Are Facet Orientation and Tropism Risk Factors for Cervical Spondylotic Radiculopathy? A Retrospective Study in a Chinese Population

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Research Article

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Abstract

Background

Facet parameters, such as facet orientation (FO) and tropism (FT) are thought to be predisposing factors for pathological changes in the lumbar spine. This study aimed to explore the association between facet parameters and cervical spondylotic radiculopathy (CSR) on 3-dimensional views.

Methods

A total of 226 patients with single-level CSR and 182 normal control participants were included. FO, FT and the incidence of FT (defined as $FT \geq 7$) based on reconstructed CT images were measured. Univariate and multiple logistic regression analysis were used to investigate the association between facet joint parameters and the incidence of CSR. The Pearson Chi-square test was used to find out the relationship between the side of herniation and facet joint parameters in CSR patients.

Results

Axial FT of CSR group was significantly larger compared to control group at each spinal level, while sagittal except C5/6 and coronal FT shown not. The differences of incidence of axial FT at all levels between groups were statistically significant, as well as incidence of sagittal FT at C4/5 and C5/6. Incidence of axial FT with respect to all levels was significantly associated with CSR, and incidence of sagittal FT only at C4/5 and C5/6 was associated with CSR. The proportion between the left and right side of greater FO was significantly different on axial view.

Conclusion

Axial and sagittal FT but not FO were associated with CSR, and axial FT might exert more dominant function on the development of CSR. Moreover, CSR might be more vulnerable to more severe axial FT, which should be paid more attention. The side of herniation might prefer the side of greater axial FO.

Background

Cervical spondylotic radiculopathy (CSR) refers to the most common type of cervical spondylosis, accounting for 60–70% of the occurrence of cervical spondylosis seen in clinical practice [1–3], characterized by the dysfunction of the roots of nerve, cervical spinal nerves, or both. Intervertebral disc degeneration, herniation, bone hyperplasia, osteophyte formation, or other conditions are all able to bring about the stimulation of spinal canal or intervertebral foramen, eventually compressing the cervical nerve root [4]. The patients with CSR severely suffer lower quality of life, less work capabilities or efficiency, and even significantly increased financial burden.

Within the spine, stability and mobility are fundamentals driving its anatomic morphology, especially in the cervical spine. As with the lumbar spine, stability is essential for maintenance and protection of the cervical neural elements, while mobility may be of greater importance to be responsible for larger scope of cervical movements to drive the direction of the head. The spine can be considered as a structure composed of numerous motion segments connected in series. Anatomically and functionally distinct from the fibrocartilaginous articulation of the intervertebral disc of the anterior spine, the facet joints of the posterior spine exhibits feature typical of only true synovial joints between adjacent spinal levels in humans, otherwise known as the zygapophyseal joints. Thus, the so-called “three-joint complex”, or motion segment, is formed by the three articulations between adjacent vertebrae: one disc and two facet joints [5]. It is believed that the three joints in each motion lesion are highly interdependent, such that changes in one affect the other two and vice versa [6–8].

Facet orientation (FO) and facet tropism (FT) serve as two important structural parameters of facet joint associated with degenerative changes in the facet joints, either as the cause of degenerative changes or as the result of abnormal forces produced by degeneration [9, 10]. FO is the facet joint angle in the transverse view relative to the coronal plane in the lumbar spine, and FT is defined as asymmetry between the left and right facet orientation [11, 12]. Currently, facet parameters, such as FO and FT are thought to be predisposing factors for pathological changes in the lumbar spine, including disc degeneration [13–15], facet degeneration [16, 17], as well as several degenerative diseases, consisting of lumbar disc herniation [13, 18–20], degenerative spondylolisthesis [21], and low back pain [22]. In our previous studies [19, 20, 22, 23], we also suggested the association between facet parameters and lumbar diseases and even their specific biomechanical effects on lumbar disc. Interestingly though, there exist rare clinical studies concerning the facet parameters in the cervical spine, particularly in the patients with CSR, to the best of our knowledge. Besides, based on its peculiarity of anatomical characteristics and more dexterity or movement in cervical vertebral column, FO and FT should be measured and calculated in 3-dimensional plane, including axial, sagittal and coronal plane, respectively.

The purpose of the present study was therefore to investigate the relationship between FO and FT and CSR in 3-dimensional plane and further analyze the risk factors for CSR. Due to the lower incidence of CSR at C2/3, C6/7 and C7/T1, the patients with CSR at middle-level cervical spine at C3/4, C4/5 and C5/6 were enrolled in this study.

Methods

Participants

This was a retrospective study approved by the Ethical Committee of First Affiliated Hospital of Dalian Medical University. From July 2016 to March 2021, 226 patients of middle-aged suffering CSR at our institution (First Affiliated Hospital of Dalian Medical University) were reviewed as experimental group in this study. Information gathered included demographic details, etiology, clinical findings, diagnosis, and radiological investigations. All patients aged 30 to 65 years, who had CSR undergoing clinical intervention, were included. Inclusion criteria were patients (1) aged from 30 to 65 years; (2) with single-level CSR at C3/4, C4/5 or C5/6; (3) undergoing both computer tomography (CT) and magnetic resonance imaging (MRI); (4) diagnosed with CSR by confirming clinical findings in agreement with radiological findings. Exclusion criteria were patients (1) aged less than 30 years or more than 65 years; (2) with cervical infections and tumors; (3) with a history of previous cervical surgery; (4) diagnosed by ossification of the posterior longitudinal ligament; (5) with cervical fracture or trauma; (6) spondylolysis; (7) severe osteoporosis; (8) congenital deformity; (9) and those with incomplete data or poor image quality. 182 normal participants without CSR who underwent both cervical CT and MRI for physical examination in our center were selected as the control group, as well as according with other inclusion and exclusion criteria above-mentioned. All participants had given informed consent to use their information for research purposes

Evaluation of Cervical FO and FT

Bilateral facet joint angles at C3/4, C4/5 or C5/6 were measured on reconstructed axial, sagittal and coronal CT images, respectively. In detail, on axial view (Fig. 1a, b), axial FO (α) was defined as the angle between facet line and midsagittal line which was draw perpendicular to the posterior wall of vertebral body, using the measurement method of lumbar FO described by Noren et al [12]; on sagittal view (Fig. 1c, d), sagittal FO (β) was defined as the angle between the superior facet line and a line perpendicular to the posterior wall of inferior vertebral body described by Sebastien et al [24], it was worth noting that this measurement method of sagittal FO is not influenced by head position and cervical curvature, and more accurate thanks to more straighter line of superior facet than inferior one, compared with other method [25]; on coronal view (Fig. 1e, f), coronal FO (γ) was defined as the angle between the facet line and a midsagittal line perpendicular to the superior margin of inferior vertebral body. Additionally, a view showing the largest scale of the facet was chosen for the purpose of more accurate results. Axial, sagittal and coronal FT were then calculated by $|FO_{left}-FO_{right}|$ on the respective view. The incidence of cervical FT or called cervical FT (+) was defined as $FT \geq 7$ in accordance with Rong et al [26].

Statistical Analysis

Data analysis was performed with the SPSS 22.0 software (International Business Machines Corporation, Armonk, State of New York). A cohort of 20 patients, picked randomly among enrolled patients, was used to have an intimate knowledge of the measurement by one experienced spine surgeon and one experienced musculoskeletal radiologist. Based on the above measuring method, they evaluated FO and disc degeneration of CT and MRI images independently to determine intra- and inter-reader reliability by intraclass correlation coefficients (ICC), with no prior clinical information or knowledge of the results of other readers. Measurements were repeated after 2 weeks.

Measurement data conformed to the normal distribution were expressed as the mean $\pm$ standard deviation, while results conformed to abnormal distribution were expressed as median [P_{25} , P_{75}]. The Independent-Sample t test was used to assess normally distributed variables, the Mann-Whitney U test was used for non-normally distributed variables, and the Chi-square test was used for categorical variables. Firstly, univariate analysis including the Independent-Sample t test, the Mann-Whitney U test and the Pearson Chi-square test was taken to compare the difference of demographic and facet parameters, as well as cervical FT (+) between CSR and control group. Next, the Mann-Whitney U test was taken to compare between axial and sagittal FT in CSR patients, and the Pearson Chi-square test was performed to compare between axial and sagittal FT (+) in CSR patients, to further explore which is more influential. Then, univariate logistic regression analysis was performed to estimate the potential factors associated with CSR. Further, multiple logistic regression analysis was established to identify if facet parameters as risk factors associated with CSR adjusting for gender, hypertension or other parameters. Finally, the Pearson Chi-square test was used to find out the relationship between the side of herniation and the side of larger FO in CSR patients. $P < 0.05$ was considered statistically significant.

Results

Reliability of Measurement Readings

The intra-observer reliability for axial, sagittal and coronal FO varied between 0.82 to 0.94, 0.81 to 0.91 and 0.82 to 0.92, respectively. The intra-observer reliability for grading cervical disc degeneration ranged from 0.94 to 0.98. While the inter-observer reliability for axial, sagittal and coronal FO varied between 0.79 to 0.93, 0.79 to 0.91 and 0.80 to 0.92, respectively. The inter-observer reliability for grading cervical disc degeneration ranged from 0.90 to 0.96. Overall, both the intra-observer reliability and inter-observer reliability were excellent.

Study Population and Demographic

After the application of inclusion and exclusion criteria, 226 CSR patients were included in this study, aged from 18 to 65 years (median 56 [49,59]) and composed of 89 male and 137 female. 182 non-CSR control participants were selected, aged from 18 to 65 years (median 55 [48,59]) and composed of 105 male and 77 female. In addition to age and sex, other data such as BMI, smoking, drinking, diabetes mellitus and hypertension were gathered, and the results of univariate analysis of parameters were summarized in Table 1.

FO, FT and FT Incidence

The results of left and right FO measured on axial, sagittal and coronal view at C3/4, C4/5, C5/6 in CSR and control group were listed in Table 2, as well as FT and FT incidence or called FT (+). First of all, there was no statistical significance in the difference of left or right FO in 3-dimensional views between groups except C5/6 axial view (left: $P=0.000$, right: $P=0.003$). Then, compared to control group, axial FT of CSR group was larger and shown significant difference between groups at each spinal level (C3/4: $P=0.000$, C4/5: $P=0.000$, C5/6: $P=0.000$), whilst sagittal and coronal FT shown not. However, sagittal FT at C5/6 also revealed significant difference between groups ($P=0.004$). To identify which is more influential, the Mann-Whitney U test was performed to compare between

axial and sagittal FT in C5/6 CSR patients, and results indicated that the degree of axial FT was substantially larger and significantly different from sagittal FT ($P=0.000$). Next, the difference of axial FT (+) at all levels between groups was statistically significant ($P=0.000, 0.000, 0.000$), as well as sagittal FT (+) at C4/5 and C5/6 ($P=0.000, 0.000$). Similarly, the Pearson Chi-square test was taken to compare between axial and sagittal FT (+) in C4/5 and C5/6 CSR patients, exploring that the number of axial FT (+) was substantially more and significantly different from sagittal FT (+) ($P=0.000, 0.000$). Further, the results of univariate and multiple logistic regression analysis were displayed in Table 3, meaning that axial FT (+) with respect to all levels was significantly associated with CSR ($P=0.000, 0.000, 0.000$) and sagittal FT (+) only at C4/5 and C5/6 was associated with CSR ($P=0.044, 0.000$). And, axial FT was also significantly associated with CSR at C5/6 ($P=0.002$). Lastly, the relationship between the side of herniation and the side of greater FO was shown in Table 4. The proportion between the left and right side of greater FO was significantly different on axial ($P=0.000$) but no statistically difference on sagittal and coronal view, amongst left, central and right herniation groups.

Discussion

Facet joint, as a crucial element of the three-joint complex in the posterior aspect of the vertebrae column, provides a far-reaching influence on the spine, and plays significant roles in guiding spinal motion and transmitting axial loading [27]. Biomechanical models of isolated spinal segments have confirmed that the load carried by facets can more than 33% of total load borne by the spinal segment, and will be more or less transmitted through facets joints during spinal extending or flexing[28]. Meanwhile, these paired diarthrodial joints transmit shear forces and help the intervertebral discs carry out 16% of the vertical load [29, 30]. Some previous studies have demonstrated that any abnormality of one facet joint could affect others and cause asymmetric stress transmission to both disc and facet, ultimately resulting in abnormal stress concentrations in regions of disc and facet joints [31, 32]. Owing to complicated geometry, researchers considered FO and FT as anatomical parameters to represent the geometric characteristics of facet joints. Some prior studies have found out that there was a relationship between FO and FT and lumbar degenerative diseases, such as lumbar disc herniation, lumbar stenosis and low back pain [22, 33, 34]. Distinct from the lumbar spine, facet tropism in cervical region might be more common in sub-axial cervical spine [35]. Additionally, the lumbar facet articular surface area is relatively smaller compared with vertebral end plate, but in the cervical region the facet surface area is about two-thirds the size of the area of the cervical disc, which means that the biomechanical and pathological role of facet joints in cervical degenerative diseases might be more dominant than that in lumbar.

Although FT has been considered common phenomenon in the sub-axial cervical spine [35], it is still unclear whether there is an association between facet parameters and cervical degenerative diseases, even specific effects. As far as we know, this is the first investigation to analyze the relationship between FO and FT and CSR based on more accurate and practical measuring methods on 3-dimensional views. In this work, middle-aged participants (aged from 30–65 years) were included because various conflicting factors might interfere final results in elderly individuals [26, 36, 37].

In this study, we considered FO, FT and incidence of FT as potentially risk factors to analyze the relationship between these facet parameters and CSR. First of all, differences in several characteristics between CSR and control group were found after inter-group comparison and these statistically different parameters were regarded as confounding factors in the following logistic analysis. Then, bilateral FO, FT and FT (+) on axial, sagittal and coronal planes in CSR group were compared with those in control group at C3/4, C4/5, C5/6 levels, respectively. In terms of FO, there was no statistical significance in the difference of left or right FO on 3-dimensional views between groups except C5/6 axial view (left: $P = 0.000$, right: $P = 0.003$), this result was in harmony with the conclusion of a biomechanical visualization study in lumbar spine [23]. In aspect of FT, axial FT of CSR group was larger and shown significant difference between groups at each spinal level (C3/4: $P = 0.000$, C4/5: $P = 0.000$, C5/6: $P = 0.000$), whilst sagittal and coronal FT shown not. However, sagittal FT at C5/6 also revealed significant difference between groups ($P = 0.004$). To identify which is more influential, further comparison between axial and sagittal FT in C5/6 CSR patients were performed. The result suggested that the degree of axial FT was substantially larger and significantly different from sagittal FT ($P = 0.000$). In addition, we also compared FT between axial or sagittal view in control group and obtained identical outcome ($P = 0.000$), meaning that the degree of axial FT was larger in both CSR patients and normal individuals. Thus, as a more common pre-existing anatomical feature, axial FT might play a more important role in pathogenesis of CSR between axial and sagittal FT. With regard to FT (+), the result was similar to that of FT. Axial and sagittal FT (+) were both statistically different between CSR and control group, whereas the number of axial FT (+) was more in CSR patients or normal humans, pointing out that as with axial FT, axial FT (+) might exert a more dominant function on the development of CSR.

Next, the results of univariate and multivariate logistic analysis demonstrated that axial FT (+) might be the risk factor of CSR at C3/4; axial FT (+) and sagittal FT (+) might be the risk factors of CSR at C4/5; axial FT (+), sagittal FT (+) and axial FT might be the risk factors of CSR at C5/6, adjusting for other potentially confounding factors such as sex, hypertension and smoking. Notwithstanding, sagittal FT (+) might be considered as a predisposing factor but its incidence was not equal to that of axial FT (+). Thus, axial FT (+) should be pay more attention to prognostication of CSR in comparison to sagittal FT (+). Of note, FT was also an influential factor in CSR at C5/6 but not at C3/4 and C4/5. FT represented asymmetry between left and right, while FT (+) delegated that asymmetry was equal to or more than 7. As a result, if only FT is larger to a certain extent, FT might have an effect on occurrence of CSR. Therefore, axial FT (+) might show stronger correlation on CSR.

Finally, the side of disc herniation was associated with the side of larger axial FO, meaning that the direction of herniation preferred the side of greater FO. It has been demonstrated in a previous cervical study that the greater facet angle at the left or right side did not affect the side of herniation in patients with cervical disc herniation [25]. This could be explained by the different experimental design, study population and methodology. In our study, we selected cervical spondylotic radiculopathy, in which not only disc herniation but other secondary changes of cervical discs such as osteophyte stimulated the nerve roots. And secondary changes of cervical discs might carry out considerable or even more abnormal load in the development of CSR. A prior study [23] has revealed biomechanical mechanism between FT and side of lumbar disc herniation, thus our finding should be further investigated and confirmed by biomechanical study of cervical spine. Also, it has been reported that there was an association between lumbar FT and disc degeneration [9, 32, 38]. Still, more longitudinal studies were needed to verify the relationship among FT, cervical disc degeneration and CSR, and their intrinsic and specific mechanism.

Biomechanically, the interplay between facet joints and cervical disc may be similar to lumbar but not the same. A rat model study reported that participating factors to disc herniation were not only axial compression but flexion and torsion[39]. It is commonly held that cervical facet joints are 3-dimensional, including that axial cervical spine is responsible for rotation movement, sagittal cervical spine is responsible for flexion-extension, and coronal cervical spine is responsible for lateral bending [24, 25]. Previous biomechanical findings proposed that the biomechanical effects of FT rather than FO contributed to the increases in disc stress and facet joint contact at the corresponding segment [32, 40]. Consequently, FT should be the first topic of interest in clinical practice of predicting cervical degenerative diseases. Ke et al [23] suggested that under flexion, extension and torsion movement, disc stress and facet joint contact force increased with increasing axial FT in the lumbar biomechanical modelling. Increased axial FT caused more severe stress asymmetry and held a stronger effect on disc stress, eventually aggravating the disc degeneration and causing clinical degenerative diseases. In particular, the increasing trend was most obvious for the torsion moment [23]. Rong et al [41] indicated that under flexion, extension, lateral bending and axial rotation moments, sagittal FT increased disc pressure and facet contact force. The increased loading on the intervertebral disc could cause micro-injury to the disc. The accumulation effect of these repetitive micro-injury could give rise to initiating or accelerating the degenerative process accordingly. However, the incidence of sagittal FT is not common as axial FT in clinical practice. As far as we known, there was no study exploring the biomechanical role of coronal FT in cervical spine, which is imperative to implement. Ke et al [23] found that when FT existed, stress was concentrated on the disc region ipsilateral to the facet joint with smaller axial FO, which means the side of disc herniation were supposed to prefer the side of smaller axial FO. This result was not in line with our finding. This may be the fact that cervical loading transmitting is different from lumbar. More specifically, axial FO of cervical spine would be near or more than 90°, while axial FO of lumbar spine might be much smaller, generally being an acute angle. This might result in distinct biomechanical mechanism in the prognosis of cervical diseases. Moreover, movement pattern of cervical spine could be more complicated than that of lumbar. Further both numerous clinical and biomechanical studies of cervical spine should be performed. The finite element analyses in both cervical and lumbar spine concluded that FT might be anatomical risk factor for inducing disc degeneration [23, 41]. Although the specific mechanism of facet parameters inducing CSR was not the scope of this study, we hypothesized that axial FT (+) might deteriorate cervical disc degeneration and then induce CSR. There exist two explanations: 1) In cervical region, axial rotation was performed more frequently than flexion-extension, thus producing more load on axial facet surfaces. 2) As is reported in the prior study, the increasing trend of disc stress was most obvious for the torsion moment, contributing to more far-reaching cumulative effects on disc degeneration with repetitive rotation. Equally, sufficient evidences are imperative to confirm these hypotheses.

Several limitations existed in the present study. Firstly, the number of cases was relatively small. Further multicenter studies with larger sample sizes are necessary to carry out. Secondly, the findings of this studies were based on the CSR patients undergone clinical intervention, which might represent greater FT or more FT (+) in CSR population. Thirdly, given its nature as a retrospective study, CT and MRI images were not completely controlled by protocols, which may lead to bias. Besides, although the measuring methods in our studies were more comprehensive and is not influenced by cervical curvature or head position, there still existed measurement bias. Finally, this study only revealed superficially positive correlation between FT (+) and cervical disc degeneration, further studies should focus on inherent biomechanical effects and more specific association among FT (+), cervical disc degeneration and CSR.

Conclusion

Axial and sagittal FT but not FO were associated with CSR at C3/4, C4/5 and C5/6. However, compared to sagittal FT, axial FT might exert more dominant function on the development of CSR. Moreover, based on higher incidence of more severe axial FT, the condition of more severe axial FT should be paid more attention to predicting, diagnosing and judging the pathogenesis and prognosis of CSR. The side of herniation might prefer the side of greater FO. Further studies investigating the side of cervical herniation are needed to verify the association between side of herniation and degree of FO.

Abbreviations

CSR

Cervical spondylotic radiculopathy; FO:Facet orientation; FT:Facet tropism; CT:Computer tomography.

Declarations

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Availability of data and materials

Summarized data have been presented in this manuscript. The raw data for this study are located and protected at First Affiliated Hospital of Dalian Medical University. Sharing of the raw data is not suggested, because a secondary analysis is planned.

Authors' contributions

ZHL contributed to the design of the study. YXZ drafted the manuscript with the help from ZHL, MY and WTZ. YXZ and BW helped in the statistical analyses. Statistical analyses were discussed with MY and TZS. ZHL and YXZ contributed to the revision. All authors have read and approved the final manuscript.

Competing interest

The authors declare that they have no competing interests.

Availability of data and materials

The datasets generated and/or analyzed during the current study are not available based on the protection of patient privacy, but are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

This research was approved by the ethics committee of the First Affiliated Hospital of Dalian Medical University and performed in accordance with the Declaration of Heisinki. And agreement to participate was given by the participants. All participants had given informed consent to use their information for research purposes by telephone.

Consent for publication

Not applicable.

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Tables

Table 1. Demographic Characteristics between CSR and normal control group.

Characteristics	CSR (n=226)	control (n=182)	P
Age (yr)	56 [49,59]	55 [48,59]	0.028*
Gender (Male)	89 (39.4%)	105 (57.7%)	0.000*
BMI (kg/m ²)	24.63 [22.59,26.87]	24.61 [22.77,26.95]	0.870
Smoking	47 (20.8%)	22 (12.1%)	0.020*
Drinking	22 (8.8%)	15 (8.2%)	0.357
Diabetes Mellitus	19 (8.4%)	9 (4.9%)	0.169
Hypertension	50 (22.1%)	24 (13.2%)	0.020*

* Statistical significance was achieved when p<0.05.

Table 2. Comparison of FO, FT and FT (+) between CSR and control group on 3-dimentional view.

Axial view				Sagittal view			Coronal view	
level	CSR	Control	P	CSR	Control	P	CSR	Control
C3/4								
left-FO	87.60[79.95,94.05]	87.30[81.00,95.10]	0.576	48.10[43.10,53.85]	47.35[42.78,51.10]	0.153	81.47±2.85	81.17±2.85
right-FO	93.00[80.95,103.35]	88.61[81.76,95.66]	0.153	48.61±7.08	46.65[42.90,51.01]	0.155	81.33±3.94	82.33±3.94
FT	10.31±5.73	4.38 [2.19,6.61]	0.000*	4.20 [2.10,6.05]	2.95 [1.70,5.53]	0.215	3.08±2.13	2.70±2.13
FT (+)	44 (77.2%)	40 (22.0%)	0.000*	11 (19.3%)	22 (12.1%)	0.169	3 (5.3%)	11 (6.2%)
C4/5								
left-FO	91.44±10.26	92.60[86.34,100.64]	0.351	46.00[40.10,50.70]	45.35[39.60,49.60]	0.358	80.90[78.90,84.3]	81.17±2.85
right-FO	94.96[87.00,102.50]	94.61[88.20,102.43]	0.938	46.05±7.47	45.17±6.84	0.575	83.50[80.50,85.8]	82.33±3.94
FT	10.30 [8.10,13.80]	4.61 [2.54,6.94]	0.000*	3.20 [1.70,5.20]	3.10 [1.30,5.40]	0.386	3,23±2.14	2.50±2.13
FT (+)	58 (81.7%)	44 (24.2%)	0.000*	15 (21.1%)	19 (10.4%)	0.025*	5 (6.9%)	12 (6.2%)
C5/6								
left-FO	88.64±12.60	95.55[88.48,102.60]	0.000*	49.60[42.80,56.53]	49.40[43.35,55.33]	0.874	81.80[79.58,84.03]	82.33±3.94
right-FO	93.70 [82.90,99.38]	97.72[89.62,102.43]	0.003*	50.90 [43.98,55.65]	49.15 [44.68,53.83]	0.195	81.75[79.18,83.53]	82.33±3.94
FT	9.90 [5.68,14.50]	4.14 [2.00,6.59]	0.000*	5.10 [2.58,8.03]	3.80 [1.87,5.68]	0.004*	2.80[1.85,4.53]	3.30±2.13
FT (+)	73 (75.3%)	39 (21.4%)	0.000*	34 (34.7%)	22 (12.1%)	0.000*	5 (5.1%)	10 (5.1%)

* Statistical significance was achieved when p<0.05.

FO, facet orientation; FT, facet tropism; FT (+), the incidence of FT; CSR, cervical spondylotic radiculopathy.

Table 3. Univariate and multiple logistic analysis of factors associated with CSR according to levels.

		Univariate Logistic Regression Analysis			Multiple Logistic Regression Analysis		
Level	Variable	OR	95%CI	P	OR	95%CI	P
C3/4							
	gender	0.496	0.271~0.909	0.023	0.491	0.245~0.985	0.045
	axial FT	1.145	1.084~1.210	0.000			
	axial FT (+)	0.083	0.041~0.169	0.000	0.083	0.040~0.170	0.000
C4/5							
	gender	0.478	0.273~0.836	0.010			
	smoking	0.473	0.232~0.964	0.039			
	axial FT	1.167	1.104~1.233	0.000			
	axial FT (+)	0.071	0.036~0.143	0.000	0.070	0.035~0.141	0.000
	sagittal FT (+)	0.435	0.207~0.914	0.028	0.393	0.158~0.976	0.044
C5/6							
	gender	0.464	0.281~0.767	0.003			
	hypertension	0.495	0.263~0.934	0.030	0.339	0.151~0.760	0.009
	axial FT	1.153	1.100~1.200	0.000	1.086	1.031~1.143	0.002
	axial FT (+)	0.093	0.053~0.166	0.000	0.119	0.061~0.231	0.000
	sagittal FT	1.125	1.053~1.203	0.000			
	sagittal FT (+)	0.259	0.141~0.476	0.000	0.206	0.095~0.447	0.000

* Statistical significance was achieved when $p < 0.05$.

OR, odd ratio; CI, confidence interval. FT, facet tropism; FT (+), the incidence of FT.

Table 4. Relationship between the location of CSR and different FO of bilateral facet joints in 3-dimentional view.

Variable	CSR _L (n = 88)	CSR _M (n = 62)	CSR _R (n = 76)	P
Axial				
FO _{L/R} , n (%)	69 (78.41%)	29 (46.77%)	20 (26.32%)	
FO _{L/R} , n (%)	19 (21.29%)	33 (53.23%)	56 (73.68%)	0.000*
Sagittal				
FO _{L/R} , n (%)	47 (53.41%)	33 (53.23%)	40 (52.63%)	
FO _{L/R} , n (%)	41 (46.59%)	29 (46.77%)	36 (47.37%)	0.941
Coronal				
FO _{L/R} , n (%)	43 (48.86%)	34 (54.84%)	38 (50%)	
FO _{L/R} , n (%)	45 (51.14%)	28 (45.16%)	38 (50%)	0.757

* Statistical significance was achieved when $p < 0.05$.

CSR, cervical spondylotic radiculopathy; FO, facet orientation; L, left; R, right; M, median; FO_{L/R}, the degree of FO_L higher than the degree of FO_R; FO_{L/R}, the degree of FO_R higher than the degree of FO_L; CSR_L, left side protrusion of CSR; CSR_R, right side protrusion of CSR; CSR_M, utterly central protrusion of CSR.

Figures

Figure 1

Images of the measuring methods of facet angles on axial, sagittal and coronal view based on reconstructed CT images. On axial view, a midsagittal line (a) was draw perpendicular to the posterior wall of the vertebral body, axial FO (α) was defined as the angle between facet line and midsagittal line which was draw perpendicular to the posterior wall of vertebral body (b). On sagittal view, sagittal FO (β) was defined as the angle between a line perpendicular to the posterior wall of inferior vertebral body (c) and the superior facet line (d). On coronal view, coronal FO (γ) was defined as the angle between a midsagittal line perpendicular to the superior margin of inferior vertebral body (e) and the facet line (f).