphagia and adjacent segment disease compared to ACDF with a cage-plate technique. However, the cage-plate technique had better radiographic outcomes with less subsidence and improved restoration of cervical lordosis. There were no other significant differences in outcomes or complications. Overall, ACDF with a stand-alone cage showed better clinical outcomes, while the cage-plate technique had better radiographic outcomes.[1] Noh and Zhang demonstrated that Perfectc-C has less cage subsidence in comparison to conventional cage and accordingly less loss of alignment correction.[4]

Faldini *et al*., in a study on 107 patients concluded that restoration of cervical lordosis after ACDF has a protective effect on adjacent segment degeneration.[12]

In terms of the type of cage used, the our results demonstrated significant differences in certain spinal measures between patients treated with a conventional interbody cage versus those treated with Perfect-C. In early postoperative imaging measures despite alteration of all sagittal spinal alignment indices, there is no significant differences between the two groups. This can be due to the spacer effect of different types of interbody cages.

This study implies that after 3 months the type of cage utilized in ACDF impacts the restoration of local and total cervical lordosis, as well as global spine measures. The type of cage used influences the degree of correction in cervical lordosis and the change in lumbar lordosis and pelvic tilt. Perfect-C cages lead to higher total cervical lordosis

**Table 4: Effect of cage type on the alterations of spinal measures 3 months after anterior cervical discectomy and fusion**

| Spinal measure | Perfect-C cage ($n$=15) | Conventional cage ($n$=17) | $P$ |
|---|---|---|---|
| C2–C7 lordosis change (°) | 10.2±4.9 | 6.45±2.9 | 0.001 |
| Local cervical lordosis change (°) | 6.7±2.8 | 6.17±4.6 | 0.067 |
| Lumbar lordosis change (°) | 2.3±1.9 | 1.2±1.3 | 0.029 |
| Thoracic kyphosis change (°) | 1.1±1.1 | 0.8±1.4 | 0.377 |
| C7-S1 SVA change (mm) | −1.9±9.3 | −2.3±6.7 | 0.940 |
| Sacral slope change (°) | 2.3±1.6 | 2.2±1.3 | 0.124 |
| Pelvic tilt change (°) | −2.5±1.7 | −1.3±1 | 0.049 |

Data are demonstrated with mean±SD; $P<0.05$ is considered statistically significant. SVA - Sagittal vertical axis; SD - Standard deviation

correction ($P$ = 0.001), with greater changes in lumbar lordosis ($P$ = 0.029) and pelvic tilt ($P$ = 0.049). Patients with Perfect-C cages had better local cervical lordosis maintenance but this was not statistically significant ($P$ = 0.067). However, no significant differences were observed in other spinal measures such as thoracic kyphosis, C7-S1 SVA, and sacral slope between the groups. These may be an implication of better local biomechanical stability and lesser micro-subsidence in Perfect-C cages.

Global spinal alignment, including the whole-spine sagittal alignment and pelvic alignment, was significantly altered 3 months after ACDF. Cage type had a significant effect on the correction of global spinal alignment following the ACDF, and this effect was pronounced in pelvic alignment so that pelvic tilt alteration was significantly more in patients for whom a Perfect-C cage was used.

It is important to consider these findings as the limitations of the study. Further research and larger sample sizes are necessary to validate and generalize the observed effects. In addition, a long-term follow-up should be managed to assess the sustained impact of the number of fusion levels and cage type on spinal measures after ACDF. Nonetheless, these findings offer valuable insights into the influence of these variables on the restoration of cervical lordosis and global spine alignment.

## CONCLUSION

In patients with cervical disc herniation who undergo ACDF, the global spinal alignment is affected by the change of cervical alignment, and these alterations are affected by cage type. The pelvic tilt is the most affected parameter in this association, so more significant changes in pelvic tilt are observed in ICP.

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Nil.

## Conflicts of interest

There are no conflicts of interest.

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