Magnetic resonance imaging of the craniocervical junction in rheumatoid arthritis: value, limitations, indications

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Abstract. The cervical spine is the second most common location for manifestation of rheumatoid arthritis (RA). Symptoms are typically related to involvement of the craniocervical junction. Unfortunately, conventional radiographic examination is often unable to demonstrate that RA is the cause of such symptoms. Magnetic resonance imaging (MRI) provides a unique opportunity to visualize nerves, connective tissue, and bone in all planes without the use of contrast agents. These features suggest that MRI could provide important information related to RA of the cervical spine. The possibilities and limitations of MRI were therefore evaluated in 60 patients with cervical RA. The main objective of this study was to correlate symptoms and clinical findings with MRI results to establish indications for this imaging procedure.

Key words: Rheumatoid arthritis – MRI – Cervical spine – Atlantoaxial subluxation – Compression

The cervical spine is second only to the hand and foot joints as the most common location for manifestation of rheumatoid arthritis (RA). According to the literature, involvement of the cervical spine in RA ranges between 28% and 86% [3, 7, 12, 13, 15, 16]. The cervical spine not only protects part of the central nervous system but also consists of a complex system of small joints essential for maximal movement of the head. This polysynovial system offers a large surface area for the rheumatoid process, and this explains the multitude of pathologic findings associated with RA of the cervical spine. These changes in RA have been characterized by Bland [3] and Schilling [13, 14].

Involvement of the craniocervical junction in RA typically affects the atlantoaxial articulation, a highly differentiated joint in terms of morphology and function. Destruction of this joint may cause ventral or cranial displacement of the odontoid process leading to atlantoaxial subluxation and craniovertebral settling, respectively. The corresponding loss of joint motion is associated with serious neurologic complications, which can be life-threatening and require a stabilizing operation [5, 7, 9, 12, 13, 16].

An experienced radiologist can depict typical RA changes of the cervical spine with conventional radiography [3], although the findings are often insufficient to explain functional or neurologic symptoms [6, 9, 11, 13, 14, 16]. The routine use of MRI for imaging of the central nervous system and connective tissues suggests that this procedure could provide important information about RA of the cervical spine [5–8, 12, 16]. This study was designed to evaluate the possibilities and limitations of MRI for cervical RA to establish indications for this imaging procedure.

Materials and methods

The present study was carried out at the German Diagnostic Clinic (Wiesbaden) and Center for Rheumatology (Schlangenbad) between May 1986 and March 1989. Seventy patients with an established diagnosis of RA with involvement of the cervical spine were investigated. Radiologic criteria for patient selection were an atlantoaxial distance of at least 5 mm under maximal flexion or craniovertebral settling according to McRae (Fig. 1B). Complete data for statistical evaluation were obtained from 60 patients in the selected group. There were 49 females and 11 males with an average age of 51 years (range 26–79 years).

All patients were examined by a rheumatologist and a neurologist. The results were collected retrospectively from the patient records. Functional imaging of the cervical spine with lateral views and tomographs of the odontoid process, atlantoaxial joint, and atlantoooccipital joints were performed. The radiologic findings were evaluated without prior knowledge of MRI results.

MRI was carried out with 0.28 T (Bruker, BMT 1100) and 1.0 T (Siemens, Magnetom) systems. T1- and T2-weighted images in the sagittal, axial, and coronal planes were obtained from the cervical spine with slice thicknesses between 5 and 8 mm. Recovery and echo times were 400–600 ms and 15–34 ms, respectively. For
better resolution of the craniocervical junction a head coil was used. All patients were investigated in the supine position with normal head positioning.

The interpretation of $T_1$-weighted images in the middle sagittal plane was based on the following criteria:

- Displacement, compression, and nonuniform signals of the cervical cord or medulla oblongata
- Structural lesions
- Geometric relationships of the craniocervical junction
- Orientation of the posterior longitudinal ligament
- Presence of pannus

Clinical characteristics and conventional radiologic findings were compared with the number of cord compressions and obliterations found with MRI using descriptive and analytic methods. Significance was determined using the Wilcoxon signed rank test for paired samples.

**Results**

$T_1$-weighted sagittal images enable evaluation of bone, connective tissue, and nervous system of the head and cervical spine (Fig. 1A). For example, the medulla oblongata, pons, and cerebellum are shown. At the level of the foramen magnum is the transition between medulla and cervical cord with good demarcation from the surrounding hypointense spinal fluid. Bony structures show strong signals, arising from fatty bone marrow, which are enveloped by weak signals representing compact bone. The wedge-shaped clivus descending to the foramen magnum, the base of the skull, and the cervical vertebrae are well seen. The anterior and posterior arches of the atlas appear as ring structures with a central bright signal lying ventral to the odontoid process and dorsal to the cervical cord. The apical portion of the odontoid process often has a nonuniform signal. The posterior longitudinal ligament is found posterior to the odontoid process. There is often fatty tissue cranial to the odontoid process producing contrast which allows better differentiation between the arch of the atlas and the base of the skull.

The geometry and measurements of the craniocervical junction are shown in Fig. 1B. The average diameter of the cervical cord, measured at C1, was 8 mm in the patients studied. There were large variations in the diameter of the spinal canal due to subluxations and tissue formation; here, the average diameter was 15 mm. The diagnosis of craniovertebral settling was made using the foramen magnum line of McRae and the palato-suboccipital line of McGregor. Physiologically, the tip of the odontoid process does not extend above the McRae line or more than 4.5 mm beyond the McGregor line [11, 12]. A craniovertebral settling verified by both methods was found in 10% of the patients and, according only to McGregor, in 3%. In 28% of the patients the odontoid process was below the McGregor line.

As with conventional radiography, the most common finding with MRI was erosion of the odontoid process which appeared as a defect in the medullary or compact bone signal in 88% of all patients (Figs. 2–4). In all cases the erosion was typically found on the dorsal side of the odontoid process at the level of the transverse ligament of the atlas, and in 37% erosion was also observed on the ventral side.

New tissue formation with an intermediate signal intensity was found between the odontoid process and the anterior arch of the atlas in 87% of patients; in 63% this finding was discrete and in 23%, readily apparent (Fig. 2). This tissue is also recognized with computerized tomography (CT) [4] and represents a proliferative synovitis of the atlantoaxial joint. This tissue, together with the instability of C1/C2, produced displacement of the posterior longitudinal ligament in the direction of the cervical cord in 72% of patients. Severe displacement led to obliteration of the subarachnoid space in 22% of patients. $T_2$-weighted images of the cerebral spinal fluid were especially useful for the interpretation of such findings (Fig. 3).

The demarcation of the cervical cord from the surrounding cerebral spinal fluid and extradural structures over the entire length of the area investigated was possible in all patients examined. Ventral compression of the