Laterality of cervical disc herniation

Yuichi Takahashi · Takao Yasuhara · Shinji Kumamoto · Kotaro Yoneda ·
Takashi Tanoue · Masayuki Nakahara · Takafumi Inoue · Yasukazu Hijikata ·
Tejin Lee · Cesario V. Borlongan · Koichi Ogawa · Kenki Nishida

Received: 3 May 2012 / Revised: 6 September 2012 / Accepted: 28 October 2012 / Published online: 13 November 2012
© Springer-Verlag Berlin Heidelberg 2012

Abstract

Purpose Cervical disc herniation (CDH) is found more frequently at the lower cervical spine than at the upper or middle level. However, there is scarcity of data about the laterality of CDH. The aim of this study is to detect the laterality of CDH.

Methods We retrospectively evaluated preoperative computed tomography myelograms and magnetic resonance images of 75 cases of CDH who underwent single level anterior cervical discectomy and fusion at C4–5, C5–6, or C6–7 levels from 2008 to 2010 in our institute. Statistical analyses were performed using the Chi-square test.

Results Eleven cases were found at C4–5 level, 42 cases at C5–6 level, and 22 cases at C6–7 level. At C4–5 level, CDH was recognized at the right side in 2 cases, at the left side in 2 cases, and at the center in 7 cases. At C5–6 level, CDH was found at the right side in 20 cases and at the left side in 22 cases. At C6–7 level, CDH was found at the right

side in 3 cases and at the left side in 19 cases with significantly high frequency of left-sided CDH ($p < 0.025$).

Conclusions In this study, it was revealed that the left-sided CDH was more frequent than the right-sided CDH at C6–7 level.

Keywords Cervical disc herniation · C6–7 level · Handedness · Laterality

Introduction

Cervical disc herniation (CDH) is found more frequently at the lower cervical spine than at the upper or middle level. However, there is scarcity of data about the laterality of CDH. Mechanical stress plays an important role in the development of disc herniation and degeneration of the facet joint. In addition, repeated mechanical stresses on one side might result in unilateral symptoms with asymmetrical degeneration of the facet joint and disc. Facet joint arthrosis is provoked by some physical daily behavior. As an illustration, right-handed men usually twist their spines leftward in walking and sitting [1] indicating a relationship between handedness and the direction of spinal torsion in daily lives.

The aim of this study is to detect the laterality of CDH by using the retrospective data in our institute.

Materials and methods

In 3 years from January 2008 to December 2010, we performed 334 anterior cervical discectomy and fusion (ACDF) procedures using an Apaceram[®] spacer with anterior cervical plate system (ATLANTIS or VENTURE,

Y. Takahashi (✉) · T. Yasuhara · S. Kumamoto · K. Yoneda ·
T. Tanoue · M. Nakahara · K. Ogawa · K. Nishida
Department of Spine and Spinal Surgery,
Shinkomonji Hospital, 2-5, Dairishinmachi, Moji,
Kitakyushu, Fukuoka 800-0057, Japan
e-mail: yuichi5356@yahoo.co.jp

T. Inoue
Department of Spine and Spinal Surgery, Fukuokawajiro
Hospital, Higashiku, Fukuoka, Japan

Y. Hijikata · T. Lee
Department of Spine and Spinal Surgery, Shintakeo Hospital,
Takeo, Saga, Japan

C. V. Borlongan
Department of Neurosurgery and Brain Repair, University
of South Florida College of Medicine, Tampa, FL, USA

Medtronic). Among the 334 cases, 75 patients received a single level of ACDF for CDH at C4–5, C5–6, or C6–7 levels. All the cases were treated conservatively for several months without subsequent amelioration of symptoms. Cases with cervical spondylotic myelopathy/radiculopathy, trauma, ossification of posterior longitudinal ligament, previous cervical spine surgery, or multi-level fusion were excluded in this study. Pre-operative computed tomography myelograms (CTM, 3 mm slices) using a 64 slice multi-detector CT scanner (Light Speed VCT, GE Medical System, WI), with a slice thickness of 3 mm and magnetic resonance images (MRI: 1.5T, Excelart Vantage, Toshiba, Japan, or 1.5T, Signa Infinity Excite, GE Medical System, WI) of these cases were evaluated retrospectively. The location of the CDH was determined holistically using CTM, MRI and intraoperative findings. The location of CDH was classified as the right, center and left in accordance with the most protruding site posteriorly to the spinal cord (Fig. 1). Sex and the location of CDH of the cases were analyzed.

We also examined handedness of the patients in this study. Handedness was judged by asking the patients, as part of a standard assessment protocol, “Are you right- or left-handed?” In difficult cases for the judgment, writing hand was considered as the dominant hand.

Statistical analysis was performed using the Chi-square test. Statistical significance was preset at $p < 0.05$.

Results

In the 75 CDH patients, there were 50 males and 25 females with an average age of 52 (27–79 years old). Seventy-three patients among the 75 patients were right-handed without ambidexterity. Eleven cases (M/F: 5/6) were found at the C4–5 level, 42 cases (M/F: 29/13) at C5–6, and 22 cases (M/F: 16/6) at C6–7 level (Fig. 2). At C4–5 level, CDH were recognized at the right side in 2 cases, the left side in 2 cases, and the center in 7 cases. At C5–6 level, CDH were found at the right side in 20 cases and at the left side in 22 cases. At C6–7 level, CDH were found at the right side in 3 cases and at the left side in 19 cases (Fig. 3). In the two left-handed patients, both of them are male with CDH at C5–6 level. The CDH were found at the right side in one case and at the left side in the other. All of the patients with unilateral CDH have ipsilateral symptoms. In all cases, intraoperative findings were consistent with pre-operative radiological findings of CTM and MRI. After the surgery, all patients experienced symptom improvement. There were no significant differences in the

Fig. 1 Representative cases of CDH. CTM (a, c, e) and MRI (b, d, f) demonstrate the *right side* (a, b), *center* (c, d) and *left-side* (e, f) CDH. g Representative postoperative radiogram of the cervical spine (*lateral view*)

Fig. 2 Sex differences in cases with CDH. The graph demonstrates that the C5–6 level was the most common level of CDH. At the lower cervical spine, male cases might be more than female, although there was no significant difference (Chi-square: 2.54, p value: 0.28)

Fig. 3 Laterality of CDH. The graph demonstrates at C6–7 level, the frequency of left-sided CDH was significantly higher than the right one, although there was no significant differences at C4–5 and C5–6 level (Chi-square: 7.38, p value < 0.025)

sex of cases at each level ($p = 0.28$). At C6–7 level ($p < 0.025$), the frequency of left-sided CDH was significantly higher than the right one, although there were no significant differences at C4–5 and C5–6 level.

Discussion

To our knowledge, this is the first study to investigate the laterality of CDH and to demonstrate that the frequency of left-sided CDH was significantly higher than the right one at C6–7 level, although there are a few studies demonstrating a weak correlation of the degeneration between cervical disc and facet joint [2], and that the degree of cartilage degeneration of left-side facet joints did not significantly differ from those on the right side [3].

There is controversy concerning the relationship between facet joint asymmetry and lumbar spinal degeneration [4–16]. Karacan and colleagues [5] stated that asymmetry of the facet joints strongly correlates with the development of lumbar disc herniation. Moreover, facet joint asymmetry might be a risk factor for the development of lumbar disc degeneration [7], or lumbar spondylolisthesis [4, 6]. Facet

joint arthrosis is considered as an age-dependent phenomenon with subsequent facet asymmetry. The prevalence of facet joint arthrosis is greater for the right side in the lower lumbar spine [6, 8]. On the contrary, there are several studies which demonstrated that little correlation exists between facet asymmetry and lumbar spinal degeneration including spondylolisthesis [9, 10], degeneration of facet joint [11, 12], and lumbar disc herniation in adults [13–16]. Interestingly, juvenile and adult patients with lumbar disc herniation display distinct differences in facet joint asymmetry in that the frequency of facet joint asymmetry in the juvenile group (12–20 years old) was five times higher than that in the adult group (30–49 years old) [17]. This finding indicates that facet joint asymmetry is a radiologic feature of lumbar disc herniation in children and adolescents, although controversies remain on the onset of the asymmetry [17].

Laterality, including the curve pattern of scoliosis, has been documented in thoracic spinal lesion. Asymmetry in facet orientation is commonly found in the whole thorax in the adult, whereas facet asymmetry in children exists only in the superior facets of the thoracic spine, but not of the lumbar spine [18]. The right superior facet is significantly shorter than the left in whole thoracic vertebrae and significantly wider than the left in thoracic vertebrae Th1–9 [19]. Facet asymmetry in thoracic vertebrae appears in early childhood, although the pattern of this asymmetry differs from the adults [19]. Notwithstanding, facet asymmetry partly contributes to idiopathic scoliosis [19]. In cases of vertebral rotation, there is a predominant rotation to the left of the high thoracic vertebrae, and to the right of the mid and lower thoracic vertebrae in the normal, non-scoliotic spine, which corresponds to the most prevalent types of thoracic idiopathic scoliosis [20]. In the present study, left-side dominance of CDH at C6–7, but not C4–5 and C5–6, was shown. That intervertebral space at C6–7 is close to the upper thoracic spine and likely affected by the rotation with left-dominant load to the C6–7 disc likely contributed to this laterality.

The involvement of handedness in patients may also contribute to the laterality. Indeed, handedness already persists in the fetus. Between 12 and 27 weeks of fetal life, over 80 % of fetuses show more right-arm movement than left-arm movement suggesting that asymmetrical behaviors of fetuses are probably under muscular or spinal, rather than cortical, control [21]. The presence of lateralized motor behavior in the fetus also suggests that early gestation affords a potential causative role for subsequent lateralized behavior and asymmetric brain development [21]. Thus, the facet tropism in the cervico-thoracic vertebrae may even start in the early months of embryonic life, due to an ongoing preference to right-arm activities including sucking the right thumb [21–23]. Of note,

habitual asymmetrical activities in children and adolescents likely influenced by the handedness accelerate asymmetrical forces on the growing spine with consequent development of asymmetrical facets [8]. Meanwhile, in over 80 % of patients with idiopathic scoliosis, the curve pattern matched handedness with 197 of 228 right-handed children exhibiting a right convex curve pattern; 26 left-handed children, 12 had a left convex pattern at the low thoracic component [24]. Furthermore, high impact activity may be involved in arm and spinal diseases. Fast bowling in cricket is closely associated with the development of incomplete stress fractures of lumbar pars interarticularis that occurs more frequently on the left than the right. Within cricketers, unilateral spondylolyses is usually found on the contralateral side to the bowling arm [25]. Thus, there are several reports implicating handedness in the resulting unilateral lumbar and/or thoracic lesion. However, there is paucity of data on cervical facet asymmetry and disc herniation. Furthermore, there is no report on the laterality of CDH in relation to handedness. One can speculate that rotatory/torsional movement induced by the dominant hand affects the development of cervical disc and facet because it affects a more remote region, i.e., thoracic and lumbar spine, although the movement to the cervical spine may be smaller than that exerted to the thoracic and lumbar spine. To this end, CDH at C6–7 may be the result of asymmetrical movements that cause uneven forces on the both sides of the disc. In addition, lesser rhomboid muscle originating from C5–7, which moves scapula inward and upward or superior posterior serratus muscle originating from C5–T1, which helps breathing might be related to the fact that left-side dominance of the CDH was recognized at the lower cervical spine, although there is no evidence.

This report represents an initial step towards a better understanding of the critical role of posture and motion in daily activities on the degeneration of the cervical spine. The potential weaknesses of this study are that the instabilities in facet joint are not discussed, and that the number of left-handed patients is small. Handedness is the most strongly lateralized of unilateral actions and the extent to which other actions are congruent with handedness varies between individuals and between functions [26]. Although many factors other than handedness may contribute to the development of CDH, handedness is shown here as one of the critical factors mediating unilateral CDH at C6–7 level.

Conclusion

In our study, the frequency of left-sided CDH was significantly higher at C6–7 level than right-sided one. Right-handedness most likely contributed to the left-sided CDH,

although other factors may be involved in the location of the CDH.

Acknowledgments There is no disclosure of funding receiving for this work.

Conflict of interest None.

References

1. Gracovetsky S, Farfan H (1986) The optimum spine. *Spine (Phila Pa 1976)* 11:543–573
2. Walraevens J, Liu B, Sloten JV (2009) Qualitative and quantitative assessment of degeneration of cervical intervertebral discs and facet joints. *Eur Spine J* 18:358–369
3. Kettler A, Werner K, Wilke HJ (2007) Morphological changes of cervical facet joints in elderly individuals. *Eur Spine J* 16: 987–992
4. Dai LY (2001) Orientation and tropism of lumbar facet joints in degenerative spondylolisthesis. *Int Orthop* 25:40–42
5. Karacan I, Aydin T, Sahin Z, Cidem M, Koyuncu H, Aktas I, Uludag M (2004) Facet angles in lumbar disc herniation: Their relation to anthropometric features. *Spine (Phila Pa 1976)* 29: 1132–1136
6. Masharawi YM, Alperovitch-Najenson D, Steinberg N, Dar G, Peleg S, Rothschild B, Salame K, Hershkovitz I (2007) Lumbar facet orientation in spondylolysis: a skeletal study. *Spine (Phila Pa 1976)* 32:E176–E180
7. Noren R, Trafimow J, Andersson GB, Huckman MS (1991) The role of facet joint tropism and facet angle in disc degeneration. *Spine (Phila Pa 1976)* 16:530–532
8. Abbas J, Hamoud K, Peleg S, May H, Masharawi Y, Cohen H, Peled N, Hershkovitz I (2011) Facet joints arthrosis in normal and stenotic lumbar spines. *Spine (Phila Pa 1976)* 36:E1541–E1546
9. Berlemann U, Jeszenszky DJ, Buhler DW, Harms J (1998) Facet joint remodeling in degenerative spondylolisthesis: an investigation of joint orientation and tropism. *Eur Spine J* 7:376–380
10. Boden SD, Riew KD, Yamaguchi K, Branch TP, Schellinger D, Wiesel SW (1996) Orientation of the lumbar facet joints: association with degenerative disc disease. *J Bone Joint Surg Am* 78:403–411
11. Grogan J, Nowicki BH, Schmidt TA, Haughton VM (1997) Lumbar facet joint tropism does not accelerate degeneration of the facet joints. *AJNR Am J Neuroradiol* 18:1325–1329
12. Kalichman L, Guermazi A, Li L, Hunter DJ (2009) Association between age, sex, BMI and CT-evaluated spinal degeneration features. *J Back Musculoskelet Rehabil* 22:189–195
13. Ko HY, Park BK (1997) Facet tropism in lumbar motion segments and its significance in disc herniation. *Arch Phys Med Rehabil* 78:1211–1214
14. Lee DY, Ahn Y, Lee SH (2006) The influence of facet tropism on herniation of the lumbar disc in adolescents and adults. *J Bone Joint Surg Br* 88:520–523
15. Murtagh FR, Paulsen RD, Rehtine GR (1991) The role and incidence of facet tropism in lumbar spine degenerative disc disease. *J Spinal Disord* 4:86–89
16. Vanharanta H, Floyd T, Ohnmeiss DD, Hochschuler SH, Guyer RD (1993) The relationship of facet tropism to degenerative disc disease. *Spine (Phila Pa 1976)* 18:1000–1005
17. Ishihara H, Matsui H, Osada R, Ohshima H, Tsuji H (1997) Facet joint asymmetry as a radiologic feature of lumbar intervertebral

- disc herniation in children and adolescents. *Spine (Phila Pa 1976)* 22:2001–2004
18. Masharawi Y, Rothschild B, Dar G, Peleg S, Robinson D, Been E, HersHKovitz I (2004) Facet orientation in the thoracolumbar spine: three-dimensional anatomic and biomechanical analysis. *Spine (Phila Pa 1976)* 29:1755–1763
 19. Masharawi YM, Peleg S, Albert HB, Dar G, Steingberg N, Medlej B, Abbas J, Salame K, Mirovski Y, Peled N, HersHKovitz I (2008) Facet asymmetry in normal vertebral growth: characterization and etiologic theory of scoliosis. *Spine (Phila Pa 1976)* 33:898–902
 20. Kouwenhoven JW, Vincken KL, Bartels LW, Castelein RM (2006) Analysis of preexistent vertebral rotation in the normal spine. *Spine (Phila Pa 1976)* 31:1467–1472
 21. McCartney G, Hepper P (1999) Development of lateralized behaviour in the human fetus from 12–27 weeks' gestation. *Dev Med Child Neurol* 41:83–86
 22. Hepper PG, McCartney GR, Shannon EA (1998) Lateralised behaviour in first trimester human foetuses. *Neuropsychologia* 36:531–534
 23. Hepper PG, Shahidullah S, White R (1991) Handedness in the human fetus. *Neuropsychologia* 29:1107–1111
 24. Goldberg C, Dowling FE (1990) Handedness and scoliosis convexity: a reappraisal. *Spine (Phila Pa 1976)* 15:61–64
 25. Gregory PL, Batt ME, Kerslake RW (2004) Comparing spondylolysis in cricketers and soccer players. *Br J Sports Med* 38:737–742
 26. Porac C, Coren S (1979) Individual and familial patterns in four dimensions of lateral preference. *Neuropsychologia* 17:543–548