Classification of Odontoid Destruction in Patients with Rheumatoid Arthritis Using Reconstructed Computed Tomography: Reference to Vertical Migration

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ABSTRACT. ***Objective.*** To reveal the factors that determine the natural course of subluxation of occipital-cervical lesions in rheumatoid arthritis (RA). The atlanto-axial region is one of the most common locations for lesions in RA. Some cases progress from reducible atlanto-axial subluxation (AAS) to irreducible vertical migration, while others continue to exhibit reducible AAS. No study has revealed the factors that determine the natural course of subluxation. We focus on the odontoid as a key structure of the progression of occipito-cervical lesions and investigated this region in patients with RA using reconstructive computed tomography (CT) images, and analyzed factors in association with CT findings.

Methods. Fifty-eight patients with RA and 40 age-matched controls, all women, were studied. Associated factors, including C-reactive protein, erythrocyte sedimentation rate, steroid usage, and the severity of local osteoporosis, were analyzed as measurements in association with odontoid destruction.

Results. The destruction of odontoid and atlanto-odontoid joint were common in patients with RA. The more destruction observed in the odontoid process, the greater is the degree of progression of vertical migration. Local osteoporosis is a significant factor in odontoid destruction, based on a cortico-cancellous index of 42% in cases of grade III odontoid destruction.

Conclusion. The odontoid process is a key structure in the progression of occipito-cervical lesions in patients with RA. (First Release March 1 2011; J Rheumatol 2011;38:863–7; doi:10.3899/jrheum.100942)

Key Indexing Terms:
OSTEOPOROSIS CERVICAL SPINE COMPUTED TOMOGRAPHY
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The cervical spine, particularly the atlanto-axial region, is one of the sites most commonly affected by rheumatoid arthritis (RA)[1,2,3,4]. Atlanto-axial lesions are often associated with atlanto-axial subluxation (AAS) and vertical migration (VM), or a combination of them. These lesions feature neural involvement and intractable pain that requires surgical intervention[5,6,7,8].

Study of the natural course of cervical spine lesions in RA has revealed that in some patients upper cervical lesions progress from reducible AAS to irreducible VM, while other patients continue to exhibit reducible AAS[9]. AAS is reported in about 25% of patients with RA and VM in 5%–22% of such patients[10,11]. However, no study has revealed the factors that determine the natural course of subluxation.

The odontoid process is one of the structures most commonly associated with atlanto-axial subluxation. The cruciform ligament holds the odontoid in string-like fashion to the anterior ring of the atlas. AAS is common in RA because rheumatoid synovitis occurs in the articulation between the odontoid and anterior arch of the atlas, or the articulation between the odontoid and cruciform ligament[11,12,13], causing capsular distension. Some patients with AAS exhibit odontoid destruction, with progressive VM.

Deformity of the odontoid has been detected by several authors using plain radiography[2] or magnetic resonance imaging (MRI). Several authors have reported the advantages of MRI in the diagnosis of inflammation and synovitis in the cervical spine affected by RA[14,15,16]. Vetti, *et al*[15] obtained high-resolution MR images of transverse and alar ligaments, and found that inflammatory changes of these structures showed strong correlations with atlantoaxial subluxation, RA disease activity, and neck pain. Suppiah, *et al*[14]

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also described the usefulness of observation of bone marrow edema in rheumatoid cervical spine in investigation of inflammation and bone destruction in patients with RA. However, since CT is superior to MRI in detection of bony structures, we used multiplanar reconstructed (MPR) CT images to investigate with precision the morphology of destruction of the odontoid process.

We focused on the odontoid as the key structure in the progression of subluxation. MPR CT images were used for evaluation of the odontoid in RA. We classified grades of destruction of the odontoid in patients with RA and also analyzed factors by type of odontoid destruction to determine the clinical usefulness of this classification.

MATERIALS AND METHODS

Fifty-six women patients with RA who had cervical symptoms were studied in prospective fashion. Twenty-six patients had severe neck pain (Ranawat criteria: pain assessment, grade 3; neural assessment, class II) and 28 patients exhibited myelopathy (Ranawat criteria: pain assessment, grade 3; neural assessment, class III A)[17]. The characteristics of the patients studied are shown in Table 1. All patients received medical treatment and 54 patients underwent surgical treatment. A total of 40 age-matched volunteers comprised a control group (Table 1). This study was approved by the Ethics Committee on Epidemiological Studies of the Kagoshima University Graduate School of Medical and Dental Sciences (No. 169).

Morphological evaluation of the occipito-atlanto-axial region was performed using MPR CT imaging (GE Medical Co.; slice thickness 1 mm). Using frontal views of MPR CT images, we examined odontoid erosion and fracture. Using axial views on reconstructed CT images, we examined the atlanto-odontoid joint and osteoporosis of the axis[18]. The degree of erosion of the odontoid was classified into 4 grades (grade 0: normal; grade 1: slight erosion; grade 2: moderate erosion; grade 3: severe erosion; Figure 1). The severity of atlanto-odontoid joint destruction was classified into 4 grades according to the modified Larsen classification[19]. All the images were measured using an X-Plan 360i instrument (Ushikata Shokai, Tokyo, Japan), and interpreted independently by 3 experienced orthopedists. The final diagnosis was made and measurements determined after agreement of at least 2 readers.

Measurements related to the severity of odontoid destruction were analyzed (Table 2). Local osteoporosis was measured as the ratio of cortical bone surface and cancellous bone surface in axial reconstructed CT images of the odontoid (cortico-cancellous index; CCI). CCI was defined as the area of cortex divided by the area of cancellous bone in the central part of the odontoid (Figure 2). Radiological measurements, including the atlanto-dental interval (ADI), the Ranawat method, and the Redlund-Johnell method, were determined using lateral-view plain radiographs, and the associations of degree of joint destruction of the occipito-atlanto joints (O-C1) and lateral atlanto-axial joints[19] with degree of destruction of the odontoid were also determined (Table 2). The significance of differences was determined using 1-way ANOVA. If significant differences were observed ($p < 0.05$), the post-hoc Fisher's protected least significant differences test was performed to determine where significant differences existed, with $p < 0.05$ considered significant.

Table 1. Characteristics of patients with rheumatoid arthritis and controls.

Characteristic	Patients, n = 56	Controls, n = 40
Sex	All women	All women
Age, yrs (mean)	27–85 (61)	39–78 (60)
RA duration, mean	17 years 1 month	

RESULTS

Forty-three patients (74%) exhibited some destructive changes of the odontoid. Among them, 5 cases were classified as grade 3. In the atlanto-odontoid joint, 48 patients (83%) exhibited some degenerative changes (Figure 3). On the other hand, most of the control cases (39 cases; 98%) were classified as grade 0, although 1 case (2%) was grade 1 for odontoid destruction. In the atlanto-odontoid joint, all control cases were classified as grade 0.

Interestingly, the more eroded the odontoid process and the atlanto-odontoid joint, the lower was the Ranawat score (Figure 4A, 4B). These results showed that odontoid erosion was a significant factor in the progression of VM. Among the several factors examined, CCI was significantly associated with odontoid erosion (Figure 4C). Other factors, such as C-reactive protein (CRP) value and erythrocyte sedimentation rate (ESR), were not significantly associated with the degree of odontoid erosion.

Five cases exhibited odontoid fracture without erosive changes. Excluding these cases, CCI was significantly associated with some clinical features. The CCI of patients with myelopathy (mean ± SD; 94.57 ± 67.56) was significantly higher than that of patients without myelopathy (49.89 ± 40.75; p =0.026). A CCI cutoff of 71.5 or lower is correlated with myelopathy.

DISCUSSION

RA typically affects the cervical spine, and the results of conservative treatment of it in this region are poor[19]. Lesions in this region feature neural involvement and intractable pain, necessitating surgical intervention.

Radiographic evaluation has been widely performed using lateral views of occipito-cervical lesions with determination of Redlund-Johnell or Ranawat scores or ADI[20,21]. Generally, the operative management is based not only on radiographic evaluation such as Redlund-Johnell or Ranawat score, but also on CT and/or MRI to more accurately assess anterior subluxation or superior migration and odontoid destruction, along with the presence of clinical symptoms.

We previously reported that destruction of the occipito-atlanto joints was more common than expected in patients with RA who did not have VM[22]. This suggests that even after C1/2 fusion, patients with AAS may have symptoms resulting from destruction of the occipito-cervical joints. Therefore, spine surgeons are interested in determining the natural course of this lesion in each patient with RA.

There have been no reports on the anatomical correlates of the progression of subluxation. We therefore focused on the odontoid process as a key structure in this region and performed analysis using MPR CT images for patients with RA in our study. The grade of odontoid erosions varied, and the degree of destruction was related to the severity of VM. This finding indicated that the degree of odontoid erosion is important in indicating the natural course of subluxation.

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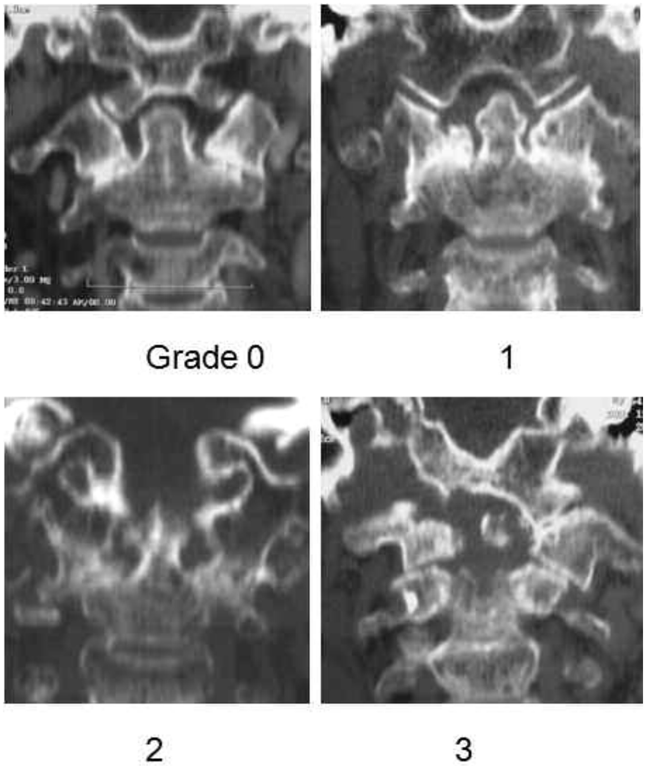

Figure 1. Classification of odontoid fracture in coronal view on reconstructed CT images. Grade 0: normal; grade 1: slight erosion; grade 2: moderate erosion; grade 3: severe erosion.

Table 2. Measurements used in statistical analysis.

Age, months
RA duration, months
CRP, mg/dl; ESR, mm/h
Corticosteroid use, mg/day
Cortico-cancellous index, %
Atlanto-dental interval, mm; Ranawat value, mm; Redlund-Johnell value, mm
Grade of occipito-atlanto joints or lateral atlas-axial joints (modified Larsen classification)

RA: rheumatoid arthritis; CRP: C-reactive protein; ESR: erythrocyte sedimentation rate.

Local bone quality (using CCI) was an important factor in determining regional destruction. Several risk factors for progression of subluxation have been suggested, including rheumatoid factor seropositivity, high initial CRP, and the presence of subcutaneous nodules[9,23]. On the other hand, CRP, ESR, and the amount of gluticosteroid usage were not significantly related to destruction in our study. In recent medical treatment using disease-modifying antirheumatic drugs (DMARD) or antitumor necrosis factor-α agents, the natural course of RA has been modified dramatically. For these patients, systemic factors including CRP and ESR are controlled even with local bony destruction. Indeed, most of our patients were treated not only with corticosteroids but with methotrexate or other DMARD as well. This might be why CCI alone was significantly related to odontoid erosion in our study. CCI was importantly related to odontoid erosion but also significantly related to clinical features. The finding of a significant difference in CCI between patients with and without myelopathy suggests that CCI is useful for clinical features of patients with RA who have cervical lesion.

MRI is known to be useful for evaluating pathological changes in the occipito-cervical region[24,25]. Enhanced T1-weighted MR imaging can discriminate between joint effusion and pannus formation[25]. CMA in T1-weighted sagittal imaging has also been reported as a measure of VM[19]. However, because CT is superior to MRI in detection of bony structures, we used MPR CT images to investigate the odontoid process. Of course, combined evaluation with MRI for soft tissue and CT for bony structures may be preferable in diagnosing subluxation in RA.

Multiplanar reconstructed CT images are useful for evaluating odontoid destruction in patients with RA. The greater the destruction observed in the odontoid process, the greater the degree of progression of VM. Local osteoporosis, measured as the CCI, is a significant factor in odontoid destruction. CCI is correlated with superior migration and clinical findings, and patients with CCI cutoff of ≤ 71.5 should undergo surgical fusion.

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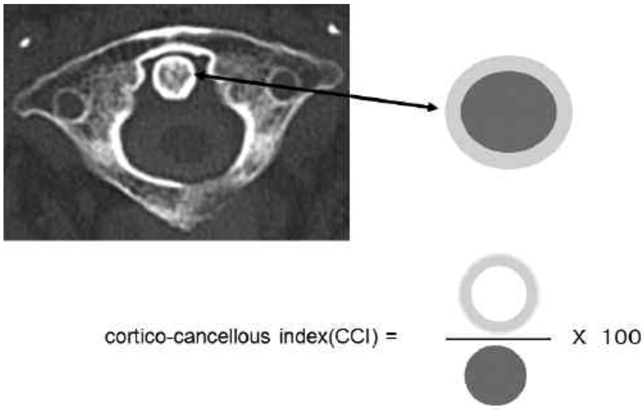

Figure 2. Cortico-cancellous index (CCI) in axial reconstructed CT images. CCI equals the area of cortex (light gray zone) divided by the area of cancellous bone (dark gray zone) in the central part of the odontoid.

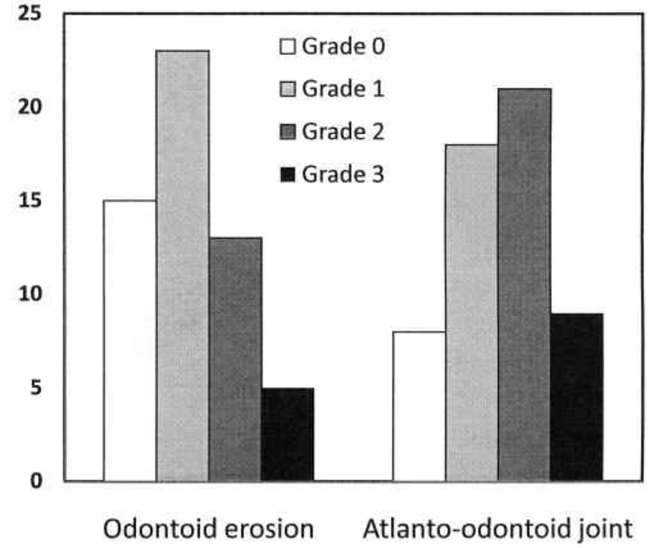

Figure 3. Numbers of patients in grades of 0, 1, 2, and 3 with odontoid erosion and atlanto-odontoid joint destruction.

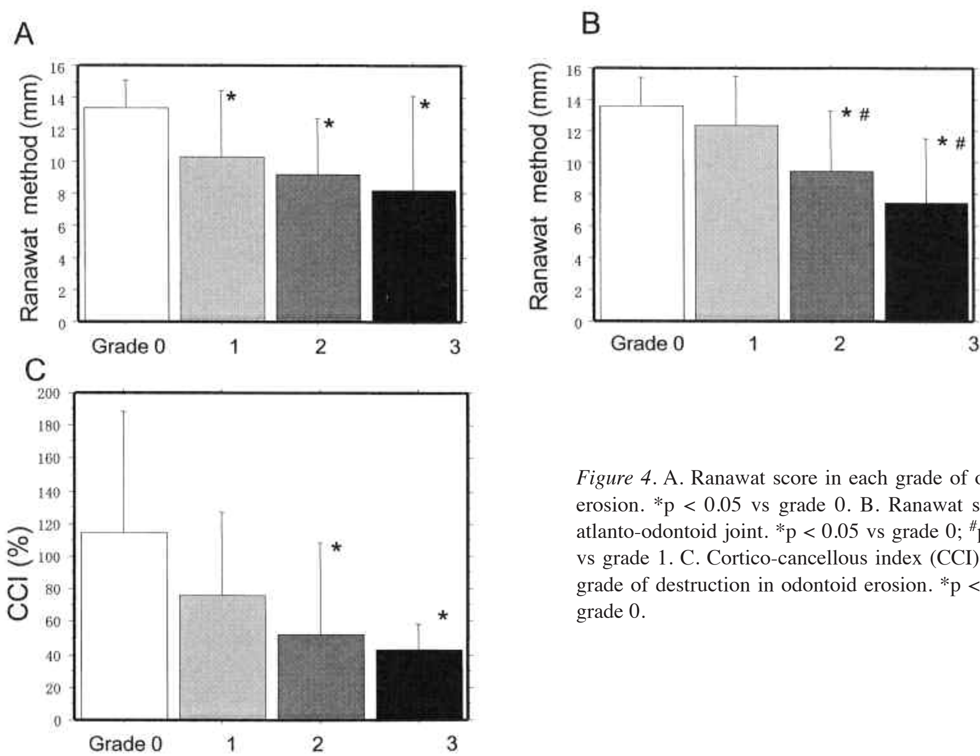

Figure 4. A. Ranawat score in each grade of odontoid erosion. *p < 0.05 vs grade 0. B. Ranawat score for atlanto-odontoid joint. *p < 0.05 vs grade 0; #p < 0.05 vs grade 1. C. Cortico-cancellous index (CCI) of each grade of destruction in odontoid erosion. *p < 0.05 vs grade 0.

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