The computed tomography characteristics of lumbar facet joints in spondylosis patients

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Summary

Objective: To demonstrate the computed tomography (CT) features of lumbar facet joints in spondylosis patients. *Subject and method:* It was a cross-sectional and descriptive study including 42 spondylosis patients (416 lumbar facet joints) who took consultation in 108 Military Central Hospital, from December 2021 to July 2022. The subjects were recruited as the correspondence between Gomez Vega 2019 clinical criteria and CT scan. The examined index included: Joint shapes which were C-shaped, straight shape, J-shaped; joint angles regarding sagittal line; joint tropisms. Osteoarthritis characteristics of lumbar facet joints based on Pathria classification with 4 grades. Data were analyzed by SPSS, comparisons of two means were performed by T-test. Statistical significance was defined by $p<0.05$. *Result:* Average age of patients was 63.79 ± 2.24 years old, female/male ratio was 4.25. 2/42 (4.76%) patients had sacralization of L_5. The proportions of joint shapes (C, straight and J) were 86.76%, 13.24%, 0% respectively. The angle of joints increased in respect of descending levels, from 31.14 ± 8.78° (L_{12}) to 45.61 ± 11.20° (L_5S_1). The average of articular tropisms in each level were ranged from 5.47 ± 4.09° to 7.58 ± 7.22°. The percentages of Pathria classification (grade 0, 1, 2, 3) were 2.40%, 59.62%, 11.06%, 26.92%, respectively. Pathria 3 dominantly distributed at L_{45} level (Left 47.62% and right 42.86%). Subchondral sclerosis and hypertrophy contributed to the highest rate of degenerative characteristics (99.03% and 92.51% respectively). *Conclusion:* C-shaped joint was the most popular. Large tropism might be a consequence of prolonged osteoarthritis. Subchondral sclerosis and hypertrophy presented at almost facet joints. Pathria grade 3 was the most popular at L_{45} level which had higher percentage of severe osteoarthritis features.

Keywords: Facet joint, osteoarthritis, low back pain.

1. Background

Low back pain (LBP) is the most well-known reason for medical consultation after fourth decade of life, of which facet joint osteoarthritis is the cause of 40-75% cases [1], [2]. The term "lumbar spondylosis" is defined as degeneration of facet joints (Fjs) and discs without herniation. The diagnosis of facetogenic LBP has been mainly based on typical clinical signs and symptoms versus imaging diagnostic in order to rule out other possible diagnosis. Of note, computed tomography (CT) is still better method to evaluate all degenerative features. Given the lack of data in Vietnam which examined these features, this study aimed to demonstrate the CT characteristics of facet joints in spondylosis patients.

2. Subject and method

This was a cross-sectional and descriptive study. 42 spondylosis patients with facetogenic chronic LBP, who took consultation at 108 Military Central

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Hospital from December 2021 to July 2022, were included. All patients were satisfied with the inclusive criteria: 1, Factogenic chronic LBP based on the correspondence between Gomez Vega clinical diagnostic criteria 2019 and results of CT scan; 2, Without history of lumbar trauma, surgery, typical radicular signs and symptoms; 3, Patient's consent for CT scan. Patients who had another cause for LBP and disagreed were excluded from the study.

Diagnostic criteria of facetogenic LBP by Gomez Vega 2019 includes 3 symptoms and 3 signs. The symptoms are unilateral/bilateral axial lumbar pain, alleviation with rest, absence of radicular pattern. The signs are Kemp's sign, point of pain in the articular or transverse apophysis, sign of facet stress or new lumbar facet sign [3].

All patients were scanned with CT 580 Optima machine of GE Healthcare, USA. Target region was lumbar spine. Scanning length was 512mm. All measurements were performed by Picture Archiving and Communication System (PACS) of Hologic, Universal Viewer Zero Footprint Client, version 6.0 SP 11.2.2.

The degenerative characteristics of facet joint were examined in the CT scan with 6 features. Osteophyte is the excrescent new bone which lacks medullary space, protrudes from margin of the joint. Hypertrophy is the enlargement of articular process with the normal ratio of medullary cavity/cortex. Joint space is defined as the distance between two opposite points in the cortical surfaces of the superior and inferior articular processes in the interverbal slice. Vacuum phenomenon is described as the tissue in the joint space with the absorption less than -100 Hounsfield units (HU). Calcification is defined as the tissue in the joint capsule which has an attenuation greater than 80HU. Subchondral cyst is the cyst which appears in the subchondral region with the attenuation around 0-10HU [4]. From the assessment of these features, we classified the osteoarthritis severity of facet joint according to Pathria classification: Grade 0: Normal, Grade 1: Joint space < 2mm, small osteophytes, mild hypertrophy, Grade 2: Joint space < 2mm, moderate osteophytes, moderate hypertrophy, mild subarticular bone erosions, Grade 3: Narrowing facet joint space, large osteophytes, severe hypertrophy, severe subarticular erosion, subchondral cysts and vacuum phenomenon [5].

In this study, the morphology of degenerative facet joint was also evaluated. The shape of facet joint was categorized into 3 types: C, J shaped and straight, according to the shape of superior process. The angle of the joint was defined by two lines which were the sagittal line versus the line through anteromedial and posterolateral ends of joint cavity (C and J shaped joints), or the line of inferior process (straight joints), in the slice through the intervertebral disc. Tropism was the reduction between the right and left angle of one level [6].

Data was analyzed by SPSS 2.0. Continuous variables were presented by Mean ± SD. Categorized variables were presented by percentage. Paired samples T-test and Wilcoxon signed rank test were used to compare two means. The value p inferior of 0.05 was considered as statistical significance.

3. Result

Table 1. General characteristics

Characteristics (n = 42)	Index
Age ($\overline{X}$ ± SD) (years old)	63.79 ± 2.24
Gender ratio (Female/Male)	34/8 = 4.25
BMI ($\overline{X}$ ± SD) (kg/m^2)	23.10 ± 3.16
Manual occupation (n, %)	33/42 (78.42)
Sacralization of L_5 (n, %)	2/42 (4.76)
Number of lumbar facet joints (n)	416 (including 8 destructive joints)

Table 2. Angle of joints

Facet joints	($\bar{X}$ ± SD)° (Right)	($\bar{X}$ ± SD)° (Left)	($\bar{X}$ ± SD)° Average (Right, Left)	($\bar{X}$ ± SD)° Tropism
L_{12}	31.52 ± 8.99	30.77 ± 9.84	31.14 ± 8.78	5.47 ± 4.09
L_{23}	33.20 ± 7.69	32.76 ± 8.88	32.98 ± 7.49	5.75 ± 4.22
L_{34}	39.77 ± 9.35	39.04 ± 7.80	39.40 ± 8.17	4.35 ± 3.29
L_{45}	43.26 ± 10.05	42.33 ± 9.74	42.80 ± 8.72	7.32 ± 5.79
L_5S_1	45.39 ± 12.97	45.83 ± 11.75	45.61 ± 11.20	7.58 ± 7.22

From cephalad to caudal, facet joints angles were relatively larger, statistically significant p<0.05 (T-test).

Table 3. Joint shapes

Fjs	C-shaped (n, %)	Straight (n, %)
L_{12}	79/84 (94.05)	5/84 (5.95)
L_{23}	84/84 (100)	0/84 (0)
L_{34}	79/83 (95.18)	4/83 (4.82)
L_{45}	69/79 (87.34)	10/79 (12.66)
L_5S_1	43/78 (55.13)	35/78 (44.87)
	354/408 (86.76)	54/408 (13.24)

The C-shaped facet joint was more common among the population with symptomatic degenerative facet joints.

Table 4. Joint spaces and comparisons

	Widest ($\bar{X}$ ± SD) mm	Narrowest ($\bar{X}$ ± SD) mm	p		Widest ($\bar{X}$ ± SD) mm	Narrowest ($\bar{X}$ ± SD)mm	p
L_{12}(R)	1.59 ± 0.44	0.71 ± 0.32	<0.05	L_{12}(L)	1.49 ± 0.37	0.69 ± 0.22	<0.05
L_{23}(R)	1.84 ± 0.67	0.74 ± 0.27	<0.05	L_{23}(L)	1.75 ± 0.56	0.73 ± 0.35	<0.05
L_{34}(R)	2.04 ± 0.67	0.78 ± 0.37	<0.05	L_{34}(L)	1.78 ± 0.59	0.8 ± 0.39	<0.05
L_{45}(R)	1.95 ± 0.56	0.81 ± 0.35	<0.05	L_{45}(L)	1.95 ± 0.52	0.94 ± 0.43	<0.05
L_5S_1(R)	1.88 ± 0.53	0.72 ± 0.28	<0.05	L_5S_1(L)	1.58 ± 0.44	0.78 ± 0.32	<0.05

T-test was used in order to compare the narrowest and widest space. It was noted that the joint space was asymmetrically narrowed which was characterized by the degenerative process.

Table 5. Degenerative characteristics of facet joints

	Subchondral sclerosis	Bone Erosion	Adhesive	Calcification	Hypertrophy	Osteophyte	Cyst	Vacuum
Yes (n, %)	407/411 *(99.03)*	59/416 (14.18)	16/416 (3.85)	20/416 (4.81)	383/414 *(92.51)*	62/416 (14.90)	32/416 (7.69)	34 (8.17)

The mild degenerative characteristics were the most common. The severe ones such as cyst, vacuum contributed to small percentages.

Table 6. Pathria classification

Pathria	0 (n, %)	1 (n, %)	2 (n, %)	3 (n, %)
L_{12} (Right)	2/42 (4.76)	31/42 (73.81)	4/42 (9.52)	5/42 (11.90)
L_{23} (Right)	1/42 (2.38)	24/42 (57.14)	4/42 (9.52)	13/42 (30.95)
L_{34} (Right)	2/42 (4.76)	24/42 (57.14)	2/42 (4.76)	14/42 (33.33)
L_{45} (Right)	1/42 (2.38)	18/42 (42.86)	3/42 (7.14)	*20/42 (47.62)*
L_5S_1 (Right)	0/40 (0)	22/40 (55.00)	7/40 (17.50)	11/40 (27.50)
L_{12} (Left)	1/42 (2.38)	34/42 (80.95)	3/42 (7.14)	4/42 (9.52)
L_{23} (Left)	2/42 (4.76)	30/42 (71.43)	4/42 (9.52)	6/42 (14.29)
L_{34} (Left)	0/42 (0)	25/42 (59.52)	5/42 (11.90)	12/42 (28.57)
L_{45} (Left)	1/42 (2.38)	18/42 (42.86)	5/42 (11.90)	*18/42 (42.86)*
L_5S_1 (Left)	0/40 (0)	22/40 (55.00)	9/40 (22.50)	9/40 (22.50)
	10/416 (2.40)	248/416 (59.62)	46/416 (11.06)	112/416 (26.92)

The facet joints at L_{45} level were the most affected by degenerative process with the highest percentage of Pathria 3.

4. Discussion

General characteristics

The average age of patients was 63.79 ± 2.24 years old, female/male ratio was 4.25; the majority of subjects 78.42% had manual occupation. Average BMI was 23.10 ± 3.16kg/m^2. Sacralization of L5 was witnessed in 2/42 (4.76%) patients (Table 1). Therefore, a total of 416 lumbar facet joints of 42 subjects were evaluated. Fuchs S. et al (2005) conducted a study in 60 patients with LBP [7]. The study showed that the average age was 64.97 ± 8.31 years old, female/male ratio was 4. The average age and gender ratio in this study were similar with ours. Ribeiro LH et al (2010) conducted a study in 60 Brazillian with non-radicular LBP patients. The study showed a similar average BMI with our study: 23.8 ± 2.7kg/m^2 [8]. Based on our results, we proposed some discussions. There is a lack of research which showed the clear relationship between gender, BMI and facet joint osteoarthritis. However, many studies proved that female and overweight were the risk factors for general osteoarthritis. In term of female gender, estrogen plays an important role in chondral anabolism, hence menopausal females have higher risk of osteoarthritis than normal population. In overweight patients, it was proved a high amount of serum adipocytokines which negatively affect the chondral homeostasis.

There are two anatomical features of lumbar facet joint which have been considered as having close relationship with osteoarthritis. These are the angle and tropism. Biomechanical studies showed that the larger tropism joint closely relates to osteoarthritis. However, it is unclear the relationship of cause and consequence between tropism and osteoarthritis. The angle of 60° is considered as giving the most stable for lumbar spine. In our study, regarding the lower levels, the angles of facet joints relatively increased. And the tropisms were large with the largest at L_{45} and L_5S_1 levels (Table 2). Min HK et al (2008) performed a study in 300 spondylosis patients. It showed that the angles increased regarding the descendant levels of lumbar facet joints (L_{34}, L_{45}, L_5S_1: 35°, 39°, 48°, respectively) [9]. The study also showed the tropism > 7° positively correlated with osteoarthritis characteristics of L_{45} level. These findings were also similar with our study, in which L_{45} level had the highest prevalence of severe osteoarthritis characteristics and it also had the tropism higher than 7°. Yang M et al (2020) carried out a study in 542 patients (average age 35.55 ± 7.89 years old) with spondylosis. The study demonstrated that the angles of L_{34}, L_{45}, L_5S_1 were 36.83°, 45.4°, 52.5°, respectively and the tropisms were 4.45°, 4.7°, 5.6°, respectively [10]. The patterns of angles and tropisms in Ming Yang study were quite similar with ours. However our tropisms were larger. In the context of patient's population in Yang's study was younger than ours, we supposed a hypothesis that the larger

tropism and the smaller angle could be a result of osteoarthritis process rather than its risk factors.

Theoretically, the C-shaped and J-shaped facet joints give the higher resistance against forward and lateral replacements of facet joints, consequently play an important role for lumbar spine stability. However, these shapes allow more contact of cartilage which covers two inner facets of joints during lumbar motions. Hence, the cartilage would be more degenerated. This study showed the C-shaped joint was predominant (Table 3). According to our knowledge, there was only study of Horwitz (1940) which mentioned the distribution of facet joint shape in normal population [6]. The pattern of two distributions were quite identical, however the rates of C shape was higher in our study. This means the percentage of C-shaped facet joint in spondylosis population is higher than normal population. This finding is supportive for the aforementioned theory, C-shaped facet joint might be a risk factor for osteoarthritis.

Osteoarthritis is characterized by the asymmetrical joint space narrowing. In this study, the narrowest and largest joint space of one facet joint were measured. And these spaces were significantly different ($p<0.05$) (Table 4). It is reasonable findings in spondylosis patients. The severe characteristics of osteoarthritis contributed to small percentages (Table 5).

There were some researches in 3D CT-scan which assessed the joint space at the whole joint surface during each lumbar motion. These researches showed that the joint space of L_{45} level mostly changed in every lumbar motion, hence it could be possible that L_{45} level would be the most suffered from osteoarthritis. Pathria 3 was most common at L_{45} level which had higher proportion of severe characteristics of osteoarthritis. Pathria et al (1987) investigated the prevalences of each classification in 50 male patients with average age of 52.8 years old. His study showed that the rates of Pathria 0, 1, 2, 3 were 34.6%, 39.5%, 16.4%, 9.6%, respectively [5]. These findings of osteoarthritis in Pathria's study were less serious than ours. It could be explained by the domination of younger and male population in Pathria's study. Once again, it proved the role as the risk factor of female gender regarding facet joint osteoarthritis.

5. Conclusion

C-shaped joint was the most popular. Large tropism might be a consequence of prolonged osteoarthritis. Subchondral sclerosis and hypertrophy presented at almost facet joints. Pathria grade 3 was the most popular at L_{45} level which had higher percentage of severe osteoarthritis features.

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