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Comparison of Disc Degeneration between the Cervical and Lumbar Spine

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Study Design: A retrospective radiologic study.
Objectives: To compare disc degeneration between the cervical and lumbar spine and to elucidate the patterns of degeneration according to the corresponding disc levels in the cervical and lumbar spine.
Summary of Literature Review: Disc degeneration results from the aging process in the spine. However, the incidence of disc degeneration in the cervical and lumbar spine might differ due to anatomical differences
Materials and Methods: We randomly selected 280 patients by age and sex among 6,168 patients who underwent cervical or lumbar spine magnetic resonance imaging combined with whole-spine T2 sagittal images from June 2006 to March 2012. We classified disc degeneration by the modified Matsumoto grading system and the Pfirrmann classification at 11 intervertebral disc levels from C2 to T1 and from L1 to S1.
Results: There was no significant difference in disc degeneration between the cervical and lumbar spine in either grading system. No significant difference was found in the degree of disc degeneration between the lower two disc levels of the cervical spine and the lower two disc levels of the lumbar spine in either system (C5-C6, C6-C7, L4-L5, L5-S1). However, both grading systems showed more severe degeneration in upper two disc levels of the cervical spine than in the upper two disc levels of the lumbar spine (C2-C3, C3-C4, L1-L2, L2-L3).
Conclusions: There was a significant difference in disc degeneration between the upper two disc levels of the cervical and lumbar spine. Adjacent segmental degeneration after fusion surgery might reflect the natural history of the condition, not adjacent segmental problems.

Key words: Cervical vertebrae, Lumbar vertebrae, Intervertebral disc, Degeneration

Introduction

Intervertebral disc degeneration is a result of the aging process.[1,2] Matsumoto et al. found the prevalence of disc degeneration of the cervical spine increased with age, with a decrease in signal intensity of intervertebral disc.[3] Disc degeneration was observed on the MRI in 17% of males and 12% of females aged 20~29 years and in 86% of males and 89% of females aged 60~69 years.[3] Similarly, age was associated with the presence of disc degeneration in the lumbar spine.[1]

The relationship between cervical and lumbar degenerative

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spondylosis has been reported on the cadaveric specimens,[4] and on the radiographs.[5] There has been only one study to compare disc degeneration between the cervical and lumbar spines on the magnetic resonance imaging(MRI).[6] They found that disc degeneration for the cervical and lumbar spines were positively correlated.[6]

However, the incidences of disc degeneration in the cervical and lumbar spines might differ due to anatomical differences between the cervical and lumbar spines. Degeneration is seen in the thoracic spine, but less prevalence than degeneration at the cervical spine.[7] Out of 94 asymptomatic subjects who underwent MRI in both the thoracic and cervical spine, degeneration in the thoracic spine was found in about half of the subjects with degeneration in the cervical spine.[7]

The purpose of the present study was to compare disc degeneration between cervical and lumbar spines and elucidate the degeneration according to corresponding disc levels between cervical and lumbar spines.

Material and Methods

This study was approved by the institutional review board at the institution of the corresponding author (IRB number:2014-I132). This is a retrospective MRI study. In this study, we analyzed the collected digitalized image documents retrospectively. We selected randomly 280 patients from 6,168 patients who underwent cervical or lumbar spine MRI combined with the whole spine T2 sagittal image to evaluate the pain radiating to upper or lower extremities from June 2006 to March 2012 at the first author's academic institution. A total of 280 patients were selected randomly out of the 6,168 patients for the current study using a random number generator and their information was blinded to the selecting researcher. The exclusion criteria included those with the previous history of spinal fracture, any operations, infective spondylitis, tumor, and spinal deformity. A total of 5,888 patients were excluded. Finally, the subjects consisted of 14 groups by age and sex (male and female group, from 10' to 70'). Each group consists of 20 patients. Power analysis was performed by G*Power version 3.1.5 (Germany). Power was 0.3 for Wilcoxon signed rank test with the effect size of 0.5 and alpha error probability of 0.05. The total sample size should be more than 128.

Whole spinevT2 sagittal MRI image in all patients was carried out using a 1.5-T superconductive imager (Intera, Koninklijke Philips Electronics N.V.) under the following settings: sagittal T2-weighted fast spin-echo imaging [repetition time (TR)/echo time (TE) (2346/100), echo train length 16, thickness of slice 4 mm, field of view (FOV) 320mm, matrix size 548×272, number of excitation (NEX) 4]. We classified disc degeneration by modified Matsumoto's grading system[8] and Pfirrmann's grading classification[9] at eleven intervertebral disc levels from C2 to T1 and from L1 to S1 using T2 whole spine sagittal image on PACS (*Π* view, Infinitt, Seoul, Korea). Modified Matsumoto's grading system has been used for the disc degeneration of the cervical spine.[3] Pfirrmann's grading classification has been used for the disc degeneration of the lumbar spine.[9]

However, there has been no grading classification for both cervical and lumbar spine in term of the disc degeneration. Therefore, we used both grading systems to compare the degeneration of the disc between the cervical and lumbar spines.

The assessors were two spine surgeons with over than ten years' clinical experiences. The assessors were not aware of the source population of the MRIs. They also were not informed about the purpose of the study. They evaluated the MR images in a randomized sequence and without discussion of the findings to minimize possible bias. The I, II, III, IV and V of the Pfirrmann's grading system were converted to 1, 2, 3, 4 and 5 respectively to calculate the mean and standard deviation values of disc degeneration. When two experienced spine surgeons had different grading results, we have assigned the lower grade for it as the final grading results.

In addition, we compared disc degeneration at the corresponding level of cervical and lumbar spines. We excluded the C7-T1 disc level from the comparison of the corresponding two disc levels because the C5-C6 and C6-C7 disc herniations are the most common degenerative radiculopathies in the cervical spine.[10] The L4-L5 and the L5-S1 disc herniations are the most common degenerative radiculopathies in the lumbar spine.

All statistical analyses were performed with an SPSS version 24.0 for Windows (Chicago, IL, USA). Differences in continuous variables between the two groups were examined with the Wilcoxon signed rank test. Values are expressed as the mean values with standard deviation. It was considered significant when p was less than 0.05.

Results

The Kappa scores to assess the interobserver agreement of modified Matsumoto's grading system were 0.87 for the signal intensity of intervertebral disc, 0.87 for posterior disc protrusion and 0.53 for disc space narrowing.[8] They show fair to perfect agreement. Landis and Koch characterized Kappa valuesv 〈0 as indicating no agreement and 0~0.20 as slight, 0.21~0.40 as fair, 0.41~0.60 as moderate, 0.61~0.80 as substantial, and 0.81~1 as almost perfect agreement.[11]

There was no difference of disc degeneration between cervical and lumbar spine based on both Matsumoto's and Pfirrmann's grades (cervical spine vs. lumbar spine: 1.01±0.57 vs. 1.05±0.71, p=0.634 by Matsumoto's grade, 2.73±0.51 vs. 2.69±0.59, p=0.121 by Pfirrmann's grade). Disc degeneration increased with age independently of gender based on both Matsumoto's and Pfirrmann's grades (female vs. male: 1.00±0.54 vs. 1.03±0.59, p=0.636 in the cervical spine by

Table 1. Disc degeneration according to anatomical regions and age groups (mean±standard deviation)

Age groups	Cervical spine Matsumoto's grade	Lumbar spine Matsumoto's grade	Cervical spine Pfirrmann's grade	Lumbar spine Pfirrmann's grade
10	0.55±0.40	0.44±0.43	2.10±0.42	2.02±0.32
20	0.66±0.34	0.49±0.40	2.40±0.41	2.15±0.31
30	0.70±0.34	0.80±0.51	2.57±0.37	2.40±0.36
40	0.87±0.29	1.13±0.48	2.76±0.30	2.82±0.38
50	1.14±0.46	1.14±0.48	2.88±0.32	2.89±0.38
60	1.43±0.46	1.62±0.61	3.11±0.24	3.24±0.30
70	1.73±0.47	1.76±0.76	3.28±0.26	3.30±0.40
Total	1.01±0.57	1.05±0.71	2.73±0.51	2.69±0.59

*The I, II, III, IV and V of the Pfirrmann's grading system were converted to 1,2,3,4 and 5 respectively to calculate the mean and standard deviation values.

Table 2. Disc degeneration according to disc levels by Matsumoto's grades

Level	0	1	2	3	4	5	6	Total
C2-C3	62 (22.1%)	214 (76.5%)	4 (1.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.79±0.44
C3-C4	47 (16.7%)	191 (68.3%)	34 (12.1%)	7 (2.5%)	1 (0.4%)	0 (0.0%)	0 (0.0%)	1.01±0.65
C4-C5	51 (18.1%)	171 (61.2%)	38 (13.5%)	14 (5.0%)	3 (1.1%)	3 (1.1%)	0 (0.0%)	1.13±0.88
C5-C6	33 (11.7%)	146 (52.0%)	60 (21.7%)	31 (11.0%)	8 (2.8%)	2 (0.7%)	0 (0.0%)	1.43±0.98
C6-C7	71 (25.3%)	138 (49.1%)	38 (13.5%)	29 (10.7%)	4 (1.4%)	0 (0.0%)	0 (0.0%)	1.14±0.96
C7-T1	142 (50.5%)	120 (43.1%)	17 (6.0%)	1 (0.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.56± 0.62
L1-L2	109 (39.1%)	152 (54.1%)	7 (2.5%)	9 (3.2%)	2 (0.7%)	0 (0.0%)	1 (0.4%)	0.74±0.79
L2-L3	105 (37.4%)	139 (49.8%)	23 (8.2%)	12 (4.3%)	1 (0.4%)	0 (0.0%)	0 (0.0%)	0.80±0.79
L3-L4	94 (33.5%)	132 (47.3%)	33 (11.7%)	19 (6.8%)	0 (0.0%)	2 (0.7%)	0 (0.0%)	0.95±0.92
L4-L5	66 (23.5%)	94 (33.8%)	80 (28.5%)	21 (7.5%)	17 (6.0%)	2 (0.7%)	0 (0.0%)	1.41±1.15
L5-S1	66 (23.8%)	101 (35.9%)	70 (24.9%)	34 (12.1%)	6 (2.1%)	3 (1.1%)	0 (0.0%)	1.36±1.10

Matsumoto's grade, 1.11±0.76 vs. 1.00±0.64, p=0.160 in the lumbar spine by Matsumoto's grade, 2.71±0.51 vs. 2.74±0.50, p=0.623 in the cervical spine by Pfirrmann's grade, 2.70±0.61 vs. 2.67±0.57, p=0.611 in the lumbar spine by Pfirrmann's grade, Table 1).

The disc degeneration gradually increased from C2–C3 and L1–L2 disc levels with most severe degeneration at C5–C6 and L4–L5 disc levels based by both Matsumoto's and Pfirrmann's grades (Table 2, 3).

Both grading systems did not show the concordant results on the corresponding disc levels between cervical and lumbar spine except corresponding two disc levels (C3–C4 vs. L2–L3,

Table 3. Disc degeneration according to disc levels by Pfirrmann's grades

Disc level	I	II	III	IV	V	Total
C2-C3	15 (5.3%)	59 (21.0%)	204 (73.0%)	2 (0.7%)	0 (0.0%)	2.69±0.58
C3-C4	6 (2.1%)	56 (19.9%)	208 (74.4%)	10 (3.6%)	0 (0.0%)	2.79±0.53
C4-C5	9 (3.2%)	57 (20.3%)	193 (69.0%)	18 (6.4%)	3 (1.1%)	2.82±0.64
C5-C6	4 (1.4%)	48 (17.1%)	185 (66.2%)	39 (13.9%)	4 (1.4%)	2.97±0.65
C6-C7	22 (7.8%)	66 (23.5%)	155 (55.2%)	34 (12.5%)	3 (1.1%)	2.75±0.81
C7-T1	34 (12.1%)	118 (42.0%)	125 (44.8%)	3 (1.1%)	0 (0.0%)	2.35±0.70
L1-L2	4 (1.4%)	135 (48.4%)	127 (45.2%)	13 (4.6%)	1 (0.4%)	2.54±0.63
L2-L3	8 (2.8%)	124 (44.1%)	130 (46.6%)	18 (6.4%)	0 (0.0%)	2.57±0.66
L3-L4	12 (4.3%)	108 (38.4%)	138 (49.5%)	20 (7.1%)	2 (0.7%)	2.62±0.71
L4-L5	14 (5.0%)	70 (24.9%)	150 (53.7%)	39 (13.9%)	7 (2.5%)	2.84±0.82
L5-S1	15 (5.3%)	66 (23.8%)	151 (53.7%)	40 (14.2%)	8 (2.8%)	2.85±0.83

*The I, II, III, IV and V of the Pfirrmann's grading system were converted to 1,2,3,4 and 5 respectively to calculate the mean and standard deviation values.

Table 4. Matsumoto's grade and Pfirrmann's grade according to the corresponding level of cervical and lumbar spines.

Disc levels	Matsumoto's grade	p-value	Pfirrmann's grade	p-value
C2-C3 vs. L1-L2	0.79±0.44 vs. 0.74±0.79	0.121	2.69±0.58 vs. 2.54±0.63	0.001
C3-C4 vs. L2-L3	1.01±0.65 vs. 0.80±0.79	0.000	2.79±0.53 vs. 2.57±0.66	0.000
C4-C5 vs. L3-L4	1.13±0.88 vs. 0.95±0.92	0.002	2.82±0.64 vs. 2.62±0.71	0.000
C5-C6 vs. L4-L5	1.43±0.98 vs. 1.41±1.15	0.794	2.97±0.65 vs. 2.84±0.82	0.010
C6-C7 vs. L5-S1	1.14±0.96 vs. 1.36±1.10	0.003	2.35±0.71 vs. 2.86±0.83	0.000

*The I, II, III, IV and V of the Pfirrmann's grading system were converted to 1,2,3,4 and 5 respectively to calculate the mean and standard deviation values.

Table 5. Disc degeneration between the corresponding groups of upper or lower two disc levels of cervical and lumbar spines (mean±standard deviation)

Disc levels	Matsumoto's grade	p-value	Pfirrmann's grade	p-value
C2-C3, C3-C4 vs. L1-L2, L2-L3	0.90±0.57 vs. 0.77±0.79	0.000	2.74±0.56 vs. 2.55±0.64	0.000
C5-C6, C6-C7 vs. L4-L5, L5-S1	1.29±0.87 vs. 1.38±0.93	0.094	2.86±0.66 vs. 2.85±0.71	0.694

*The I, II, III, IV and V of the Pfirrmann's grading system were converted to 1,2,3,4 and 5 respectively to calculate the mean and standard deviation values.

C4–C5 vs. L3–L4, C6–C7 vs. L5–S1, Table 4).

The disc degeneration was mild in upper two disc levels of cervical spine and those of lumbar spine (C2–C3, C3–C4, L1–L2, L2–L3) and severe in lower two disc levels of cervical spine and those of lumbar spine (C5–C6, C6–C7, L4–L5, L5–S1) based on both Matsumoto's and Pfirrmann's grades (Table 2,3). There was no difference in the degree of disc degeneration between the groups of lower two disc levels of the cervical spine and that of lumbar spine based on both grading systems (Table 5). However, both grading systems showed more severe degeneration in the group of upper two disc levels of a cervical spine than in the group of the upper two disc levels of the lumbar spine (Table 5).

Discussion

There has been only one report showing the disc degeneration for the cervical and lumbar spines were positively correlated on the MRI.[6] However, the incidences of disc degeneration in the cervical and lumbar spines might differ due to anatomical differences between the cervical and lumbar spines.

There was no difference in disc degeneration between cervical and lumbar spine. The disc degeneration was severe in lower two disc levels of the cervical spine and those of lumbar spine (C5–C6, C6–C7, L4–L5, L5–S1) and mild in upper two disc levels of the cervical spine and those of lumbar spine (C2–C3, C3–C4, L1–L2, L2–L3). There was no difference in the degree of disc degeneration between the group of lower two disc levels of the cervical spine and that of the lumbar spine. However, degeneration in the group of upper two disc levels of the cervical spine was more severe than that in the group of upper two disc levels of the lumbar spine.

The similar results were found in the study for osteoarthritis evaluated in cadaveric spines,[4] osteoarthritis formation based on the radiographs,[5] and the disc degeneration evaluated by MRI.[6] Master et al. examined lumbar and cervical segments from 234 cadaveric spines.[4] Concurrent lumbar and cervical arthrosis was present in 80% of the study population.[4] Stepwise multiple linear regression analysis revealed significant associations between lumbar arthrosis and cervical arthrosis.[4] Lawrence et al. graded degeneration based on the radiographs and found the positive relationship of the degeneration between the cervical and lumbar spines based on osteoarthritis formation of the radiograph.[5] Morishita et al. found that the disc degeneration for the cervical and lumbar spines were positively correlated and the severe disc degeneration identified at lower two disc levels of cervical spines (C5–C6, C6–C7) and lower two disc levels of the lumbar spine (L4–L5, and L5–S1) based on the modified Pfirrmann's grading classification.[6] However, they did not elucidate the relationship of disc degeneration according to the corresponding disc levels between the cervical and lumbar spines. In the current study, we elucidated the relationship of disc degeneration according to the corresponding disc levels that degeneration in the group of upper two disc levels of the cervical spine was more severe than that in the group of upper two disc levels of the lumbar spine. In addition, they used modified Pfirrmann's grading classification to evaluate the degeneration of a disc in the cervical spine, which has been used for the disc degeneration of lumbar spines.[6]

Degeneration in the group of upper two disc levels of the cervical spine was more severe than that in the upper two disc levels of the lumbar spine in the current study. It might be explained by the fact that the L4–L5 and L5–S1 disc space have taller heights and a larger range of motion than L1–L2 and L2–L3 disc spaces. There was no similar relationship having taller heights and a larger range of motion between the group of C5–C6 and C6–C7 and the group of C2–C3 and C3–C4 in the cervical spines. However, there are controversies over the relationship between a range of motion and disc degeneration. Lee et al. found the segmental range of motion at levels with degenerated discs was decreased.[12] Fujiwara et al. found that the flexibility of the spine increases in moderate disc degeneration, and decreases in severe disc degeneration.[13] However, Nachemson et al. found that the degree of degenerative changes in the lumbar segments does not correlate with the segmental range of motion.[14]

The disc degeneration was associated with advancing age in the current study. The same results were found in the study for osteoarthritis evaluated in cadaveric spines,[4] osteoarthritis formation based on the radiographs,[5,15] and the disc degeneration evaluated by MRI.[6,8] The disc degeneration was independent of gender in the current study. There have been the controversies over the disc degeneration according to gender. There was no difference of disc degeneration between female and male in the study for osteoarthritis evaluated in cadaveric spines,[4] and osteoarthritis formation based on the radiograph.[15] However, the greater prevalence of osteophytes was found in the radiographs of males,[5] and in the lumbar autopsy specimens of males.[16] In contrast, female subjects tended to have slightly more severe lumbar disc degeneration than male subjects in the MRI evaluations.[17]

As with any study, the present investigation has several limitations. First, this is a retrospective study. Second, we did not evaluate the symptoms correlated with disc degeneration in the study population. However, our purpose was to compare the radiologic degeneration of all disc levels of both regions, but the not symptomatic degeneration of specific disc level. Third, we used the both modified Matsumoto's and Pfirrmann's grading system to compare the degeneration of disc between the cervical and lumbar spines because modified Matsumoto's grading system has been used for the disc degeneration of the cervical spine,[8] and Pfirrmann's grading classification has been used for the disc degeneration of the lumbar spine.[9] It will be necessary to develop the grading system for the disc degeneration of both cervical and lumbar spines in the future. Fourth, both modified Matsumoto's and Pfirrmann's grading system is not the quantitative but the qualitative analytic method. Because there is no quantitative grading system for disc degeneration until now, previous studies have used the qualitative grading system for disc degeneration.[6,8] Fifth, the statistical difference of radiologic findings in the disc degeneration does not show the clinical significance. It will be necessary to evaluate the clinical significance according to the radiologic difference of disc degeneration. Despite these shortcomings, to our knowledge, this is the first report comparing disc degeneration according to the corresponding disc levels between cervical and lumbar spines. The current report might help to understand the disc degeneration, disc herniations and adjacent segmental problems of cervical and lumbar spine fusion surgeries. The adjacent segmental degeneration in the group of the upper two disc levels of the cervical spine might be the natural history of cervical spondylosis but not adjacent segmental problems.[18]

Conclusions

There was no difference in disc degeneration between cervical and lumbar spine. However, there was a difference in disc degeneration between the corresponding upper two-disc level groups between cervical and lumbar spines. The adjacent segmental degeneration in the group of the upper two disc levels of the cervical spine might be the natural history of cervical spondylosis but not adjacent segmental problems.

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추간판 퇴행성 변화의 경추와 요추간 비교

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연구 계획: 방사선학적 영상 고찰에 의한 후향적 연구

목적: 경추 및 요추 추간판의 퇴행성 변화를 비교하고 추간판 분절에 따른 변화를 규명하고자 함.

선행 연구문헌의 요약: 추간판의 퇴행성 변화는 노화과정에 시작된다. 그러나, 경추와 요추의 해부 구조의 상이성 때문에 퇴행성 변화의 차이가 있을 수 있다.

대상 및 방법: 2006년 6월부터 2012년 3월까지 T2 전척추 시상면 영상을 포함하여 자기 공명 영상 검사를 시행한 6,168명의 환자 중 총 280명을 무작위로 선발하여 연구대상으로 하였다. Modified Matsumoto's grading system과 Pfirrmann's grading classification을 이용하여 제 2경추부터 제 1흉추까지, 제 1요추부터 제 1천추까지의 추간판의 퇴행성 변화를 평가하였다.

결과: 경추부와 요추부의 추간판의 퇴행성 변화는 차이가 없었다. 하부 경추와 하부 요추는 추간판의 퇴행성 변화에 차이가 없었다(제 5-6경추, 제 6-7경추, 제 4-5요추, 제 5요추-제 1천추). 그러나, 상부 경추와 상부 요추는 추간판의 퇴행성 변화에 차이가 있었다(제 2-3경추, 제 3-4경추, 제 1-2요추, 제 2-3요추).

결론: 상부 경추와 상부 요추는 추간판의 퇴행성 변화에 차이가 있었다. 전방 골유합술 후 발생하는 인접 분절의 퇴행성 변화는 노화에 의한 자연 경과이며 인접 분절 질환은 아닌 것으로 추정한다.

색인 단어: 경추, 요추, 추간판, 퇴행성 변화

약칭 제목: 추간판 퇴행성 변화 경추 요추

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