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Correlation between Loss of Cervical Lordosis and Degenerative Diseases of the Sub-axial Cervical Spine Columns

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ABSTRACT

Background: Subaxial cervical spine is the cervical segment which commonly undergo degenerative changes. There are numerous cervical lordosis angle measurement, however posterior tangential method is considered more accurate to detect any degenerative related changes.
Aim: This study aimed to find the profile of cervical lordotic curve among patients with cervical degenerative disease, and to determine the correlation between degenerative process of subaxial cervical spine columns and cervical curve malalignment.
Method: A cross sectional study was conducted by adopting the posterior tangent measurement. Cervical alignment was measured from cervical MRI mid sagittal section to identify loss of cervical lordotic and the presence of kyphosis. Degenerative disease of each vertebral column of subaxial cervical spine, anterior and posterior were evaluated. Spearman correlation test was done to identify the relationship between degenerative process of each column of subaxial cervical spine with loss of cervical lordosis and the presence of kyphosis. Multivariate analysis was done to adjust the effect of confounding variable.
Result: Total of 90 subjects with male predominance (62%), mean age 54± 1.3 years. Neck pain contributes the most presenting complain (92%). As many as 51 subjects have hypo-lordosis, while 32 subjects have kyphotic changes. There was no significant correlation between degenerative process of each column of subaxial cervical spine and loss of cervical lordotic, but significant correlation was found between posterior listhesis and cervical kyphosis defomity. ($p < 0.05$).
Conclusion: There was significant correlation between cervical kyphotic malalignment with posterior listheis in all three vertebra columns instead of hypo-lordosis.

Keywords : *Loss of cervical lordosis, cervical kyphotic, degenerative disease, vertebral column, MRI*
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INTRODUCTION

Cervical spine has C shaped alignment in normal condition, which is important to maintain head posture and movement. The cervical spine had important role in inducing global spinal alignment and pelvic tilt as compensatory alteration happen to maintain horizontal gaze.[1] There are various studies that have diverse outcome on correlating loss of cervical lordosis and neck pain or stiffness.[2,3] Several studies[4,5] claimed that hypo-lordosis is statistically associated with neck pain. A study conducted by Ha et al, demonstrated strong relationship between neck pain and cervical lordosis, particularly in patients with posterior tangential angle below 20° and above 40°.[6]

The ultimate caution is that cervical malalignment can cause disability due to the pressure of the spinal cord, increase intramedullary pressure, myelopathy, and headache. Only about 20% asymptomatic individual that has cervical hypo-lordosis.[2] Neck instability, improper posture, aging, history of laminectomy, trauma, arthritis, inflammation, and tumor around the neck area are the common etiologies underlining abnormal cervical curve.[7,8] Therefore cervical alignment changes must be observed thoroughly in patients following cervical reconstruction surgery.

In elderly the wear and tear mechanisms on intervertebral disc lead to disc collapse, therefore in aging the more reduction of disc height may cause head to be more forward in position and the cervical curve will become more angulated anteriorly.[9] Load of the head can create further forward head position as well as straining the surrounding muscle and deteriorating cervical ligaments which lead to hypo-lordosis and worsen into kyphotic.[5,10] This condition will eventually decrease cervical motion, and can even compresses the adjacent nerve root, spinal cord, as well as paralysis.

Instability is the main pathogenesis that leads to spinal degeneration. Cervical segmental instability may point out early degeneration of intervertebral disc in the cervical vertebrae.[11] Instability is associated with poor strength of neck and back muscle, which provoke either listhesis or overriding facet joint. Vertical instability of collapse formed the initial degenerative disease, subsequently causing

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buckling of the flava ligament, posterior longitudinal ligament, and osteophyte formation.[12]

Subaxial cervical spine (C3-C7) has a pivotal role in flexion, extension, side-bending and maintains neck rotation.[13] These segments undergo degenerative changes more frequent than axial cervical spine segment (C1-C2). Cervical sagittal alignment influences the alignment of subjacent segments of thoracolumbar spine and pelvis as well. Patients with deprived sagittal alignment frequently progress into painful compensatory mechanisms that affect the cervical spine, including hyper-lordosis of subaxial segment.[1] Up to now, there were lack of explanation about the relationship between degeneration of subaxial cervical spine and cervical curve malalignment. This study was conducted to find the profile of cervical lordotic curve among patients with cervical degenerative disease, and to determine the correlation between degenerative process of subaxial cervical spine columns and cervical curve malalignment such as loss of cervical lordotic nor the presence of cervical kyphotic.

MATERIAL AND METHODS

Research Subject and Design

A cross sectional study was conducted to evaluate the relationship between degenerative disease of vertebral column and cervical curve malalignment. Retrospective observation of patient's medical record and radiological findings was done for patient with diagnosis of cervical degenerative disease. Inclusion criteria were patient aged 21 year-old or more, with chronic neck or shoulder pain (more than 6 months), and or suffered from cervical radiculopathy, and the radiological findings showed cervical degeneration process. Exclusion criteria comprised of history of cervical trauma or surgery of cervical spine, and radiological finding showed, spinal congenital anomaly, tumor of the neck, cervical spondylitis or cervical inflammatory arthritis. Once the population meets inclusion and exclusion criteria, their cervical Magnetic Resonance Imaging (MR imaging) was measured and evaluated.

Radiological Evaluation

Radiological evaluation of cervical lordotic curve and cervical degeneration disease was performed on patient's cervical MRI findings (using a 1.5 Tesla MR, consisted of T1 weighted-, T2 weighted- and fat suppression images). Adopting the posterior tangent angle method by Harrison,[14] cervical spine angle is measured from cervical MRI in midsagittal section with cut off value +31-40°. Hypo-lordosis is the term use for cervical angle below +31° and hyper-lordosis for angle above +40°, positive value means the cervical alignment is in lordosis pattern, while negative value indicates the reversed angulation of the cervical alignment which demonstrate a kyphotic condition (Figure 1).

Degenerative disease of each cervical vertebral column which was divided into anterior and posterior column, was re-evaluate to detect any characteristic of degenerative process such as, vertebral body compression, spondylolisthesis, osteophytes, signs of disc degeneration, marrow changes, ligamentum changes, facet arthropathy, and spinal cord compression. Vertebral body compression determined by loss of height of the vertebral body in the anterior, middle, or posterior dimension that exceeds 20%, spondylolisthesis characterized by slippage of one vertebra relative to the one below, osteophytes was defined as bony outgrowths which may project into the joint. Disc degeneration was determined by the presence of loss of disc signal intensity, reduced disc height and or disc herniation. Marrow changes was described as signal marrow changes of the vertebral endplates according to Modic I, II and III marrow changes. Ligamentum changes was classified as ligamentum thickening, and or ligamentum calcification or ossification. Facet arthropathy was defined as reduction of zygapophysial joint space, formation of osteophyte and articular processes hypertrophy. Those findings were classified into dichotomic scale as present and absent. Before enrolled this study, ethical clearance was obtained from the local ethical committee (Ethical Clearance Number: 1089/UN14.2.2.VII.14/LP/2019)

Statistical Analysis

Data from medical record and MR findings was tabulated. Dependent variables were loss of cervical lordotic and the presence of kyphotic, independent variables were degenerative process of each column of subaxial cervical spine, and confounding variable was age. Spearman correlation test were done to identify the relationship between degenerative process of each column of subaxial cervical spine with loss of cervical lordosis and the presence of kyphosis. Multivariate analysis was done to adjust the effect of confounding variable.

RESULT

Total of 90 subjects were included in the current study, which consist of 62% male and 38% female. The mean age was 54 ± 1.3 years. Subject characteristic depicted in Table 1.

The occurrence of all degenerative diseases parameter of each vertebral column described in Table 2. From 83 subjects who have loss of normal cervical lordosis angle, 32 subjects have kyphotic

Table 1 Baseline characteristic of 90 subjects with degenerative disease of cervical spine

Parameters	Mean ± Standard Deviation (SD)	Percentage
Age (years)	54 ± 1.3	
Male		56 (62 %)
Female		34 (38 %)
Clinical findings		
Neck pain 6 months		83 (92%)
Neck stiffness		44 (49%)
Cervical radiculopathy		57 (63%)
Relating diseases		
Cervical trauma		0 (0%)
Cervical spine surgery		0 (0%)
Congenital spine dissease		0 (0%)
Tumor of the cervical region		0 (0%)
Inflammatory arthritis of the cervical spine		0 (0%)
Cervical spondylitis		0 (0%)

Table 2 Radiological findings

Parameters	Mean ± Standard Deviation (SD)	Percentage
Degenerative disease of cervical spine		
Anterior column		
Anterior listhesis		8 (9%)
Anterior ostephyte		74 (82%)
Anterior disc narrowing		35 (39%)
Anterior compression		19 (21%)
Ossification of anterior longitudinal ligament		9 (10%)
Anterior disc herniation		39 (43%)
Anterior marrow degeneration		32 (36%)
Posterior listhesis		17 (19%)
Posterior osteophyte		80 (89%)
Posterior disc space narrowing		54 (60%)
Ossification of the posterior longitudinal ligament		29 (32%)
Loss of intensity of the disc		76 (84%)
Posterior disc herniation		84 (93%)
Posterior marrow degeneration		16 (18%)
Spinal cord compression		63 (70%)
Posterior column		
Calcification of the Nuchal ligament		57 (63%)
Thickening of Nuchal ligament		45 (50%)
Hypertophy of flava ligament		57 (63%)
Facet degeneration		11 (12%)
Cervical curve characteristics		
Posterior tangential angle	12.3° ± 1.1°	
Cervical lordotic curve		
Normal		7 (8%)
Loss of lordotic		83 (92%)
Kyphotic curve		32 (36%)

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Table 3 Correlation of degenerative process of each cervical column and loss of cervical lordosis

Variable	Coefficient correlation (r)	*p* value
Age	0.29	0.784
Sex	-0.03	0.776
Anterior column		
Anterior listhesis	0.91	0.395
Anterior osteophyte	-0.14	0.204
Anterior disc narrowing	-0.02	0.825
Anterior compression	0.05	0.649
Loss of disc intensity	-0.11	0.285
Anterior disc herniation	0.17	0.109
Anterior marrow degeneration	0.04	0.692
Calcification of the anterior		
longitudinal ligament	0.10	0.364
Posterior listhesis	0.14	0.188
Posterior osteophyte	-0.10	0.336
Posterior disc narrowing	0.02	0.874
Posterior compression	0.08	0.429
Ossification of the anterior		
longitudinal ligament	0.11	0.296
Posterior disc herniation	-0.78	0.467
Spinal cord compression	0.12	0.247
Posterior column		
Facet degeneration	0.11	0.309
Hypertrophy of flava ligament	0.12	0.247
Calcification of Nuchal ligament	0.17	0.105
Thickening of Nuchal ligament	0.04	0.698

*Dependent variable : loss of cervical lordosis ; *: significant (p<0,05); r=coefficient correlation*

Table 4 Correlation of degenerative process of each cervical column and cervical kyphosis

Variable	Coefficient correlation (r)	*p* value
Age	0.19	0.075
Sex	0.04	0.683
Anterior column		
Anterior listhesis	0.26	0.014*
Anterior osteophyte	0.04	0.693
Anterior disc narrowing	0.22	0.040*
Anterior compression	-0.43	0.688
Loss of disc intensity	0.02	0.865
Anterior disc herniation	0.10	0.349
Anterior marrow degeneration	0.13	0.232
Calcification of the anterior		
longitudinal ligament	-0.09	0.384
Posterior listhesis	0.35	0.001*

Table 4 Continue

Variable	Coefficient correlation (r)	*p* value
Posterior osteophyte	0.04	0.701
Posterior disc narrowing	0.18	0.089
Posterior compression	0.22	0.039*
Ossification of the posterior		
longitudinal ligament	0.13	0.210
Posterior disc herniation	0.11	0.323
Spinal cord compression	0.28	0.008*
Posterior column		
Facet degeneration	0.08	0.470
Hypertrophy of flava ligament	0.28	0.008*
Calcification of Nuchal ligament	0.18	0.085
Thickening of Nuchal ligament	0.05	0.664

*Dependent variable : cervical kyphosis ; *: significant (p<0,05); r=coefficient correlation*

Table 5 Multivariate analysis result of cervical kyphotic, degeneration of each cervical column and confounding variable

Variable	B	95% CI	p value
Age	-0.780	0.050 - 4.206	0.490
Anterior listhesis	-1.041	0.058 - 2.164	0.260
Anterior disc narrowing	-0.169	0.291 - 2.450	0.756
Posterior listhesis	-1.337	0.073 - 0.940	0.040*
Posterior compression	-1.223	0.045 - 1.932	0.203
Hypertrophy of flava ligament	-0.916	0.127 - 1.263	0.400

*Dependent variable : cervical kyphotic; *: significant (p<0,05); CI : confidence interval; B=constant*

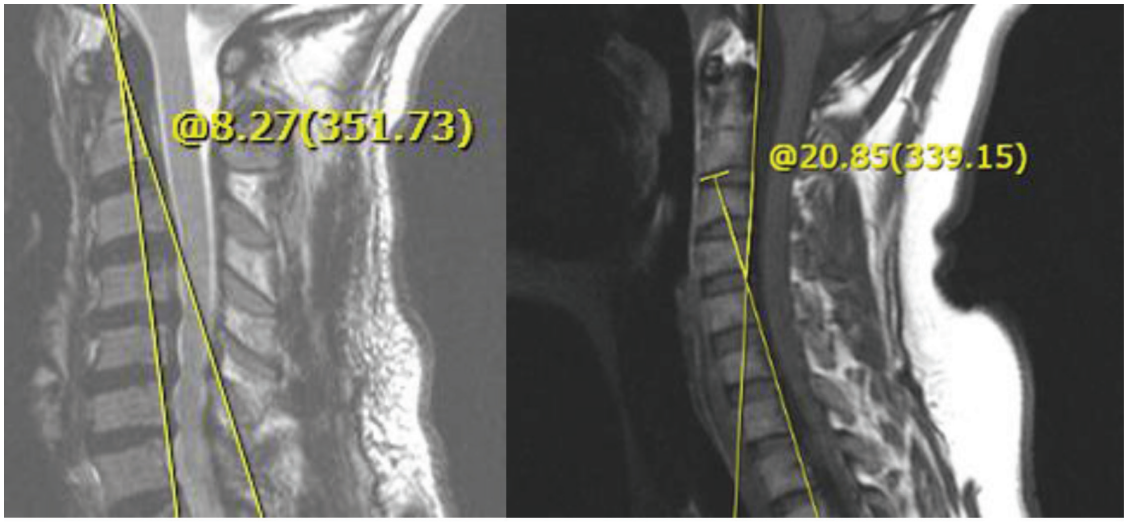

Figure 1 Cervical MRI demonstrated a kyphotic deformity (A) with posterior tangent angle -8.27°, and hypo-lordotic with posterior tangent angle 20.85° (B)

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changes and 51 subjects have hypo-lordosis. Spearman correlation test proved that loss of cervical lordosis did not show any significant correlation with degenerative process of anterior nor posterior vertebral columns (Table 3).

Meanwhile, kyphotic curve is significantly correlated with degenerative process in cervical columns, the changes on anterior column associated with kyphotic mal-alignment were anterior listhesis (r = 0.26; p = 0.014), anterior disc narrowing (r = 0.22; p = 0.04), posterior listhesis (r = 0.35; p = 0.001), posterior compression (r = 0.22; p = 0.039), and spinal cord compression (r = 0.28; p = 0.008). Hypertrophy of flava ligament is the only degenerative process from posterior cervical column that was found correlated with kyphotic changes (r = 0.28; p = 0.008) (Table 4). Multivariate analysis showed that cervical kyphosis is statistically significant correlated with posterior listhesis (p = 0.04) as seen in Table 5.

DISCUSSION

Normal lordosis nature of cervical spine relies on the middle and posterior columns for weight bearing, thus any kind of process that harm the middle and posterior elements causes load shifting from middle to anterior column of cervical spine, which causes stress, constant contraction of surrounding muscle to maintain head position, hence become fatigued and resulting in neck pain and eventually limited range of motion as well as stiffness. Those mechanisms will certainly lead to reverse alignment angulation, kyphosis, which progresses the main load anteriorly.[1] Cervical kyphosis is the manifestation of advanced cervical degenerative disease,[15] the anterior pressure causes the spine and intervertebral disc become more wedge, can lead to listhesis and disc herniation which create and worsened cervical myelopathy.[1,15,16]

Previous studies have shown many associations between degenerative process and cervical kyphosis. An et al showed that global cervical kyphosis is associated with modic changes, while modic changes in patient with cervical kyphosis are also correlated with axial neck-ache.[17] Ligament laxity also causing further anterior translation of the cervical spine.[15] Ossification of the nuchal ligament significantly correlated with decrease active range of motion, and almost all patient with an ossified nuchal ligament has moderate loss of cervical lordotic curve. Severe ossification degree of nuchal ligament also causing more severe cervical radiculopathy, as well as stiffness in flexion/extension direction, also lead to advanced miscellaneous degenerative process of cervical spine and worsened cervical neural foramen stenosis. In this study, despite 63% subjects have nuchal ligament ossification, there was no association found between ossified nuchal ligament and loss of lordosis (r = 0.04; p = 0.743).

In spite of all subject complaining neck disturbances, hypo-lordosis remain the most major finding in this present study (92%). Meanwhile loss of lordosis did not demonstrate any correlation with degenerative process in each vertebral column, in contrary to cervical kyphotic which showed significant correlation with degenerative process, moreover the posterior column pathologies. Posterior listhesis, which is in the posterior column group degenerative parameter, was correlated with cervical kyphotic in multivariate analysis. This study result is in tune with the affirmation from prior published literature that kyphosis is formed due to the anterior load shifting due to disturbances at middle and posterior pillars, which represents as the biomechanics load of cervical spine.[1]

Spondylosis was the most common degenerative process evaluated on anterior columns. The utmost degenerative process from all column following osteophyte formation was posterior disc herniation from the anterior column group, therefore explaining the anterior shifting load process which came from the middle or posterior part of cervical column.

This present study showed mean posterior tangent angle was 12.3° ± 1.1° with subjects complaining of neck disturbances, such as neck pain for 6 months long, neck stiffness as well as cervical radiculopathy. This was in accordance with other study.[4] The mean posterior tangent angle from pre-existing study is 23.10° ± 8.07 in patient presenting with neck complaint.[8] In the study of Lee et al.[18] neck tilting was maintained at approximately 44° to minimize energy expenditure of the neck muscles. Lordosis below 20° is strongly associated with cervical problems (p<0.001), furthermore minus degree is also correlated statistically with cervical pain (p<0.0001).[4]

In the other hand, age and gender did not show any association with loss of lordosis in this study, while some other study also have the same result.[2,19] In contrary, several studies from Gore et al,[20] Yukawa et al,[21] and Kim et al[22] demonstrated that cervical lordosis angle is increase with age significantly in patient over 50 years old. It is believed that daily activities posture of an individual will affect cervical alignment toward kyphosis or in the other way around.[22] Forward gazing will eventually be causing cervical curve to be more lordotic, while

downward gazing will decrease lordosis curve in cervical region.[22] Physiologically cervical lordosis curve will adapt to any changes on both thoracic kyphosis and lumbar lordosis, while aging can cause increase thoracic kyphosis and decrease lumbar lordosis which causes the cervical spine curve changes either into lordosis or straight or even kyphotic.[8] When the cervical kyphosis begins, the deformity tends to propagate itself, with accelerative instability of the head and neck persuading abnormal forces that lead to further development of the deformity, and may compress the spinal cord. This stae may lead to several distressing symptoms, including loss of horizontal gaze, myelopathy, and dysphagia.[1] Therefore, another challenge should be made into further research plan to evaluate cervical curve adaptation due to thoracic and lumbar curve imbalance.

CONCLUSION

Cervical kyphotic deformity is related with cervical degenerative process, moreover on the anterior column, such as posterior listhesis, posterior compression, and spinal cord compression. Posterior listhesis is the degenerative parameter on the anterior column that showed significant correlation in multivariate analysis. Other pillar group degenerative process that correlate significantly with cervical kyphosis are as follows, from anterior column are anterior listhesis, anterior disc narrowing, and from posterior column is hypertrophy of ligamentum flavum. Age and gender do not have any correlation with cervical loss of lordosis.

DISCLOSURE

This work will be presented in 2nd International Conference on Science Technology and Humanities (2nd ICOSTH 2019) on 14-15 November 2019, Bali. Instead of that, no conflict of interest regarding this manuscript.

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