Ann Med Res

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Annals of Medical Research

journal page: www.annalsmedres.org

The improvement rates in disc height and lordotic angle following anterior cervical discectomy and fusion with disc prosthesis

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ARTICLE INFO

Keywords:
Anterior cervical fusion
Cervical kyphosis
Cervical lordosis
Sagittal vertical axis
Cervical disc prosthesis

Received: Oct 31, 2024
Accepted: Dec 12, 2024
Available Online: 25.12.2024

DOI:
10.5455/annalsmedres.2024.10.232

Abstract

Aim: The objective of this study is to illustrate the impact of disc prosthesis instrumentation in the intervertebral disc space following discectomy on cervical lordosis (CL) as observed in radiographic images by measuring the Cobb angle and cervical disc height taken before and after surgery. Furthermore, the study seeks to evaluate the functionality of the disc prosthesis employed. The objective was to evaluate the functionality of the surgical procedure and the type of disc prosthesis employed.

Materials and Methods: A total of 106 patients with cervical disc herniation who underwent surgical intervention using cervical disc prostheses were included in the study. Pre- and post-surgical lateral direct radiographic evaluations were obtained from each patient. The following variables were recorded for evaluation: preoperative Cobb angles, cervical disc height, surgical level, age, and gender.

Results: The most frequent site of cervical disc operation was the C5-6 level. There was a significant increase in the cervical Cobb angle after surgery, as well as a significant increase in postoperative disc height in comparison to preoperative values. The change in Cobb angle and disc height was found to be statistically significant ($p<0.05$).

Conclusion: A variety of cervical interbody grafts are currently in use. The use of cervical disc prostheses in cervical disc herniation surgery allows achieving optimum lordotic angulation. There is a continued need for new studies to support our physical examination findinds on the long-term clinical follow-up.

Introduction

Cervical disc herniation (CDH) results from the displacement of the nucleus pulposus into the spinal canal and posteriorly. Disc herniation is frequently observed in the lumbar region but it can also be seen in the cervical region. The compression of the nucleus pulposus may either occur towards the roots or the right and left canal. The severity of compression determines whether the muscle that is innervated is weakened, or where the pain and paresthesias will radiate in the upper extremity.

CDH has a major impact on the social activities of adults. Approximately 1 in 1,000 individuals may experience cervical disc-related pain in middle-aged population which results in considerable economic costs [1]. The size and position of the herniated disc, along with the compressed nerves, can result in a wide range of symptoms [2]. The treatment algorithm of the patients with CDH includes medical therapy, physical therapy, and surgery. Depending on the severity and type of symptoms, surgical therapy may become a viable option for patients who have not responded to conservative treatment [3].

Anterior cervical discectomy (ACD) and instrumented fusion is the standard surgical therapy for cervical disc herniation [4]. In recent years, the development of versatile biomaterials suitable for use in spinal surgery has led to the increased utilization of cervical disc prostheses and cervical cage instruments. These devices are designed to reduce the incidence of adjacent segment degeneration which is an unavoidable consequence of the surgical intervention. It offers a comfortable life to the patient by increasing the range of motion (ROM) of the cervical vertebra. The system allows for surgery to be performed under optimal con-

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ditions using the necessary materials, enabling individual adjustments to dimensions.

Studies have shown that there is a decrease in the total range of motion (ROM) of the operated cervical segment over time following anterior cervical discectomy and fusion (ACDF), while the ROM of the adjacent cervical spine increases. Following ACDF, the stress peak on the adjacent segments of the intervertebral disc and facet joint significantly increases, altering the shear stress on the intact cervical vertebra. Consequently, this affects the adjacent cervical segment. The incidence of symptomatic adjacent segment disease after ACDF is approximately 25% [5]. However, the incidence of adjacent cervical spine disease requiring re-surgery is even much lower [6].

Lim et al. [7] conducted a comparative analysis of the 30-day outcomes following anterior cervical surgery, reviewing 2352 elective cases of cervical spondylosis. They discussed the outcomes of discectomy and fusion, both with and without instrumentation. The results demonstrated that the 30-day outcomes were comparable between the two cohorts, indicating that the additional instrumentation step did not significantly influence the occurrence of postoperative complications in cervical spondylosis. It was concluded that instrumentation could be safely performed without concerns about postoperative complications. There are several techniques to measure cervical lordosis. Among these measurements are the Harrison posterior tangent, the Jackson physiological stress line and the Cobb angle. The C2-C7 Cobb angle is the preferred method to assess lordosis and kyphosis in cervical spine. The Cobb angle is measured by drawing two parallel lines extending through the inferior endplates of the C2 (uppermost vertebra) and C7 (lowermost vertebra). The angle at the intersection of these two lines is the Cobb angle, which indicates the degree of lordosis of the cervical vertebra [8]. Despite the alterations in the sagittal alignment of the cervical region, the Lordotic angle (Cobb) ranges between 20-35 degrees and is typically maintained in the spine. Kyphosis is defined when the Cobb angle is less than 0°, meaning a negative Cobb angle value indicates the presence of kyphosis [9,10].

In this study, we aimed to evaluate the impact of disc prosthesis instrumentation on intervertebral disc space following discectomy by measuring the Cobb angle to assess cervical lordosis (CL) both preoperatively and postoperatively.

Materials and Methods

A retrospective study was conducted on patients who had undergone surgery for the treatment of cervical disc herniation and ACDF between January 2018 and March 2024. Radiographic images obtained before and after the surgical procedures were analyzed by members of our team. We included patients aged between 18 and 75 years who had undergone surgery for cervical disc herniation in the study. Patients with a history of trauma, tumors, myelopathy, or spondylolisthesis due to neurological disease were excluded from the study. A total of 106 patients who were operated on during the study period were included. The study was approved by the local ethics committee (Kayseri City Hospital Non-Invasive Clinical Research Ethics Committee, approval number: 21.02.2024-76397871). We strictly adhered to the principles set forth in the 1975 Declaration of Helsinki, as revised in 1983.

Determination of the surgical indication

The indications for surgery for cervical disc herniation include motor loss, long-standing tract disease, severe and refractory radicular pain, worsening radicular pain and symptoms despite at least three weeks of conservative treatment, and changes observed on imaging studies. Patients with advanced spondylosis, discopathy due to cervical trauma, a history of secondary cervical disease, and those with anterior plate application were not treated surgically.

Processing of images

Cervical lateral direct radiographs of the participants were routinely obtained during the preoperative and postoperative sixth week to evaluate the localization and function of the prosthesis. The radiographic measurements, including the Cobb angle and cervical disc height, were determined directly from the X-rays with patients in a neutral position by a radiologist with at least 10 years of experience (Figures 1-4). Pre- and postoperative Cobb angles, cervical disc height, the level of the operated cervical spine, age, and gender of the patients were recorded.

Statistical analysis

The normal distribution of the continuous variables was evaluated using the Shapiro-Wilk test. Descriptive statis-

Figure 1. Preoperative images showing cervical disc height, sagittal direct radiograph.

Figure 2. Postoperative image showing cervical disc height, sagittal direct radiograph.

Figure 3. Preoperative images showing cervical lordotic angle measurement on sagittal direct radiograph.

Figure 4. Postoperative. images showing cervical lordotic angle measurement on sagittal direct radiograph.

tics included frequency, percentage, mean value, standard deviation, median value, and the highest and lowest (min-max) values. Continuous variables are expressed as mean ± standard deviation and median (range: minimum, maximum). Categorical variables are expressed as the number of affected individuals and the percentage of the population. The Wilcoxon test was used to evaluate the presence of differences in continuous variables between preoperative and postoperative measurements. The Mann-Whitney U test was used for independent sample comparisons of the continuous variables. Any p-value less than 0.05 was considered statistically significant. All statistical analyses were performed using the Statistical Package for the Social Sciences version 22 (SPSS v 22) (IBM, USA).

Results

In total, 106 patients were included in the study. Fifty-one (48.1%) patients were female, and 55 (51.9%) were male. The average age of the patients was 50.43 ± 10.95 years (range: 28-79 years). The most frequently operated cervical spine site was the C5-6 level (52.8%), with the operation sites summarized in Table 1.

We compared the preoperative and postoperative lordotic angles. The mean preoperative Cobb angle was 6.88 ± 9.13 mm (range: -12 to 29.10 mm), while the postoperative Cobb angle was 10.26 ± 8.42 mm (range: -8 to 29.3 mm). The Cobb angle showed a significant increase after surgery ($p<0.05$). The average preoperative disc height was 5.06

Table 1. Surgery of the site of cervical spine.

C2-3		C3-4		C4-5		C5-6		C6-7	
n	%	n	%	n	%	n	%	n	%
4	3.8	9	8.5	16	15.1	56	52.08	21	19.8

Table 2. Preoperative and postoperative change of Cobb angles and disc heights.

Patients who underwent surgery					
Measurements	Mean±SD	Min/max	Median	Z	p
Cobb angle preoperative	6.88±9.13	-12.00/29.10	7.05	-4.516	**<0.001**
Cobb angle postoperative	10.26±8.42	-8.00/29.30	11.05		
Disc height preoperative	5.06±0.96	3.10/7.60	5.05	-8.897	**<0.001**
Disc height postoperative	6.82±0.94	4.60/9.50	6.90		

*Wilcoxon Signed Ranks Test.

Table 3. Preoperative and postoperative change in cervical Cobb angles and disc heights according to gender of the patients.

Patients who underwent surgery					
Measurements in Females (n: 51)	Mean±SD	Min/max	Median	Z	p
Cobb angle preoperative	5.24±8.64	-12.00/24.60	3.70	-4.363	**<0.001**
Cobb angle postoperative	10.93±8.39	-4.20/29.30	11.40		
Disc height preoperative	4.79±0.89	3.20/6.70	4.90	-6.216	**<0.001**
Disc height postoperative	6.76±0.97	4.60/9.50	6.90		
Measurements in Males (n:55)	Mean±SD	Min/max	Median	Z	p
Cobb angle preoperative	8.40±9.38	-9.70/29.10	8.50	-1.759	0.079
Cobb angle postoperative	9.63±8.47	-8.00/29.00	10.60		
Disc height preoperative	5.13±0.96	3.10/7.60	5.20	-6.395	**<0.001**
Disc height postoperative	6.89±0.91	4.80/8.70	7.00		

*Wilcoxon Signed Ranks Test.

Table 4. Preoperative and postoperative Cobb angles and disc heights and their variation among different genders.

Preoperative and postoperative difference	Females			Males		
	Mean±SD	Min/max	Median	Mean±SD	Min/max	Median
Cobb angle	5.69±7.97	-8.50/27.70	4.10	1.23±5.26	-12.90/14.60	1.20
			p: 0.003			
Disc height	1.97±1.09	0.20/5.10	1.90	1.58±1.04	0.0/4.10	1.30
			p: 0.063			

*Mann Whitney U test.

± 0.96 cm, and the postoperative disc height was 6.82 ± 0.94 cm. The disc height also increased significantly postoperatively ($p<0.05$).

The data regarding the preoperative and postoperative Cobb angles and disc heights are summarized in Table 2.

The changes in preoperative and postoperative Cobb angles and disc height varied according to the gender of the patients. There was no significant difference in the cervical Cobb angle before and after surgery in males ($p>0.05$). However, the changes in disc height in males before and after surgery were significant ($p<0.05$) (Table 3). The change in Cobb angles in females from the preoperative to the postoperative period was 3.38 ± 7.04 (range: -12.90 to 27.70), and this change was significantly higher in women than men. The preoperative to postoperative change in disc heights was 1.76 ± 1.08 (range: 0.00 to 5.10), and this change was not significant in terms of gender (Table 4).

Discussion

Anterior cervical discectomy and fusion (ACDF) is one of the most frequently performed surgical procedures on the spine [11]. The objective of this procedure is to correct a cervical kyphotic deformity and alleviate pain. This can be achieved by using various in-body devices, including cervical disc prostheses and cervical cage instruments.Our

results demonstrated that the application of a cervical disc prosthesis as a lordotic allograft supports the sagittal anatomical contours of the spine and maintains disc height.Our results showed that the application of the disc prosthesis resulted in a positive increase and improvement in the lordotic angle. The treatment of choice for cervical disc herniation and radiculopathy is ACDF [12]. Simple discectomy, or disc surgery without fusion, is still employed in the treatment of cervical disc pathologies. However, the remaining space may be susceptible to complications such as segmental kyphosis and axial neck pain. The resulting segmental kyphosis causes collapse of the disc space, restenosis in the foramen, and relapse of symptoms [13]. However, the interbody instrument applied in the early period re-establishes the disc height, thereby resulting in an improvement in the Cobb angle. This improvement is especially prominent in females, as shown by the results of our study. In a study by Zaidi et al. [14], the results of radiographic evaluations conducted at six weeks post-procedure in 48 patients who had undergone anterior cervical discectomy and fusion were presented. They showed a change of +2.37° and +1.53° in global and segmental lordosis, respectively. In another study by Tacyıldız et al. [15], it was shown that the anatomical features and cervical sagittal alignment of the spine in textile workers had significant deterioration in cervical lordosis. They emphasized that prolonged neck flexion during textile work was a contributing factor to the prevalence of pain and distorted Cobb C2-7 angles. They also used VAS scores to support their findings [15]. ACDF is a highly effective and safe surgical treatment option for degenerative cervical pathologies. Its use is associated with a high rate of excellent clinical results when an interbody device is utilized during surgery [16]. The initial report on the anterior approach to the cervical spine was presented by Robinson and Smith [12]. These devices are employed in the reconstruction and restoration of cervical lordosis. In the early years of this field, a straightforward approach was used with fibula grafts, including iliac crest grafts and autografts, for cervical interbody fusion. The use of autografts has been a standard practice for decades due to their superior bone fusion capabilities compared to other options [17]. In our study, a cervical disc prosthesis of appropriate size for the patient was used in all cases. Grob et al. [18] randomly divided their cohort into two groups: those with (n=54) and without (n=53) axial pain. The cervical and segmental axis angles did not statistically change among different genders. They showed an increase in cervical lordosis with age in female patients. In our study, there was no improvement in Cobb angles in male patients before or after surgery, but there was an improvement in disc distance. Multiple factors may play a causative role in our observation, with the most important being the random selection of our patients without evaluation regarding their professions.

The primary objective of cervical spine disc replacement is to preserve segmental flexibility. Pitzen et al. [19] conducted a comprehensive examination of radiographic, biomechanical, and morphological findings 12 weeks following the implantation of a cervical disc prosthesis. They showed that segmental mobility is maintained for three months following the procedure. The biomechanical structure of the cervical disc prosthesis allows the preservation of movement and fusion following discectomy, providing an advantage over previous techniques. In this study, the focus was on the radiological parameters of the patients, rather than the range of motion of the joints evaluated by physical examination. Although a significant change in disc height was observed in the postoperative plain radiographs, this change was not statistically significant when analyzed by gender. Richter et al. [20] evaluated the clinical outcomes of anterior cervical fusion surgery using dynamic and non-dynamic cervical implants in patients with cervical degenerative disorders. Their findings showed that both procedures had comparable results. In the long term, adjacent segment disease can be observed following ACDF surgeries. Nevertheless, the documented fusion rates for single-level ACDF procedures have not yet reached 100%. Pitzen et al. [21] showed that the fusion rate is correlated with implant complications, including screw shear, screw fracture, and pseudarthrosis, which may be more prevalent in patients with delayed fusion. These observations emphasize the paramount importance of early bone fusion in ACDF. Rodway et al. [22] conducted a comparative analysis of two consecutive cohorts that underwent cervical anterior discectomy and fusion surgery using a composite allograft interbody spacer. They used two distinct allografts: i) one stored and frozen until the time of surgery, and ii) the other preserved with glycerol and provided at room temperature. The similarity in fusion rates observed in the short term indicated that both treatments were comparable.

Cervical kyphosis can result in several adverse outcomes, including spinal instability, spinal cord injury, and disability. Correcting cervical kyphosis is a technically demanding procedure, especially in severe cases. Lau et al. [23] employed the anterior sequential interbody dilation technique for the treatment of cervical kyphosis, resulting in an improvement of 24.7° in patients with severe preoperative kyphosis, 17.8° in those with moderate kyphosis, and 10.1° in those with mild kyphosis. They also showed a significant improvement in postoperative Cobb angle.

In addition to the measurement of the cervical lordotic angle, the formation of fusion has been examined on numerous occasions using a variety of techniques. In a prospective, multicenter study, Vanichkachorn et al. [24] placed an interbody spacer, which was used in bone grafts in 31 patients who underwent single-level ACDF with PEEK interbody spacer and complementary anterior fixation. A high rate of fusion success was observed at a single vertebral level.

Following anterior cervical discectomy and fusion, the most important indicator of patient satisfaction is the rapid improvement of radicular symptoms. Axial pain may persist in some patients, but to a lesser degree. The dreaded complication of this condition is the abnormal alignment and angulation of the cervical vertebrae after surgery, which may lead to potential limitations in movement that can develop after fusion. The postoperative satisfaction rate was observed to be high in our patients, underscoring the importance of correct surgical indication in these cases.

The natural lordotic angle of the cervical spine is altered when degenerative changes develop. This phenomenon, known as cervical kyphosis, causes compression of the spinal cord, thereby impairing mobility in the cervical region [8]. The prostheses used in cervical disc herniation surgery can help achieve optimal alignment and lordotic angles.

Limitations

Although the sample size was 106, the use of a cervical disc prosthesis in all patients increases the study's specificity. The exclusion of a physical examination from the study, coupled with the inclusion of only postoperative radiographic evaluation at the 6th postoperative week, prevented us from evaluating the extent of cervical mobility. Therefore, the short follow-up period and lack of physical examination findings are the limitations of our study. However, our results emphasize the need for further studies investigating the changes in physical examination following the application of disc prostheses.

Conclusion

In this concise yet potentially valuable study, we present evidence showing that the cervical disc prosthesis significantly improves radiographic outcomes after surgery inpatients with disc herniation. Improvement in the cervical lordotic angle prominent. There is a clear need for further studies that support our findings with the evidence including physical examination results and and prolonged follow up periods.

Acknowledgements

Not applicable.

Data availability statement

Not applicable.

Financial support and sponsorship

No fundings.

Presentation

None.

Human ethics and consent to participate declarations

Not applicable (retrospective study).

Ethical approval

Ethical approval for this study (approval number: 21.02.2024-76397871 numbered) was provided by the Ethical Committee of Kayseri City Hospital Non-Invasive Clinical Research.

Author contributions

Detailing the work; project preparation, data collection, writing scientific papers, Exp.Dr. Şule Göktürk has contributions. Exp.Dr. Yasin Göktürk contributed to the collection of data and writing and proof reading the scientific paper in the project. Assoc.Prof.Dr. Ali Koç contributed to project with the preparation of radiographic data, Assoc.Prof.Dr. Kagan Kamasak contributed to data collection with his operated patients, PhD. Ahmet Payas contributed with data related to anatomy and made the proof read of manuscript, Exp.Dr. Belgin Oral contributed to statistical analyses, preparing the tables and graphics.

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