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Objective: Similar to back pain, neck pain has recently shown to have increasing prevalence. Magnetic resonance imaging (MRI) is useful in identifying the causes of neck pain. However, MRI shows not only pathological lesions but also physiological changes at the same time, and there are few Korean data. The authors have attempted to analyze the prevalence of disc degeneration in highly selective asymptomatic Korean subjects using MRI.

Methods: We performed 3 T MRI sagittal scans from C2 to T1 on 102 asymptomatic subjects (50 men and 52 women) who visited our hospital between the ages of 14 and 82 years (mean age 46.3 years). All images were read independently by three observers (two neurosurgeons and one neuroradiologist) who were not given any information about the subjects. We classified grading for cervical disc herniation (HN), annular fissure (AF), and nucleus degeneration (ND), using disc degeneration classification.

Results: The prevalence of HN, AF, and ND were 81.0%, 85.9%, and 95.4%, respectively. High prevalence of HN, AF, and ND was shown compared to previous literature.

Conclusion: In asymptomatic Korean subjects, the abnormal findings of 3 T MRI showed a high prevalence in HN, AF, and ND. Several factors might play important roles in these results, such as population-specific characters, MRI field strength, and disc degeneration grading system.

Key Words: Degeneration · Cervical disc · Magnetic resonance imaging.
per extremities and never had any neurological deficits.

The absence of relevant symptoms in these areas was defined as never having seen a physician, physiotherapist, chiropractor, acupuncture, oriental herb medication, or other such health care professional, and never having missed workday due to these symptoms. The rationale for these criteria was the notion that episodes of transient neck pain are common and less likely to be recalled after spontaneous regression\(^6\). Cases in which hospitalization treatment was administered for trauma such as a traffic accident were also excluded, because trauma required hospitalization may have undetected cervical diseases.

### MR imaging methods

From C2 to T1, magnetic resonance (MR) scans were performed with a 3.0-Tesla imager (Achieva 3.0 T X-series, Philips Medical Systems, the Netherlands) with a dedicated receive-only spine coil. The protocol included sagittal T2-weighted [2593/120 (repetition time msec/echo time msec)] turbo spin-echo imaging of the entire cervical spine with the following sequence parameters: matrix, 516×256; field of view, 270 mm; section thickness, 3 mm; intersection gap, 0.3 mm; and echo train lengths of 16 for T2-weighted images (T2WI). Though an axial sequence is also necessary to differentiated differences in disc pathology, but the authors use only sagittal imaging for convenience.

All images were sent to the in-hospital picture archive and communication system (PACS; Infinitt PACS, invented by Infinitt Co, Seoul, Korea) and reviewed using a 21.3-inch, 5-megapixel medical flat grayscale display (MFGD 5421, Barco, Kortrijk, Belgium) on a HP xw4400 workstation base unit (Hewlett-Packard Co, CA, USA). The monitor has a 2048×2560 resolution, 0.165 mm pixel pitch, 422.4×337.9 mm active screen area, 800:1 dark room contrast, and 700 cd/m\(^2\) luminance.

### Image analysis

The imaging studies in all 102 asymptomatic subjects were read independently by three of the authors (two neurosurgeons and one neuroradiologist) who were not given any information about the subjects. To eliminate potential reading bias, the images of 30 random symptomatic patients were mixed with the subject's images. We did not analyze the random 30 patients' results in final analysis. There was no case of blocked vertebra or fusion. Six cervical disc levels were examined in each subject, and a total of 612 discs were examined.

### Degree of degeneration

To establish the criteria for determining disc abnormality, we classified the three measurement categories: hernia-
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Correlates with the extent and loss of signal intensity in the nucleus pulposus of the intervertebral disc. Intervertebral disc narrowing was diagnosed in cases in which decrease of more than 33.3% in the intervertebral disc space was present. The seven findings in the cervical intervertebral disc were: bright (homogeneous hyperintense nucleus), bright-band (nucleus clear distinction with horizontal dark band), bright-narrow (nucleus clear with disc height decreased), dim (nucleus unclear distinction with normal height), dim-slight (nucleus unclear with slightly decreased), dim-moderate (nucleus unclear with moderately decreased), dim-collapsed (nucleus unclear with collapsed). For the purpose of this investigation, grade 0-2 were grouped together and grade 3-6 were the more advanced grades of ND (Table 2, 3, Fig. 1).

Analysis of the prevalence of abnormal findings

The prevalence of the various abnormalities was calculated by disc count (DC) and person count (PC). DC is the number of...
discs regardless of subjects (0-612) and PC is the number of subjects with disc degeneration (0-102).

**Statistical analysis**

The prevalence of the various abnormalities was calculated by averaging the scores of three readers. Inter-observer reproducibility was assessed using Kendall’s coefficient of concordance. The Kendall correlation can be interpreted as the coefficient of concordance to measure the agreement among raters (0, no agreement; 1, complete agreement).

**RESULTS**

**Degree of degeneration**

**Herniation**

Authors found bulging of disc in 142.3 (23.3%) of all 612 discs in 70.0 (68.6%) of the 102 subjects (Table 4). The score of bulging slightly increased along with the age, but not proportional to the age. Bulging was almost not seen at the level of C2/3, but the most common levels were C5/6 and C4/5 (Fig. 2). In protrusion, there are 41.0 (6.7%) of all 612 discs in 30.0 (29.4%) of the 102 subjects (Table 4). The score of protrusion slightly increased along with the age, but not proportional to the age. Protrusion was almost not seen at the level of C2/3, but the most common levels were C5/6. Extrusion of disc was found in 30.7 (5.0%) of all 612 discs in 23.3 (22.9%) of the 102 subjects (Table 4). This showed that a peak point was reached at the level of C5/6 in the 60’s. In the 70’s or older, however, it was reached a peak point at the level of C6/7. Extrusion was not common in cervical levels except the level of C5/6 and C6/7. There were no sequestrations of disc (Table 4).

**Annular fissure and high-signal intensity zone**

The authors found AF of disc in 266.0 (43.5%) of all 612 discs in 87.7 (85.9%) of the 102 subjects (Table 4). This showed that the prevalence of AF, ANN, and ND in asymptomatic subjects were 81.4%, 85.9%, and 95.4%, respectively. However, cervical disc degeneration is frequently found on MRI, even in the absence of neck pain. Christe et al. reported that disc herniation (above of bulging) was found in 30.6% of asymptomatic subjects.

**HIZ** of disc was found in 37.7 (6.2%) of all 612 discs in 27.3 (26.8%) of the 102 subjects (Table 4). The score of HIZ slightly increased along with the age, but not proportional to the age. HIZ was almost not seen at the level of C2/3. But a peak value was found at the level of L5/6 in the 50’s, and at the level of C6/7 in the 40’s (Table 4).

**Nucleus degeneration**

For the analysis of prevalence, grade 0-2 were grouped together and grade 3-6 were the more advanced grades of ND. We defined that advanced grades of ND is abnormal finding of disc. The authors found disc ND in 360.0 (58.8%) of the 612 discs analyzed and in 97.3 (95.4%) of the 102 subjects (Table 4). The graph of ND according to age and level was analyzed. The graph was proportional to age at all levels. Severe ND was found at all levels in elderly group, even in young-aged people at C3/4 and C4/5. The most common level was C5/6, and the level of age-dependent were C6/7>C4/5>C7/T1 in order (Fig. 2).

The results are summarized in Table 4. Table 4 is DC and PC of herniation, annular fissure, and nucleus degeneration of abnormal findings according to subject age and level.

**Inter-observer reproducibility**

The agreement values for the ND, AF, and HN were 0.968, 0.964, and 0.972 (p<0.0001), using Kendall’s coefficient of concordance.

**DISCUSSION**

Similar to back pain, neck pain has recently shown to have increasing prevalence. Fejer et al. reported the prevalence of neck pain by performing a meta-analysis. The point, one year, and lifetime prevalence of neck pain was reported to be 7.6%, 37.2%, and 48.5%, respectively. However, cervical disc degeneration is more frequent on MRI, even in the absence of neck pain. Christe et al. reported that disc herniation (above of bulging) was found in 30.6% of asymptomatic subjects.

The authors’ analysis showed that the prevalence of HN, AF, and ND in asymptomatic subjects were 81.4%, 85.9%, and 95.4%, respectively. In our results, abnormal findings on MRI were observed with a high prevalence of more than 80%. Miyazaki et al. reported that the prevalence of degeneration in symptomatic cases was 72.3%. Our results showed higher prevalence than asymptomatic cases. These results led us to reconsider the relationships between cervical symptoms and abnormal findings on MRI.

In our results, ND showed higher score than HN and AF. Notably, degeneration was more frequent in the upper cervical segments than in the lower cervical segments, such as C2/3 and 3/4. These findings may come from frequent rotation of the upper segment, radiculopathy due to upper cervical disc degeneration.

Fig. 2. Graph of disc degeneration prevalence according to age and level, calculated by disc count. A, B and C : Herniation. D : Annular fissure. E : High-signal intensity zone (HIZ). F : Nucleus degeneration.

Table 5. International literatures comparison of herniation, annular fissure, and nucleus degeneration in asymptomatic subjects (%)

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Tesla</th>
<th>Case</th>
<th>Nuclear degeneration</th>
<th>Herniation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Annular fissure (presence)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>DC</td>
</tr>
<tr>
<td>Teresi et al.(^3) (USA)</td>
<td>1987</td>
<td>0.3</td>
<td>100</td>
<td></td>
<td>5.0</td>
</tr>
<tr>
<td>Boden et al.(^2) (USA)</td>
<td>1990</td>
<td>1.5</td>
<td>63</td>
<td></td>
<td>5.3</td>
</tr>
<tr>
<td>Christe et al.(^5) (SWZ)</td>
<td>2005</td>
<td>1.5</td>
<td>9</td>
<td>50.0</td>
<td>38.9</td>
</tr>
<tr>
<td>Authors (Korea)</td>
<td>2011</td>
<td>3.0</td>
<td>102</td>
<td>58.8</td>
<td>95.4</td>
</tr>
</tbody>
</table>

*Autopsy study, **Included protrusion and more advanced herniation (extrusion and sequestration), †Included bulging and more advanced herniation (protrusion, extrusion, and sequestration). DC : disc count, PC : person count, G : grade, US : the United States of America, SWZ : Switzerland
In asymptomatic Korean subjects, the abnormal findings of 3 T MRI showed a high prevalence in herniation, annular fissure, and nucleus degeneration. Several factors might play important roles in these results, such as population-specific characters, MRI field strength, and disc degeneration grading system.

**CONCLUSION**

In asymptomatic Korean subjects, the abnormal findings of 3 T MRI showed a high prevalence in herniation, annular fissure, and nucleus degeneration. Several factors might play important roles in these results, such as population-specific characters, MRI field strength, and disc degeneration grading system.

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