Pre- and Postoperative MR Imaging of the Craniocervical Junction in Rheumatoid Arthritis

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Pre- and Postoperative MR Imaging of the Craniocervical Junction in Rheumatoid Arthritis

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Ten patients with severe chronic rheumatoid arthritis with atlantoaxial subluxation were examined with conventional radiography and MR imaging of the cervical spine before and at an average of 6 months after posterior occipitocervical fusion. Periodontoid pannus formation was revealed by MR preoperatively in nine patients, all with mobile horizontal atlantoaxial subluxation. Compression of the medulla and/or upper cervical cord, due to subluxation and periodontoid pannus bulging into the spinal canal, was seen in seven patients. After the stabilizing surgery the periodontoid pannus had decreased in size in all patients with preoperative pannus. This reduction in the pannus seems to be the result of the atlantoaxial immobility achieved by the posterior fusion. Postoperatively, three patients had some remaining compression of the medulla and/or cord secondary to immobile subluxation, while the pannus posterior to the odontoid process had disappeared. Artifacts from the surgical stainless steel fixation material were confined to the posterior part of the neck on short TR/short TE MR images and did not interfere with the evaluation of the periodontoid region and the anterior part of the medulla/cervical cord.

We found that flexion and extension lateral radiographs, combined with sagittal short TR/short TE MR images in the neutral position, enable preoperative evaluation of patients with rheumatoid arthritis in the cervical spine. Postoperative MR should be performed only if there are residual or new symptoms.

MR imaging is useful in the evaluation of the cervical spine in patients with rheumatoid arthritis [1–5]. MR demonstrates narrowing of the spinal canal caused by vertebral dislocation and/or extradural granulation tissue, as well as the level(s) and degree of cord compression. Because the method is noninvasive and painless, it can be repeated easily and thus is suitable for the pre- and postoperative morphologic evaluation of these patients.

Compression of the medulla and upper cervical cord in patients with rheumatoid arthritis may be caused by atlantoaxial subluxation and mobility, as well as by periodontoid soft tissue; that is, pannus formation [6, 7]. The pannus consists of proliferative inflammatory granulation tissue derived from the synovia in the small joints and bursae adjacent to the odontoid process. After demonstrating significant spontaneous reduction of periodontoid pannus after posterior occipitocervical fusion in some of our patients [8] we undertook this prospective study. Our aim was to assess the extent of pannus and the degree of atlantoaxial subluxation and mobility and their effect on the medulla and cord before and after stabilizing surgery. The radiologic findings are described in this article; the clinical aspects of the patients with periodontoid pannus are discussed in another report [9].

Materials and Methods

From July 1986 through July 1987, 14 patients with chronic rheumatoid arthritis with atlantoaxial subluxation were surgically treated with posterior occipitocervical fusion. Ten of them, five men and five women 50–79 years old (mean age, 67 years), were examined with MR pre- and postoperatively and are described in this study.

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The duration of rheumatoid arthritis was 3–48 years (mean, 19 years). Preoperatively, eight patients had severe neck pain; three also had vertigo. Clinical signs of myelopathy were found in seven patients. The indications for surgery were intractable neck pain and/or progressive myelopathy secondary to horizontal and/or vertical atlantoaxial subluxation with or without pannus formation.

The standard surgical posterior fusion was performed from the occiput to C2 by using nonferromagnetic stainless steel wires introduced epidurally. The caudal ends of the wires were passed dorsal to a stainless steel pin inserted through the spinous process of C2. In five patients a C1 laminectomy was performed also; in these cases the caudal ends of the wires were passed ventral to the pin in the C2 spinous process. The wires and the spinous process of C2 were encased in acrylic bone cement on one side, while the other side was covered with bone chips [10].

Conventional radiography (including flexion-extension views) and MR imaging of the cervical spine were performed in all patients preoperatively and 4–9.5 months (average, 6 months) after surgery. In three of the patients additional MR studies were performed in the early postoperative period.

MR was performed on a permanent resistive system with a vertical magnetic field operating at 0.3 T.* A head coil (with low centering) was used to obtain optimal image quality of the craniocervical junction [5]. All patients were examined with sagittal scans with the head in the neutral position. In addition, coronal images were obtained in two patients. Spin-echo pulse sequences with short TR/short TE, 500/28 or 300/16 (TR/TE), as well as with long TR/TE, 2000/56, were performed in all cases. The slice thickness was 5 mm with an interslice gap of 2 mm and pixel size of 1.0 mm.

Horizontal and vertical atlantoaxial subluxation and erosion of the odontoid process were assessed on conventional radiographs (including tomograms in one patient), as well as on MR images. In addition, periodontoid pannus formation, the subarachnoid space and upper cervical cord, and artifacts from the surgical fixation material were evaluated on the MR scans. Measurements on conventional radiographs were made without correction for the slight magnification, while measurements on MR images were performed with the distance cursors on the MR monitor.

The preodontoid space was measured from the lower posterior border of the anterior arch of the atlas to the nearest part of the odontoid process; a value exceeding 3 mm was regarded as horizontal atlantoaxial subluxation [11]. Vertical atlantoaxial subluxation was considered to be present if the odontoid tip extended more than 9 mm above the palatooccipital line (McGregor's line) or if the distance from that line to the lower endplate of C2 was less than 34 mm in men and 29 mm in women [11].

When pannus was present, it usually surrounded the odontoid process (Figs. 1–3). The part of the pannus bulging posteriorly is of greatest interest, as it contributes to the narrowing of the spinal canal. To evaluate the size of this part of the pannus, sagittal measurements were obtained. Because the posterior border of the odontoid process was often difficult to identify on MR because of erosion, the largest sagittal diameter was measured from the anterior border of the odontoid process to the posterior border of the pannus in the spinal canal (Fig. 1). The soft tissue in the preodontoid space was not included in the measurements because its sagittal diameter is determined by the degree of subluxation.

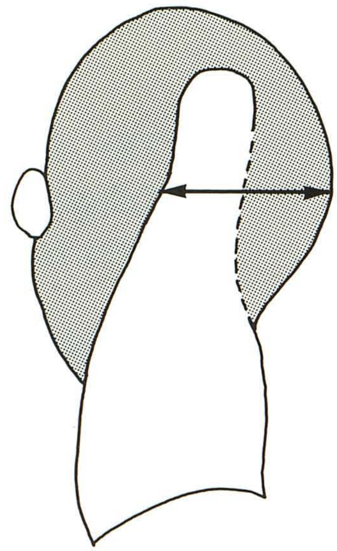

Fig. 1.—Sagittal schematic drawing of anterior arch of atlas and odontoid process surrounded by pannus. *Arrow* indicates measured sagittal diameter of odontoid process and intraspinal pannus behind it.

Results

Horizontal atlantoaxial subluxation with mobility was seen in nine patients on preoperative conventional radiographs (Table 1). MR detected the horizontal atlantoaxial subluxation in eight patients despite the neutral position of the head during this examination (Fig. 2). After surgery horizontal atlantoaxial subluxation was seen in eight patients on conventional radiographs as well as on MR, but mobility was demonstrated in only one patient. The horizontal subluxation in the neutral position had decreased in four patients (cases 1, 3, 7, and 8), had increased in three patients (cases 4–6), and was unchanged in two patients (cases 9 and 10). Thus, surgery led to stabilization as intended, but in most cases in a subluxated position.

Vertical atlantoaxial subluxation was seen in two patients preoperatively and in four patients postoperatively (Fig. 4). In one of the patients with preoperative vertical subluxation the dislocation increased postoperatively.

Erosion of the odontoid process was apparent on conventional radiographs in seven patients and on MR in nine patients.

Periodontoid pannus was revealed on preoperative MR in all patients except one (case 2) who had no atlantoaxial mobility (Table 1 and Figs. 2–4). Pannus extended not only posterior and anterior to the odontoid process but also above its tip and laterally. The measured size of the posterior portion of the pannus is shown in Table 1.

The signal intensity of the pannus was equal to or slightly lower than that of the spinal cord on short TR/TE images and equal to or higher than that of the cord on long TR/TE images (Figs. 2A and 2B).

Postoperative reduction of the pannus posterior to and above the odontoid process was demonstrated in all patients who had preoperative pannus (Table 1 and Figs. 2–4). On visual assessment the pannus reduction was more pronounced than the measurements indicate, as the portions of the pannus situated above and lateral to the odontoid process were not measured. The pannus had decreased markedly as early as 6 weeks after surgery in one of the patients who had had more than one postoperative MR examination (Fig. 3D).

Compression of the medulla and/or upper cervical cord was seen on MR preoperatively in seven patients (Figs. 2–4) and postoperatively in three patients (Table 2). The latter three

*β3000 M, Fonar Corp., Melville, NY.

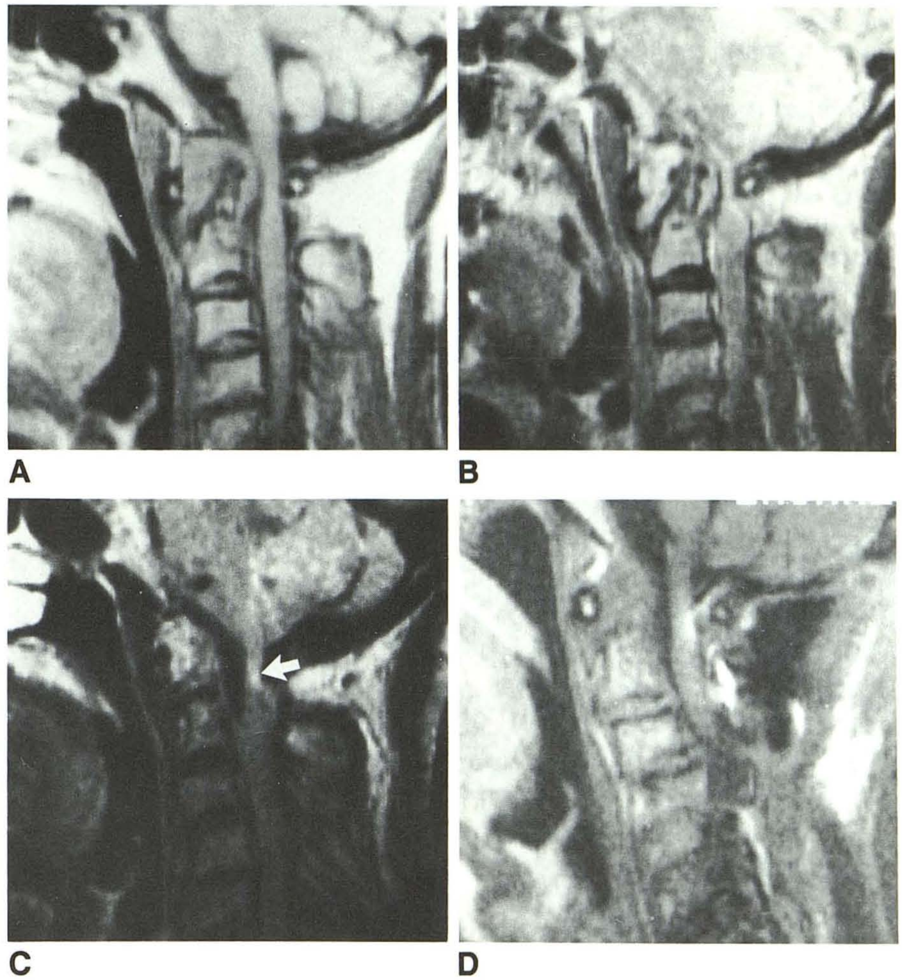

Fig. 2.—Case 3.

A, Preoperative short TR/TE sagittal MR image. Pannus with signal intensity equal to that of cord surrounds odontoid process. Compression of upper cervical cord is caused by horizontal atlantoaxial subluxation and pannus.

B, Preoperative long TR/TE sagittal MR image. Pannus exhibits high signal intensity.

C, MR slice adjacent to *B*. Increased signal intensity within cord at level of compression (*arrow*).

D, Postoperative short TR/TE sagittal MR image. Horizontal atlantoaxial subluxation and pannus have decreased. There is no remaining cord compression. (Odontoid process was better delineated on adjacent slice, which did not show spinal cord.)

patients (cases 4, 8, and 9) had no intraspinal pannus postoperatively; the compression was caused solely by the odontoid process (due to increased subluxation) (Fig. 4).

Preoperatively, five of the seven patients with symptoms and signs of myelopathy had compression of the medulla and/or cord, and one had isolated compression of the anterior subarachnoid space on MR. Postoperatively, three of these seven patients had recovered completely from their myelopathy, while four had improved. The neck pain had resolved or diminished after surgery in all eight patients with preoperative pain. The three patients with vertigo had improved postoperatively.

Increased signal intensity within the medulla or spinal cord at the level of compression was seen preoperatively on long TR/TE images in three patients (Fig. 2C), all with myelopathy, and could not be evaluated in two patients because of poor image quality. Postoperatively the upper cervical cord could not be evaluated on long TR/TE images because of artifacts from the fixation material (Fig. 5C).

Artifacts caused by the surgical fixation material (stainless steel wires and pins) were seen in the posterior part of the neck in all patients. The artifacts were smaller on short TR/TE images, usually extending to the posterior part of the cord, than on long TR/TE images, where they usually reached at least the anterior border of the cord (Fig. 5). Thus, on postoperative short TR/TE images the odontoid process, the anterior subarachnoid space, and the ventral part of the medulla and upper cervical cord could be evaluated in all patients. The postoperative long TR/TE images could not be interpreted in this region because of artifacts.

Discussion

This study shows that compression of the medulla and upper cervical cord in patients with severe chronic rheumatoid arthritis is caused not only by atlantoaxial subluxation but frequently by periodontoid pannus also. Before the introduction of MR the intraspinal components of such pannus formation could be indirectly demonstrated by myelography, which may be very difficult to perform in patients with rheumatoid arthritis who have joint deformities and pain. CT myelography with sagittal reconstruction has recently been the preferred technique, as it depicts bony as well as soft-tissue abnormalities better than conventional radiography and myelography do [7]. However, CT myelography is invasive, does not allow direct sagittal imaging, and, postoperatively, may contain artifacts from the metallic fixation. MR provides

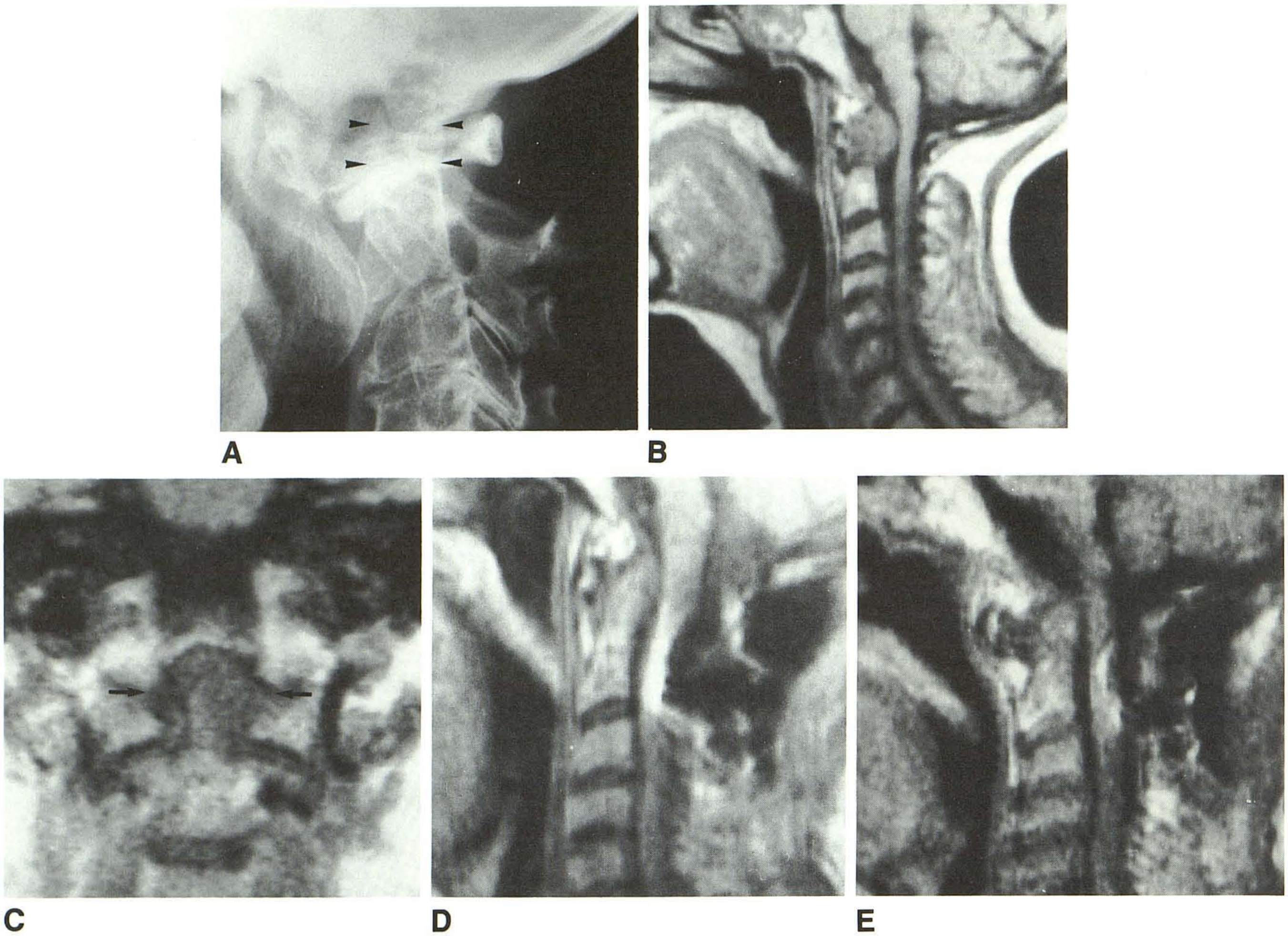

Fig. 3.—Case 5.

A, Preoperative conventional radiograph in flexion with pronounced horizontal atlantoaxial subluxation. Cortical bone of odontoid process (*arrowheads*) is thinner than normal but not eroded.

B, Preoperative short TR/TE sagittal MR image. No horizontal atlantoaxial subluxation is seen on MR in neutral position. Pannus bulging into spinal canal compresses medulla and upper cervical cord. Maximal narrowing of spinal canal can be inferred from this image, showing intraspinal pannus, combined with conventional radiograph in flexion (*A*), showing maximal subluxation. Performing an MR examination in flexion could be hazardous for patients like this one. The odontoid process appears eroded.

C, Preoperative short TR/TE coronal image shows that pannus (*arrows*) also extends laterally to odontoid process.

D, Early postoperative short TR/TE sagittal MR image (6 weeks after surgery). Pannus has decreased markedly. Anterior subarachnoid space but not cord, is compressed. There is no subluxation (and no mobility on conventional radiographs). High signal over cord represents artifact from metal fixation.

E, Late postoperative short TR/TE sagittal MR image (7 months after surgery). Atlantoaxial mobility (seen on conventional radiographs) has recurred but is less pronounced than before surgery. MR shows horizontal atlantoaxial subluxation, but pannus has disappeared. Odontoid process compresses anterior subarachnoid space but not cord.

(*B*, *D*, and *E* reprinted from [8], with permission.)

better delineation of the pannus than previous methods do because of its superior contrast discrimination [1–3, 5, 12, 13], and imaging can be performed in any plane without moving the patient. In addition, MR offers the unique opportunity to depict intramedullary lesions, in most cases seen as high signal intensities on long TR/TE images. Such lesions, noted in three patients with myelopathy in our study (Fig. 2C), may represent edema and ischemic changes caused by compression of the cord [6]. Cord compression would probably have been detected in more patients if MR had been performed in flexion, but MR examination in flexion is difficult to perform and might induce neurologic symptoms in patients with cervical rheumatoid arthritis. In our opinion the maximal narrowing of the spinal canal can be inferred from conventional radiographs in flexion, demonstrating vertebral subluxation, combined with MR in the neutral position, showing the extent of pannus posterior to the odontoid process (Figs. 3A and 3B).

Although MR provides excellent information about vertebral dislocation, it is inferior to CT and possibly conventional radiography in detecting calcification and ossification. Therefore, when the cortical bone is thinner than normal and is surrounded by pannus, erosion of the odontoid process may be overestimated on MR [5], as occurred in two of our patients (Figs. 3A and 3B).

In our investigation pannus was revealed preoperatively on MR in all nine patients with mobile atlantoaxial subluxation (Table 1). The increased signal intensity of the pannus on long TR/TE images in some patients could be consistent with an increased amount of water, as in inflammatory tissue (Fig. 2B). However, fibrous components probably are present within the pannus, since the signal intensity in pure inflammatory tissue should be higher than was noted in most patients in this study. Postmortem examinations support this assumption [6]. It has been suggested that mechanical dysfunction and instability in the craniocervical junction may cause formation of fibrous granulation tissue and hypertrophy of connective tissue elements as the abnormal response to chronic stresses and friction [14]. Thus, the rheumatoid periodontoid inflammatory granulation tissue may increase due to hypertrophy of fibrous elements when instability has occurred. This is consistent with our findings in a previous report, where we noted that the periodontoid soft-tissue mass was largest in patients who had pronounced mobile horizontal atlantoaxial subluxation [5]. Incomplete reduction of horizontal atlantoaxial subluxation during surgery in some of the patients probably was due to fibrous pannus occupying the preodontoid space. Such pannus may also be partly responsible for incomplete reduction of horizontal subluxation on extension views on lateral radiographs (Table 1).

The reduction of pannus in our investigation seems to be the result of the atlantoaxial immobility achieved by the surgical posterior fusion. Only one of the patients exhibited atlantoaxial mobility on the 6-month postoperative examination. The pannus reduction in that patient could still have been caused by stabilization, since mobility did not recur until late in the postoperative period and was then smaller than before surgery.

In conclusion, our investigation has shown that compression of the medulla and upper cervical cord caused by atlantoaxial subluxation, as well as by periodontoid pannus, can be demonstrated by MR pre- and postoperatively. Further-

TABLE 1: Pre- and Postoperative Horizontal Atlantoaxial Mobility on Conventional Radiographs Compared with Size of Pannus on MR Images

Case No.	Sagittal Measurement (mm): Atlantoaxial Mobility (Preodontoid Space in Flexion − Extension) on Conventional Radiographs		Odontoid Process + Posterior Pannus on MR Images	
	Preop	Postop	Preop	Postop
1	2 (18 − 16)	0 (12 − 12)	11	10
2	0 (2 − 2)[a]	0 (2 − 2)	–	–
3	7 (10 − 3)	0 (5 − 5)	12	10
4	5 (12 − 7)	0 (12 − 12)	11	9
5	12 (12 − 0)	4 (9 − 5)	16	10
6	7 (11 − 4)	0 (11 − 11)	10	7
7	5 (10 − 5)	0 (2 − 2)	11	9
8	3 (11 − 8)	0 (6 − 6)	13	9
9	5 (12 − 7)	0 (6 − 6)	16	10
10	9 (12 − 3)	0 (5 − 5)	16	9

Note.—Preop = preoperative; postop = postoperative.
[a] This patient had severe vertical atlantoaxial subluxation; no pannus was present.

TABLE 2: Compression of Anterior Subarachnoid Space (SAS) and Medulla/Cervical Cord (MCC) on MR

Case No.	Compression: Before Surgery	After Surgery
1	MCC	SAS
2	SAS[a]	SAS[a]
3	MCC	–
4	MCC	MCC[a]
5	MCC	SAS[a]
6	–	–
7	–	–
8	MCC	MCC[a]
9	MCC	MCC[a]
10	MCC	–

[a] No pannus behind odontoid process; compression caused solely by odontoid process due to horizontal and/or vertical subluxation.

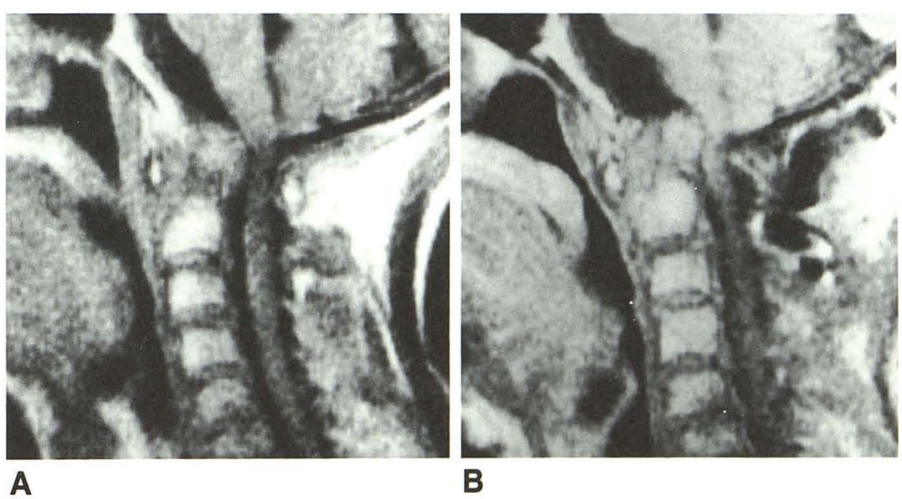

Fig. 4.—Case 9.
***A*, Preoperative short TR/TE sagittal MR image. Medulla and upper cervical cord are compressed by odontoid process (because of horizontal atlantoaxial subluxation) and pannus.**
***B*, Postoperative short TR/TE sagittal MR image. Pannus behind odontoid process has disappeared. Horizontal subluxation is unchanged, but in addition there is vertical atlantoaxial subluxation. Because of this, the medulla and cord are still compressed.**

A B C

Fig. 5.—Case 6.

***A*, Postoperative conventional radiograph. Posterior occipitocervical fusion and C1 laminectomy have been performed. Note stainless steel wires, stainless steel pin through spinous process of C2, and acrylic bone cement.**

***B*, Postoperative short TR/TE sagittal MR image. Artifacts from wires and pin are confined to posterior part of neck and do not interfere with evaluation of pannus and medulla/cervical cord. Signal void is seen at site of acrylic bone cement.**

***C*, Postoperative long TR/TE sagittal MR image. Artifacts from stainless steel wires and pin extend more anteriorly than on short TR/TE images and make evaluation of craniocervical junction impossible.**

more, MR has revealed reduction of periodontoid pannus after posterior occipitocervical fusion. In our opinion, conventional radiography, including lateral views in flexion and extension, combined with MR in the neutral position, provides all the necessary information for the preoperative evaluation of patients with rheumatoid arthritis involving the cervical spine. Because the morphologic information is most important in these patients, sagittal short TR/TE images should be sufficient. Postoperative MR is not required as a routine examination but is valuable if the patient has residual or new symptoms. Our study has shown that postoperative short TR/TE images are useful despite artifacts from surgical fixation material, since these artifacts are confined to the posterior part of the neck.

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