

Surgical Strategy and Clinical Efficacy Analysis of Adjacent Segment Disease After Anterior Cervical Discectomy and Fusion

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Abstract

Background: There are relatively few studies on the treatment of symptomatic adjacent segment disease(ASD) after anterior cervical discectomy and fusion(ACDF). The purpose of this study to compare the clinical efficacy of zero-profile(zero-p) intervertebral fusion and titanium plate combined with cage fusion for treating ASD after ACDF.

Methods: Retrospective analysis was performed on patients who underwent ACDF and readmission due to concurrent symptomatic ASD from October 2014 to June 2019. Among them, 12 cases underwent anterior cervical decompression with zero-p intervertebral fusion (zero-p group), and 14 cases underwent anterior cervical decompression with titanium plate combined with cage fusion (titanium plate group). Operative time, intraoperative blood loss, postoperative Japanese Orthopaedic Association (JOA) score, visual analogue scale (VAS) scores, neck disability index (NDI), dysphagia Bazaz grade, bone graft fusion Eck grade, C2-C7 Cobb Angle, and related complications were compared between the two groups.

Results: The intraoperative blood loss difference between the two groups was not statistically significant ($P>0.05$). The operation time of the zero-p group was shorter than that of the titanium plate group, with significant differences($P<0.05$). The Bazaz classification of dysphagia in the zero-p group was superior to the titanium plate group 1 month after the operation, and the difference was statistically significant ($P<0.05$); However, there was no statistically significant difference between the two groups in the Bazaz classification of dysphagia and the bone graft fusion Eck grade at the last follow-up ($P>0.05$). At the last follow-up, the JOA score, VAS score, NDI index, C2-C7 Cobb Angle were significantly different between the zero-P group and the titanium plate group ($P<0.05$). However, no significant difference was found between the two groups ($P>0.05$). During the follow-up period, all the patients did not have a rupture of the settler screw and esophageal injury and other related diseases.

Conclusions: Both methods can achieve good clinical efficacy in the treatment of symptomatic ASD, and can restore and maintain the physiological curvature of the cervical spine to a certain extent. However, the advantages of zero-p intervertebral fusion including shorter operation time, reducing soft tissue injury, and less postoperative dysphagia.

1. Background

Anterior cervical discectomy and fusion (ACDF) was first proposed by Robinson and Smith[1]. As its good clinical effect, it has become a classic operation for the treatment of cervical spondylotic radiculopathy, cervical spondylotic myelopathy, cervical disc herniation, cervical trauma, and other cervical degenerative diseases since its clinical application in 1950[2]. ACDF has the advantages of sufficient spinal cord and nerve decompression, maintaining or even rebuilding spinal stability, restoring, and maintaining cervical physiological lordosis[3, 4]. Though favored by most surgeons, one cannot deny that the major shortcoming of ACDF is the potential disrupture on the biomechanical characteristics of the cervical vertebra. Clinical and biomechanical studies have shown that increased mobility, intervertebral disc

pressure, and stress in adjacent segments following ACDF surgery may accelerate the degeneration of adjacent segments[5, 6]. With the study of large-scale clinical cases and the extension of follow-up time, reports on ASD after ACDF surgery also increase year by year, affecting the long-term outcome of the surgery[7]. Moreover, ASD is an important cause of recurrence of symptoms after ACDF surgery, and symptomatic ASD often requires secondary surgical treatment. However, A lot of treatment strategies have been suggested for ASD, while there is no uniform standard operation at present[8]. The treatment strategies included repeated ACDF, zero-profile intervertebral fusion system (zero-P), anterior cervical corpectomy and fusion(ACCF), and stand-alone cage implantation[4–6, 9, 10]. This study retrospectively analyzed 26 patients of symptomatic ASD who underwent reoperation after ACDF in the First Affiliated Hospital of Zhengzhou University from October 2014 to June 2019. There were 12 cases in the zero-profile group and 14 cases in the titanium plate group. The clinical effectiveness and radiological results of these two operations were compared, and are reported as follows:

2. Materials And Methods

2.1 Inclusion and exclusion criteria

2.1.1 Inclusion criteria: Meet the diagnostic criteria for symptomatic ASD[11]; No severe ossification of the posterior longitudinal ligament or the ligamentum flavum; Conventional conservative treatment for 3 to 6 months showed no significant relief of symptoms; The follow-up data were complete and the follow-up time was ≥ 12 months.

2.1.2 exclusion criteria: Multisegmental spinal cord compression, severe ossification of the posterior longitudinal ligament and/or the ligamentum flavum, requiring posterior surgery; Imaging confirmed the presence of severe cervical instability and cervical canal stenosis; Receiving ACDF for other non-degenerative factors such as trauma, tumor tuberculosis or infection; Initial operative segment number ≥ 2 or operative segment number ≥ 3 ; Patients who have difficulty dysphagia before reoperation or who have the severe organic disease and cannot tolerate the operation.

2.2 Preoperative data

This study had been approved by the ethics committee of The First Affiliated Hospital of Zhengzhou University. There is no need to obtain informed consent from patients because this is a retrospective study and all data were collected and analyzed anonymously. According to the inclusion and exclusion criteria, the complete follow-up data of 26 patients who underwent repeated ACDF treatment due to symptomatic ASD in the department of Orthopaedics, The First Affiliated Hospital of Zhengzhou University from October 2014 to June 2019 were retrospectively analyzed. There were 12 cases in the zero-p group and 14 cases in the titanium plate group. All patients underwent anterior and lateral cervical and hyperextension and flexion digital imaging, 64-slice spiral CT plain scan, and three-dimensional reconstruction, and 1.5T magnetic resonance imaging (MRI) scan.

2.3 surgical procedure

Zero-p group: All patients were treated using a standard anterior approach to the cervical spine. After successful general anesthesia, The patient was placed supine with mild neck extension. and The affected discs were exposed using the anterior right middle transverse incision. The anterior cervical automatic retractor opened the corresponding vertebral body, the affected intervertebral disc and posterior longitudinal ligament were scraped, the nucleus pulposus tissue of prolapse into the spinal canal was removed, The appropriate zero-p(ROI-C) filled with autologous bone fragments was implanted into the prepared intervertebral space. The anterior cervical zero-p(ROI-C) was firmly fixed after confirming the ideal position of the implant(Fig. 1C and 1D). Titanium plate group: The original fixed titanium plate and screw were completely removed and discarded based on the zero-p group. Like the zero-p group. A properly sized intervertebral fusion cage filled with autologous bone fragments was inserted into the responsibility gap. Titanium plates of appropriate length were selected and fixed in front of the cervical spine with screws of appropriate length(Fig. 1A and 1B).

The two groups were routinely treated with antibiotics and neurotrophic drugs for 3-5d after surgery. The drainage tablets were removed 24 h after surgery, and the drainage tube was removed 48 h after surgery. On the second day after the operation, Ambulation was allowed. The anterior and lateral X-ray examination of the cervical spine was reviewed on the 5th day after the operation. whereas external immobilization of the cervical spine was kept for 8 to 12 weeks with a cervical collar.

2.4 Evaluation criteria

The operative time and intraoperative blood loss were compared between the two groups. JOA score was used to evaluate the recovery of spinal nerve function after surgery, and the improvement rate (IR) was calculated to evaluate the improvement of spinal nerve function after surgery. The IR of the JOA score was calculated according to the formula as follows: $IR = (\text{postoperative score} - \text{preoperative score}) / (17 - \text{preoperative score}) \times 100\%$. And the recovery rates were graded as follows: 75% and greater, excellent; 50–74%, good; 25–49%, fair; and less than 25%, poor[4]. VAS score was used to evaluate the subjective perception of neck and shoulder pain. The NDI index was used to assess the degree of cervical functional limitation. Cervical curvature was represented by C2-C7cobb Angle: which was the intersection angle of the tangent line between the C2 centrum inferior margin and the C7 centrum inferior margin(Fig. 2). The above indicators were collected at two-time points of preoperative and final follow-up, and comparisons were made between groups and within groups. The occurrence of postoperative dysphagia related complications was evaluated by the Bazaz dysphagia score. The incidence of postoperative dysphagia and the duration of symptoms were calculated. Bone graft fusion Eck grade at the last postoperative follow-up was compared between the two groups.

2.5 Statistical Methods

All data were collected, and the software by SPSS Version 25.0 (SPSS Inc. Chicago, IL) was used for the statistical evaluation. Results were presented as mean \pm SD. A Paired sample t-test was used for intra-

group comparison, and The independent two-sample t-test was used to identify a significant difference between the groups. Categorical data were compared via the chi-square test (Fisher exact test for small samples). A rank-sum test was used for comparison of grade data. In all analyses, p-value < 0.05 was regarded as statistically significant.

3. Results

This retrospective study included 26 patients consisting of 17 men and 9 women with a mean age at reoperation of 54.15(41–68) years. After the reoperation, the patients were followed up with an average of 33.18 months(range 12–71 months). all patients had a single primary fused level. The adjacent levels are shown in Table 1. Of these 26 patients, there were 12 patients in the zero-p group and 14 patients in the titanium plate group. No significant differences existed in gender(P = 1.00), age(t=-1.00,P = 0.327), preoperative JOA score(t = 0.571,P = 0.573), preoperative VAS score(t=-0.151,P = 0.882), preoperative NDI(t=-0.42,P = 0.967), and preoperative C2-C7cobb Angle(t = 1.002,P = 0.326) between the two groups(Tables 1 and 2).

Table 1 General statistical data of patients

	Zero-p(n = 12)	titanium plate(n = 14)
Age(years)	52.33 ± 8.41	55.71 ± 8.75 [□]
Sex(men/women)	8/4	9/5 [□]
Follow-up (months)	25.67 ± 20.60	40.00 ± 20.21 [□]
The reoperation time (min)	95.83 ± 5.47	121.26 ± 8.24 [□]
The bleeding volume (ml)	70.00 ± 34.11	72.14 ± 30.43 [□]
Lesion segment level		
C2/3	0	1
C3/4	1	2
C4/5	3	6
C5/6	4	2
C6/7	4	3
Note: [□] Comparing these two groups P > 0.05; [□] Comparing these two groups P < 0.05		

Table 2

The comparison of different parameters between two group at the preoperation and final follow-up

	Preoperation		Final follow-up	
	Zero-p (n = 12)	titanium plate (n = 14)	Zero-p (n = 12)	titanium plate (n = 14)
JOA score(points)	9.50 ± 1.31	9.14 ± 1.79 [□]	14.33 ± 0.78 [□]	14.71 ± 0.73 ^{□□}
VAS score(points)	5.33 ± 1.67	5.43 ± 1.55 [□]	0.83 ± 0.72 [□]	1.57 ± 0.94 ^{□□}
neck disability index(%)	43.62 ± 9.32	43.76 ± 8.47 [□]	14.99 ± 3.26 [□]	14.22 ± 4.59 ^{□□}
C2-C7 Cobb Angle(°)	8.26 ± 2.92	5.53 ± 9.04 [□]	14.80 ± 4.18 [□]	14.68 ± 6.89 ^{□□}
Note: [□] The comparison between the two groups at the same time P > 0.05; ^{□□} compared with preoperation P < 0.05				

3.1 Clinical effectiveness evaluation

All 26 cases were followed up, with the zero-p group being followed up (25.67 ± 20.60) months and the titanium plate group being followed up (40.00 ± 20.21) months. In the zero-p group, the operative time was (95.83 ± 5.47) min and the intraoperative blood loss was (70.00 ± 34.11) ml. In the titanium plate group, the operative time was (121.26 ± 8.24) min, and the intraoperative blood loss was (72.14 ± 30.43) ml. The operation time of the zero-p group was less than titanium plate, with significant differences ($P < 0.05$); However, there was no statistically significant difference in intraoperative blood loss between the two groups ($P > 0.05$) (Table 1). During the follow-up period, all patients were free of morbidity related to screw loosening, fracture, and esophageal injury. On a postoperative day 7, 9 patients had different degrees of foreign body sensation in the throat and dysphagia. 1 patient in the zero-p group, graded by Bazaz: mild 1 case; 7 patients in the titanium plate group, graded by Bazaz: moderate 2 cases, mild 5 cases. The zero-p group was better than the titanium plate group, and the difference was statistically significant ($W = 126.00$, $P = 0.022$). All patients were treated conservatively and all symptoms disappeared at 3 months postoperative follow-up.

3.2 Radiological evaluation

At the last follow-up, intervertebral fusion was evaluated according to bone graft fusion Eck level: In the zero-p group, there were 8 cases of grade I and 4 cases of grade II. However, in the titanium plate group, There were 11 cases of grade I and 3 cases of grade II. No significant difference was found in the intervertebral fusion between the two groups ($W = 179.00$, $P = 0.504$). The C2-C7Cobb angle was significantly increased in both groups at the final postoperative follow-up compared with the preoperative period, and the difference was statistically significant ($P < 0.05$). However, There was no statistical

significance on the difference in the C2-C7 Cobb angle between the 2 groups at the final postoperative follow-up ($P > 0.05$), as shown in Table 2.

4. Discussion

ACDF has long been considered as the gold standard for the treatment of degenerative cervical spine diseases[2]. ACDF has the advantages of adequate decompression of the spinal cord and nerves, can maintain or even re-establish spinal stability, restore and maintain the physiological prognathism of the cervical spine. And it's a favorite of spinal surgeons[3, 4]. However, conventional procedures often use titanium plate fixation in the anterior cervical approach, which alters the biomechanical properties of the cervical spine and can accelerate the degeneration of the adjacent segments. A review of the literature, the imaging results of adjacent segmental degeneration after ACDF surgery can be as high as 92%[5, 12], and the reoperation for symptomatic ASD was ranged from 2.1–22%[5]. These results are largely in line with the studies by Hilibrand[13] and Goffin[14]. Previous studies have demonstrated that the development of ASD may be influenced by the number and location of fusion segments, plate-to-disc distances, preexisting degenerative changes at adjacent segments, and excessive disc space distraction[15]. However, Zero-p interbody fusion system features Low notch, self-anchoring, and a one-piece interbody fusion device that supports and fixes the segmental vertebrae[16]. It can be integrated into the intervertebral space without exceeding the anterior edge of the vertebral body, and no anterior titanium plate fixation is required, which can effectively avoid the injury and stimulation of the prevertebral soft tissue and esophagus caused by the traditional titanium plate, and avoid the influence of the traditional titanium plate on adjacent segments, thus effectively reducing the incidence of postoperative dysphagia and degeneration of adjacent segments of the cervical vertebra. The clinical effect of the zero-p intervertebral fusion system in the treatment of cervical degenerative diseases has been widely studied[16–18]. However, there are relatively fewer studies on symptomatic ASD after ACDF. Therefore, this study analyzed its clinical efficacy and radiological results in the application of symptomatic ASD and compared it with a traditional titanium plate combined with a cage.

Anterior cervical discectomy and fusion were mostly in C4/5, C5/6, and C6/7 segments, After ACDF, the stresses in the non-fused segments are redistributed, while the extension and rotation of the cervical spine extend from top to bottom with progressively decreasing mobility, so that degeneration occurs mostly the superior fused vertebrae[5, 19, 20]. This study followed 17 cases of superior ASD and 9 cases of inferior ASD. ASD occurred mostly in the superior adjacent segments. Besides, Hilibrand et al. found that C4/5, C5/6, and C6/7 spinal levels had a higher risk of developing symptomatic ASD than other segments[3, 5, 21]. A total of 22 cases (Table 1) of responsible segments were located in C4/5, C5/6, and C6/7 in the follow-up cases of this study, accounting for 84.62% of all cases. Consistent with the findings of Hilibrand et al.

Our study demonstrates that again ACDF is effective in improving neuro-spinal cord compression symptoms in symptomatic ASD patients, and achieve good clinical efficacy. In our study, both groups of patients achieved good symptomatic improvement and satisfactory neurological recovery after surgery,

and the postoperative JOA score, VAS score, and NDI index were significantly improved compared with the preoperative. Besides, the JOA improvement rate reached over 80% in both groups. However, the zero-p interbody fusion system also has some advantages of its own. ACDF with a zero-p intervertebral fusion system does not require removal of previous internal fixation, which can reduce the separation of scar tissue to a certain extent. Compared with conventional titanium plates combined with cage fusion, the operation time is significantly shortened, and intraoperative accidents can be reduced to a certain extent. This is consistent with the results of the retrospective studies by Wang[5] and Shen[4] et al. on post-ACDF complications of ASD while performing ACDF again, zero-p interbody fusion internal fixation significantly shortened the operative time. Dysphagia is a common complication after ACDF, and its incidence has been reported in the literature to be up to 67%[4, 5, 22]. the development of dysphagia may be influenced by postoperative soft-tissue edema, postoperative hematoma, esophageal injury, cervical plate implanting, the surrounding scar formation, and intraoperative pulling and irritation to the esophagus[5, 23, 24]. In this study, the incidence of postoperative dysphagia in the zero-p group in this study was 8.3%, which was significantly lower than the 50% in the titanium plate group. This advantage disappeared at the last follow-up. The analysis may be since the zero-p group did not require removal of previous internal fixation and reduced scar tissue separation and anterior cervical soft tissue injury relative to the titanium plate group. Besides, the operative time is significantly shortened, intraoperative pulling and irritation to the esophagus are reduced, and the zero-p fusion system does not extend beyond the anterior border of the vertebral body, reducing the irritation of the anterior titanium plate to the anterior cervical tissue and esophagus. The application of ACDF with a zero-p interbody fusion system is therefore very helpful in reducing the incidence of early dysphagia after symptomatic ASD surgery.

Anterior cervical lordosis is a protective factor in maintaining the stability of the cervical spine[22, 25]. Related studies have found a positive correlation between the loss of the C2-C7Cobb angle after ACDF and the development of ASD, and an increase in the C2-C7Cobb angle reduces the motion of adjacent segments, which in turn reduces the incidence of ASD[26, 27]. In the present study, the C2-C7Cobb angle was significantly increased in both groups after surgery compared with the preoperative, but no significant difference was seen between the 2 groups. Therefore, both the titanium plate group and the zero-p group are effective in improving and maintaining cervical curvature. However, this study also has some limitations. As a retrospective study, the sample size is small and the follow-up time is relatively short. Besides, Complications of ASD after repeat ACDF were not included in the statistics, and data measurement and case adoption may have been biased. Therefore conclusions still need to have large samples and long-term follow-up studies to obtain more reliable results and thus better guide clinical practice.

5. Conclusions

In summary, re-ACDF can achieve similar clinical and radiographic results as the initial ACDF. Moreover, anterior cervical decompression and zero-p intervertebral fusion and titanium plate combined with cage internal fixation can achieve good clinical results in the treatment of symptomatic ASD and can restore and maintain the physiological curvature of the cervical spine to some extent. However, zero-p interbody

fusion is superior in terms of shorter operative time, less soft tissue damage and less early postoperative dysphagia.

Abbreviations

ASD: adjacent segment disease; ACDF: anterior cervical discectomy and fusion; zero-profile: zero-p

Declarations

Ethics approval and consent to participate

This retrospective study was approved by the Institutional Ethics Board of The First Affiliated Hospital of Zhengzhou University. All enrolled patients were informed and agreed to provide relevant data for this study. The methods were carried out in accordance with the relevant guidelines.

Consent for publication

Not applicable.

Availability of data and materials

Data requests are available from the corresponding author.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

CYY, HY and PGF conceived and designed the study. CYY, LCX, and SX measured and recorded the data. CYY wrote the paper. PGF, HY, SJG, HSL, and LF reviewed and edited the manuscript. All authors read and approved the manuscript.

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Figures

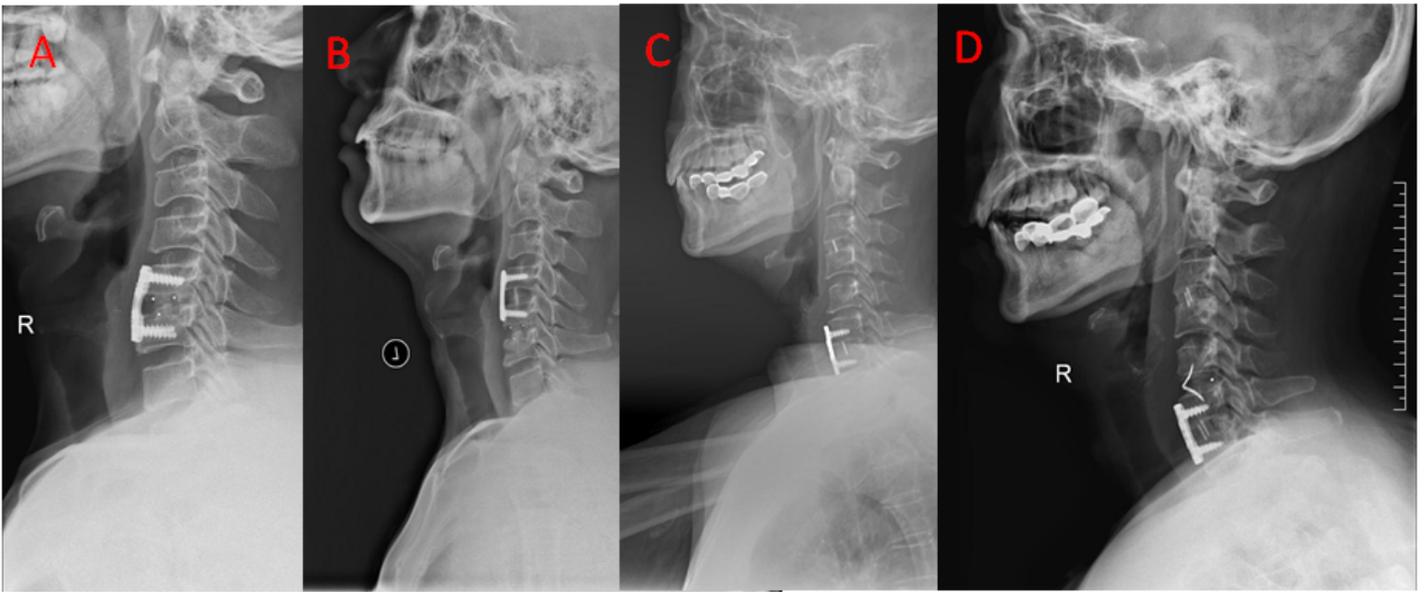


Figure 1

Titanium plate group: A: X-ray before revision; B: X-ray after revision. Zero-p group: C: X-ray before revision; D: X-ray after revision.

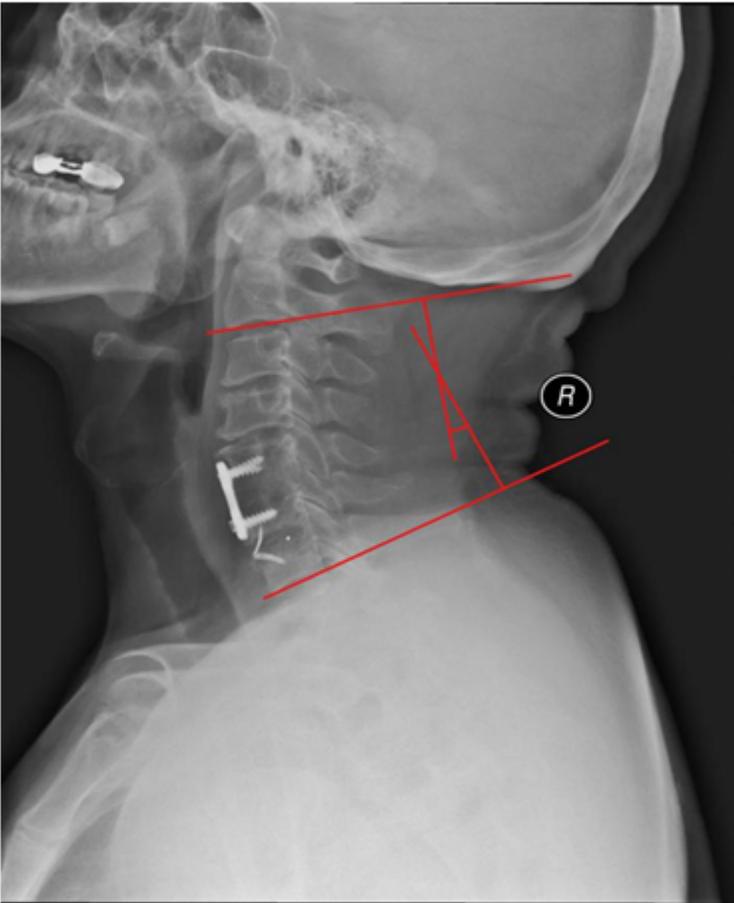


Figure 2

C2-C7Cobb angel: which was the intersection angle of the tangent line between the C2 centrum inferior margin and C7 centrum inferior margin.