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ORIGINAL ARTICLE

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Bone resorption of the facet joint in rheumatoid arthritis as a predictor of lower cervical myelopathy

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Abstract The purpose of the present study was to identify the risk factors to predict instability of the subaxial cervical spine and cervical myelopathy based on plain radiographs. The study was performed on 99 patients with mutilating rheumatoid arthritis (RA). From plain lateral radiographs of the cervical spine over time, rheumatoid cervical spine lesions were investigated and evaluation was made on the possibility to develop cervical myelopathy. The incidence of subaxial cervical spine lesions in the patients with mutilating RA was as high as 98%. In particular, resorption of the superior facet suggests high risk to develop cervical myelopathy. The presence of spinous process erosion is also likely to reveal such a possibility. There was no statistically significant difference in the anteroposterior diameter of cervical spinal canal between the cases with cervical myelopathy and those without it. Resorption of the superior facet is the most important factor for the development of cervical myelopathy. In the cases with rheumatoid cervical spine lesions, it is necessary to take special notice of the superior facet.

Key words Cervical myelopathy · Facet joint · Mutilating rheumatoid arthritis (RA)· Subaxial subluxation (SAS)

Introduction

In patients with rheumatoid arthritis (RA), cervical spine lesions are most frequently seen not only in the atlantoaxial joint but also in the subaxial cervical spine. With the progression of subaxial cervical spine lesions, there is a high possibility of developing cervical myelopathy due to instability of the cervical spine or to soft tissues such as rheumatoid granulation. Also, there are cases where the whole cervical spine turns to a state of fusion and stability, thereby not developing cervical myelopathy. Thus, it is difficult to predict the development of cervical myelopathy based on subaxial cervical spine lesions. In this respect, the purpose of the present study is to focus attention on those cases of mutilating RA with a high risk of developing cervical myelopathy, and to identify the risk factors in order to predict instability of the subaxial cervical spine and signs of cervical myelopathy, based on plain radiographs which can be assessed in ordinary outpatient clinics.

Patients and methods

The study was performed on 99 patients with mutilating rheumatoid arthritis (RA) (5 male and 94 female patients) who did not have cervical myelopathy at the first visit to our hospital. For 19 patients who had been operated on the cervical spine, the study was performed on the conditions before the time of operation. The mean age of the patients at the time of study was 64.5 years old (range: 48–83 years). The average duration of RA was 17.4 years (range: 2.0–33.7 years) at the first visit and 26.4 years (range: 6.3–51.8 years) at the time of study. The average duration of radiographic follow-up was 9.0 years (range: 2.0–22.5 years). According to the classification of Steinbrocker, all cases were in Stage III or IV. There were 23 cases in Class 2, 56 cases in Class 3, and 20 cases in Class 4. According to the definition of Murasawa et al.,[1] mutilating RA was defined as the case where radiographic bone resorption of Larsen grade 5 was found in more than three finger or toe joints and more than two major joints.

Plain lateral radiographs of the cervical spine were taken in full flexion and full extension at a 1-year interval. Patients were asked to flex and extend their necks until discomfort or stiffness inhibited further movement. The radiographs were read by two of the authors without knowledge of the

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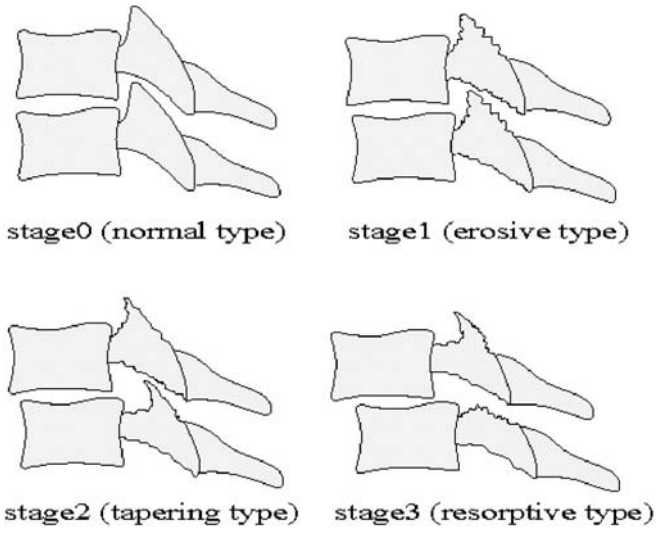


Fig. 1. Classification of the facet joint

clinical or serological data. The radiological criteria used in this study were subaxial subluxation (SAS) with 2 mm or more anteroposterior slip from the line drawn on the lower posterior vertebral margin, facet joint erosion, endplate erosion, spinous process erosion, narrow disc space without osteophytosis, and immobility of the cervical spine associated with spontaneous vertebral fusion or facet fusion, and these were considered as rheumatoid subaxial cervical spine lesions previously reported by Sharp et al.[2] and other researchers. We classified rheumatoid lesions of the facet joint into four stages according to the extent of erosion and its resultant shape. In stage 0 (normal type), the facet joint has a normal shape without noticeable erosion. In stage 1 (erosive type), the facet joint has a slight or medium macroscopic erosive change. In stage 2 (tapering type), the facet joint has a severe destructive change as the superior facet looks like a tapering pencil. At stage 3 (resorptive type), there is severe involvement of the facet joint. Its normal superior facet has disappeared and the inclination angle of the facet joint (the angle made by the line drawn along the joint surface of the inferior joint process and the line drawn on the posterior vertebral margin in the lateral view) has increased (Fig. 1). Also, the degree of SAS and the space available for the spinal cord (SAC) on the narrowest level in full flexion or extension were measured. The anteroposterior diameter of the cervical spinal canal was directly measured from the cranioanterior edge of C5 lamina to the posterior margin of C5 vertebral body. It was confirmed whether the patients had used steroids. Cervical myelopathy was determined through a careful neurological examination. However, on these patients this was always difficult. Thus, we evaluated it by mainly checking hyperreflexia, dysesthesia, sensory deficits, and activities of daily living. Ranawat's classification[3] was used for the evaluation of cervical myelopathy, and the level of responsibility for cervical myelopathy was determined according to neurological and radiographic (including magnetic resonance imaging) findings. For statistical analysis, the χ^2 test, Kruskal–Wallis test, and Mann–Whitney *U*-test were performed using JMP 5.1. (SAS Institute, Cary, NC, USA).

Table 1. Incidence of subaxial cervical spine lesions classified by items

	n (%)
Facet joint erosion	96 (97)
Narrow disc space	89 (90)
Endplate erosion	87 (88)
SAS	70 (71)
Spinous process erosion	69 (70)
Immobility of cervical spine	31 (31)

SAS, subaxial subluxation

Table 2. Relationship between plain radiographic findings of subaxial cervical spine lesions and cervical myelopathy

	P value
Classified facet joint erosion	<0.001
Narrow disc space	NS
Endplate erosion	NS
SAS	NS
Spinous process erosion	<0.05
Immobility of cervical spine	NS

NS, not statistically significant

Results

At the initial point of this study, 85% of these 99 patients already had rheumatoid subaxial cervical spine lesions on plain lateral radiographs. At the time of study, the incidence of rheumatoid subaxial cervical spine lesions was 98%. The incidence of facet joint erosion was 97%. When classified by items, the stages of the facet joint were classified into: stage 0 (normal type) 3%, stage 1 (erosive type) 71%, stage 2 (tapering type) 15%, and stage 3 (resorptive type) 11%. Each stage reflected increasing involvement and rheumatoid destruction of the facet joint. Narrow disc space without osteophytosis was found in 90% of the cases, endplate erosion in 88%, SAS in 71%, spinous process erosion in 70%, and immobility of the cervical spine associated with spontaneous vertebral fusion or facet fusion in 31% of the cases (Table 1). Subaxial cervical spine lesions were found at high frequency in C5 and C6. Eighty-seven cases had used steroids. The cases of cervical myelopathy of II or more in Ranawat's classification were seen in 29 of 99 cases. The level of responsibility for cervical myelopathy was seen at the atlantoaxial joint in eight cases, and the subaxial cervical spine in 21 cases. In plain radiographic findings of the subaxial cervical spine, a statistically significant difference from cervical myelopathy was found in SAC, classified facet joint erosion, and spinous process erosion. No significant difference was noted in SAS, endplate erosion, immobility of the cervical spine, and narrow disc space without osteophytosis (Table 2). Also, no significant association was found between the use of steroids and subaxial cervical

Table 3. Stage of the facet joint and cervical myelopathy

	Ranawat I	Ranawat II	Ranawat IIIA	Ranawat IIIB
Normal type, *n*	2	1	0	0
Erosive type, *n*	59	2	9	0
Tapering type, *n*	7	0	5	3
Resorptive type, *n*	2	3	2	4

n, number of patients

Table 4. Spinous process erosion and cervical myelopathy

	Ranawat I	Ranawat II	Ranawat IIIA	Ranawat IIIB
Yes, *n*	42	5	15	7
No, *n*	28	1	1	0

n, number of patients

myelopathy. Among the cases with facet joint erosion, cervical myelopathy was detected in 11 of 70 cases in stage 1 (erosive type), 8 of 15 cases in stage 2 (tapering type), and 9 of 11 cases in stage 3 (resorptive type). Resorptive image of the superior facet suggests a particularly high risk of developing cervical myelopathy ($P < 0.001$) (Table 3). In the cases with spinous process erosion, cervical myelopathy was found in 27 of 69 patients, and this suggested a high possibility of developing cervical myelopathy if spinous process erosion was present ($P < 0.05$) (Table 4). Subaxial subluxation became more severe as the stage of the facet joint moved from stage 0 (normal type) to stage 1 (erosive type), stage 2 (tapering type), and stage 3 (resorptive type). It was 0.5 mm on average in stage 0, 1.5 mm in stage 1, 3.3 mm in stage 2, and 7 mm in stage 3 ($P < 0.001$). Subaxial subluxation became more severe when spinous process erosion was present. It was 3.1 mm on average in the patients with spinous process erosion ($P < 0.001$) (Fig. 2). In SAC, a statistically significant difference was found depending on whether or not cervical myelopathy was present ($P < 0.0001$). Space available for the spinal cord was 11.5 ± 2.1 mm on average in the cases with cervical myelopathy and 14.2 ± 1.8 mm on the cases without cervical myelopathy (Fig. 3). On the other hand, no significant difference was noted in the anteroposterior diameter of the cervical spinal canal depending on whether or not cervical myelopathy was present (Fig. 4). However, in the patients with mutilating RA who developed cervical myelopathy, cervical myelopathy occurred even when SAS was mild if the anteroposterior diameter of cervical spinal canal was narrow (Fig. 5).

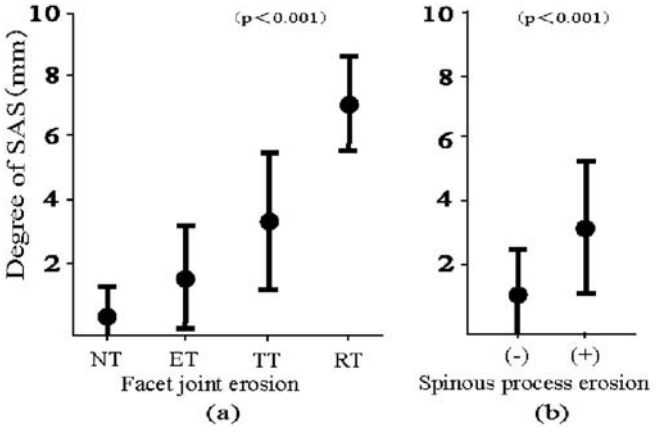


Fig. 2a,b. Plain radiographic findings and the degree of subaxial subluxation (*SAS*). **a** SAS becomes more severe as the stage of the facet joint is turned to normal type (*NT*), erosive type (*ET*), tapering type (*TT*), and resorptive type (*RT*). **b** SAS becomes more severe when spinous process erosion is present

Case reports

Case 1 (Fig. 6)

Vertebral fusion was found on C5–C6. Erosive change of the facet joint and mild SAS were seen at C4/5. Eight years later, vertebral fusion was found on C3–C4, and SAS advance was noted at C4/5. However, the facet joint of C4/5 maintained its shape and merely showed erosive change. SAS at C4/5 advanced, but remained as mild subluxation.

Case 2 (Fig. 7)

Tapering change of the facet joint and moderate SAS were found at C5/6. Nine years later, tapering change advanced, but remained as tapering type and no progress was seen in SAS.

Case 3 (Fig. 8)

Tapering change was found in the facet joint and SAS was mild at C5/6. Three years later, the superior facet disappeared and the inclination angle of the facet joint increased. Severe SAS was seen and cervical myelopathy developed.

Case 4 (Fig. 9)

Resorption of the facet joint, increased inclination angle of the facet joint, and moderate SAS were seen at C6/7. Two years later, severe SAS and cervical myelopathy developed.

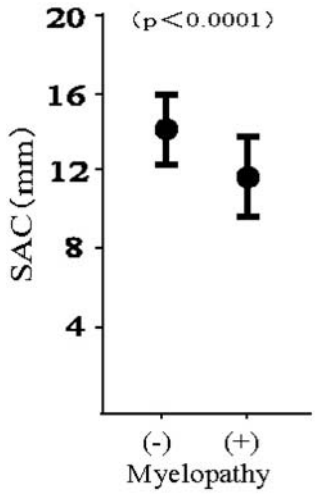


Fig. 3. Relation of cervical myelopathy and space available for the spinal cord (*SAC*). In SAC, a statistically significant difference was found depending on whether or not cervical myelopathy was present

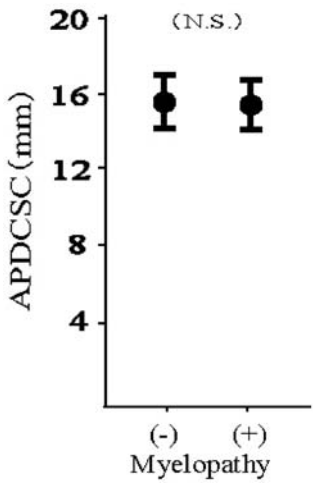


Fig. 4. Relation of cervical myelopathy and the anteroposterior diameter of cervical spinal canal (*APDCSC*). No significant difference was noted in APDCSC depending on whether or not cervical myelopathy was present

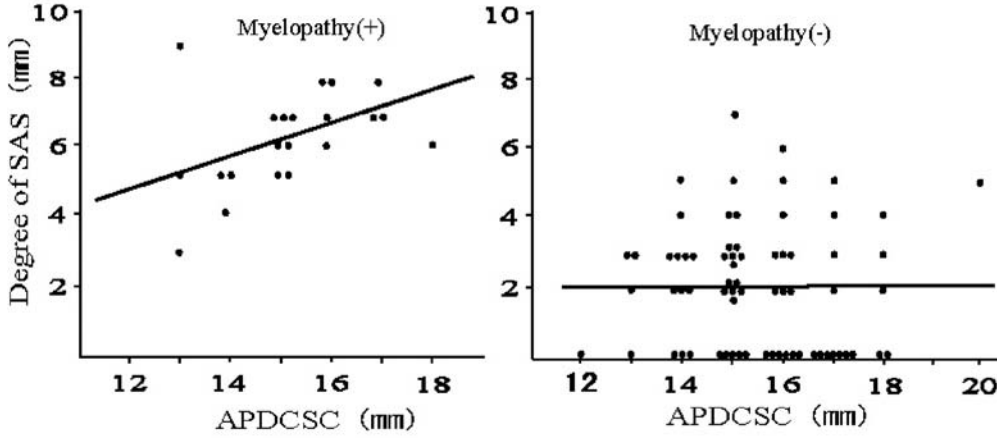
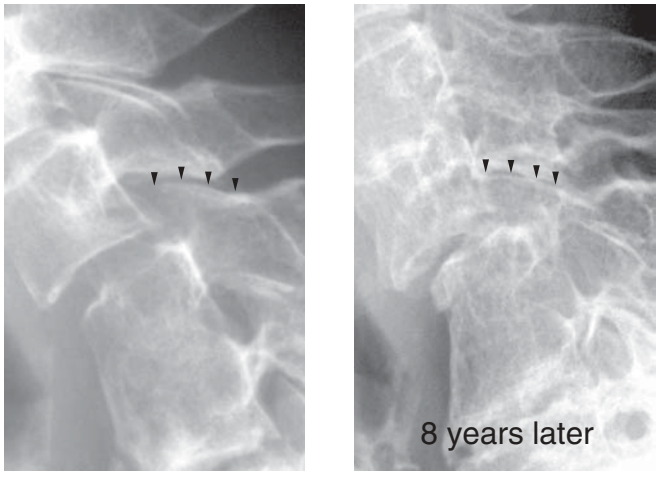


Fig. 5. In the patients with mutilating rheumatoid arthritis who develop cervical myelopathy, cervical myelopathy develops despite a mild degree of subaxial subluxation (*SAS*) if the anteroposterior diameter of cervical spinal canal (*APDCSC*) is narrow

Discussion

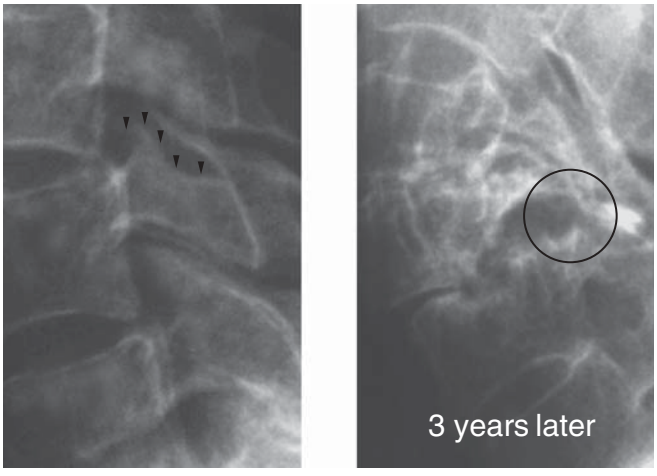
According to the report by Da Silva et al.,[4] who described the results of a retrospective study on 609 patients with RA, 242 patients had undergone the operation on joints associated with RA, and the cumulative ratio of surgical operation for 30 years was 33.7% ± 3.8%, while the cervical spine operation was found only in two cases, and the cumulative incidence was 0.4% ± 0.4%. This may mean that there was less possibility to cause clinical problems even when the cervical spine lesion was detected on plain radiographs of the patients with RA. However, patients with mutilating RA often require the cervical spine operation. Laiho et al.[5] reported that 26% of patients with arthritis mutilans hand deformity had been operated on their cervical spine. Nineteen patients (19%) in the present study had been operated on the cervical spine. If cervical myelopathy developed, the prognosis was poor. There are reports that one half of the patients died within 1 year after the diagnosis of myelopathy[6] or that, among 21 patients who did not undergo operation despite the presence of cervical myelopathy, all patients became bedridden within 3 years and died within 7 years after the diagnosis.[7] When an operation was performed to treat cervical myelopathy, activities of daily living could be maintained or improved at least for a certain period.[8] This suggests that it is important to take adequate action at an earlier stage.

Regarding the risk factor to predict cervical myelopathy based on plain radiographic images, there is no satisfactory predictor other than SAC[9–11] and rapid and extensive progress of peripheral articular lesions.[12] Up to now, there have been reports describing that rheumatoid lesions in posterior regions such as the facet joint, the spinous process, etc., are closely related to anterior slip.[13–16] Based on the results of a biomechanical study, White and Panjabi[17] reported that anterior instability appears as the result of the destruction of posterior elements of the spine around the facet joint. Kuwahara et al.[18] reported that pathological findings of the cervical spine, which were most frequently found at autopsy in patients with RA, were synovitis in the facet joints, and that RA granulation was found at high



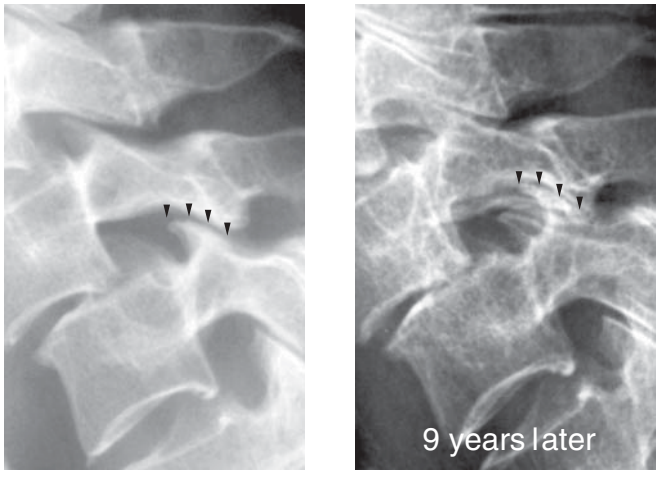
Case 1

Fig. 6. Case 1. A 63-year-old woman; duration of disease 22 years; stage 1 (erosive type) (*arrowheads*)



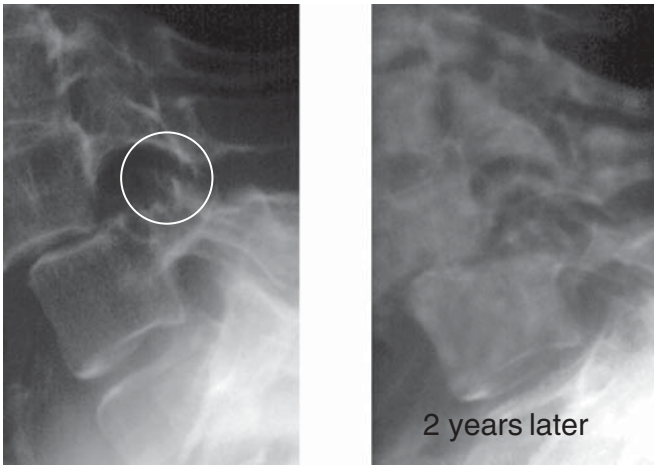
Case 3

Fig. 8. Case 3. A 73-year-old woman; duration of disease 15 years; stage 3 (resorptive type) (*area in circle*)



Case 2

Fig. 7. Case 2. A 63-year-old woman; duration of disease 17 years; stage 2 (tapering type) (*arrowheads*)



Case 4

Fig. 9. Case 4. A 50-year-old woman; duration of disease 15 years; stage 3 (resorptive type) (*area in circle*)

frequency in the facet joint or posterior elements such as bone marrow of the spinous process or the attaching region of ligaments. In the results of our present study, facet joint erosion was most frequently seen in the rheumatoid subaxial cervical spine. Therefore, we focused on the facet joint to delineate dynamic instability caused by subaxial cervical spine lesions. There is a report that anterior slip of the affected segment becomes severe when the inclination angle of the facet joint becomes greater.[13] However, this angle needs a measurement by a level because normal values are different. So we think the superior facet is a useful viewpoint to predict marked cervical instability by daily visitor medical examinations. If there is erosive change of the superior facet as seen in the upper portion of Fig. 10, mild SAS occurs but this does not become severe. If there is tapering of the superior facet as seen in the middle portion of Fig. 10, moderate SAS occurs but also does not become severe. If the superior facet is resorbed as seen in the lower portion of Fig. 10, severe SAS occurs and this is more likely to develop cervical myelopathy. In general, in cases of cervical spondylosis a narrow canal is an important factor in the development of cervical myelopathy. This has also been reported regarding RA.[10] However, in the results of the present study there was no statistically significant difference in the anteroposterior diameter of cervical spinal canal in the patients with mutilating RA, depending on whether cervical myelopathy was present. In the subaxial cervical spine of the patients with mutilating RA, a narrow canal is not an important factor in the development of cervical myelopathy. On the other hand, a narrow SAC is a risk factor connected directly with cervical myelopathy. Severe SAS that decreases SAC is closely related to resorptive change

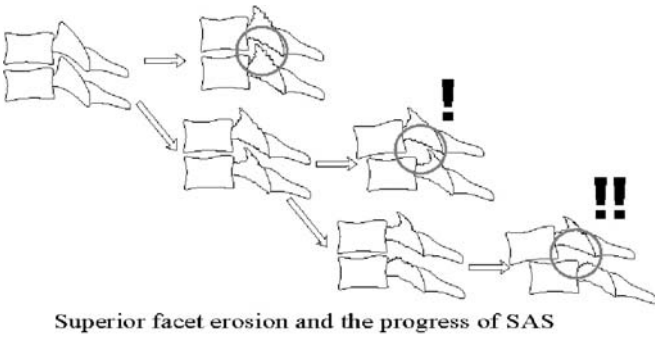


Fig. 10. Facet joint erosion and the progress of subaxial subluxation (*SAS*). As the facet joint is resorbed, anterior instability of the cervical spine increases, and cervical myelopathy develops rapidly

of the facet joint, tapering change of the facet joint, or spinous process erosion, and these may be important findings in predicting cervical myelopathy.

As causes of spinal cord compression in the subaxial cervical spine of the patients with RA, not only a bone factor associated with SAS but also rheumatoid granulation tissues or formation of constricting band on the dura mater have been reported.[19] The immunological process as well as the mechanical process due to instability may cause soft tissue proliferation and adhesion at the site of facet resorption and spinous process erosion. These are not identifiable from plain radiographs, and this suggests that magnetic resonance imaging is necessary in routine medical practice.

In summary, among rheumatoid subaxial cervical spine lesions, facet joint erosion was classified into four types depending on the morphological features of the facet joint seen on plain lateral radiographs. In patients with mutilating RA, there is a high risk for the development of cervical myelopathy if there is resorptive change and tapering change in the cervical facet joint, and it is necessary to take special note of the facet joint. Spinous process erosion is also a risk factor in the prediction of cervical myelopathy. In patients with mutilating RA, no significant difference was noted in the anteroposterior diameter of the cervical spinal canal between patients with cervical myelopathy and those without it. Resorption of the facet joint is the most important factor for the development of cervical myelopathy. In the subaxial cervical spine in those patients with mutilating RA, it is necessary to take special note of the facet joint.

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