

Ozlem Baysal · Tamer Baysal · Ahmet Sigirci
Yuksel Ersoy · Zuhale Altay

Atlanto-odontoid osteoarthritis in rheumatoid arthritis: dynamic CT findings

Received: 14 July 2003 / Accepted: 23 January 2004 / Published online: 20 April 2004
© Clinical Rheumatology 2004

Abstract We analyzed the CT appearances of degenerative change in the atlanto-odontoid joint (AOJ) in patients with rheumatoid arthritis (RA) and evaluated the effect of these changes on atlanto-axial joint (AAJ) rotation by dynamic CT. This revealed that 9 patients (24%) treated with methotrexate had degenerative features in the AOJ. The ratio of AAJ rotation to the total rotation of the cervical spine was significantly higher in normal subjects ($54 \pm 3\%$) than in patients ($38 \pm 12\%$). The degree of AAJ rotation was significantly lower in the patient group with degenerative features in the AOJ ($20.9 \pm 8.4^\circ$) than in patients without degenerative features ($28.5 \pm 7.4^\circ$). RA patients with a history of long-standing disease and treatment with antirheumatic drugs may develop AO OA. Although secondary OA was described as healing phenomena in the joints of RA patients, it can limit rotation in the AAJ and cause suboccipital neck pain. A regular check-up of the AAJ and AOJ by means of dynamic CT in all RA patients is proposed to avoid possible antirheumatic drug complications.

Keywords Axis · CT · Osteoarthritis · Rheumatoid arthritis · Spine

Abbreviations AAJ: Atlanto-axial joint · AOJ: Atlanto-odontoid joint · MTX: Methotrexate · OA: Osteoarthritis · RA: Rheumatoid arthritis

O. Baysal (✉) · Y. Ersoy · Z. Altay
Fiziksel Tıp ve Rehabilitasyon Anabilim Dalı,
İnönü Üniversitesi Turgut Ozal Tıp Merkezi,
44069 Malatya, Turkey
E-mail: ozlembaysal@hotmail.com
Tel.: +90-422-3410834
Fax: +90-4220-3410834

T. Baysal · A. Sigirci
Radyoloji Anabilim Dalı,
İnönü Üniversitesi Turgut Ozal Tıp Merkezi,
44069 Malatya, Turkey

Introduction

The atlanto-odontoid joint (AOJ) is a synovial joint between the anterior arch of the atlas and the odontoid process of the axis. Osteoarthritis (OA) at this functionally important joint occurs mainly in the elderly. The degenerative changes are similar to those commonly observed in other synovial joints, and abnormal morphology was categorized into three groups: (1) osteophytosis; (2) obliteration of the joint space; and (3) transverse ligament calcification [1, 2]. The appearance of AO OA on CT, MRI, conventional tomography and plain radiography has been documented in the literature [1, 2, 3, 4]. However, to our knowledge, no previous study has addressed the prevalence of AO OA in RA patients and the effect of degenerative abnormalities at the AOJ on AAJ rotation.

We analyzed the CT appearances of degenerative changes in the atlanto-odontoid joint (AOJ) in patients with rheumatoid arthritis (RA) and evaluated the effect of these changes on atlanto-axial joint (AAJ) rotation by dynamic CT.

Materials and methods

A total of 38 RA patients (30 women and 8 men) were investigated (mean age 51.2 years; range 31–75) years. The control group included 25 patients (20 women and 5 men) referred to paranasal sinus and brain CT with a mean age of 52.2 years (range 27–65 years). Control subjects had no history of neck trauma.

The CT examination was performed with the patients in the supine position, with the head in the neutral position (with the nasal septum vertical) and then repeated with the head rotated to the right and left. Normal subjects rotated their heads to one side that they preferred. All normal subjects and patients were asked to rotate their heads as much as possible, but without any excessive effort or discomfort. A band was used to fix the head in the rotated position. The subject was asked to

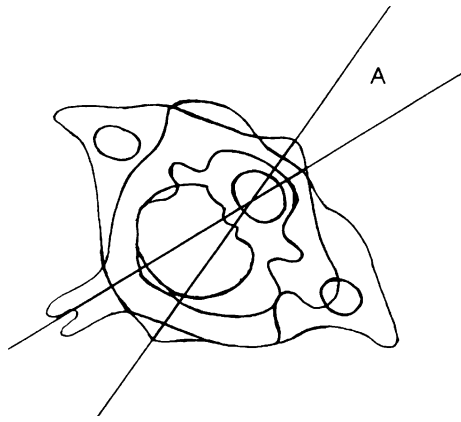
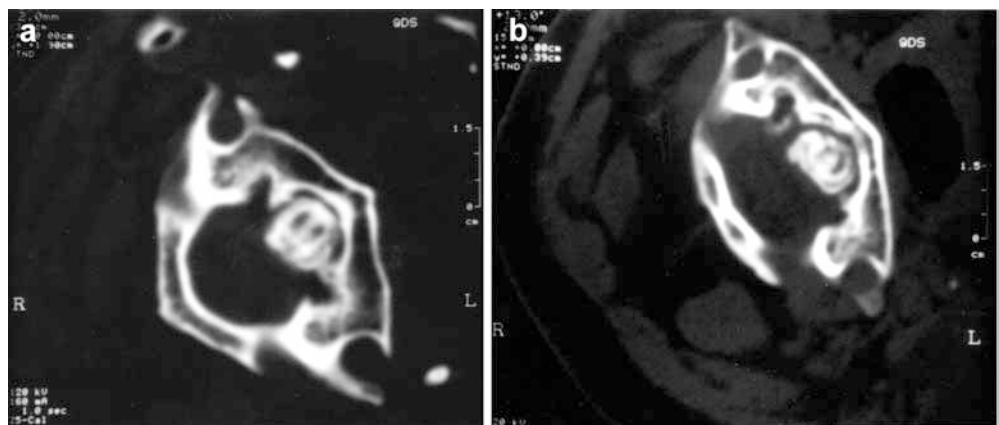


Fig. 1 Images of CT slice through the plane of atlantoaxial joints. The angle (A), formed by the intersection of the two anteroposterior lines through the midline of each vertebrae, representing the relation between atlas and axis

hold this position for the duration of the scan. A GE Prospeed (GE, Milwaukee) was used for the investigation. The gantry was vertical in each scanning position. Consecutive 3 mm slices were made with a low-dose program (120 mA per section). The investigation was started with a lateral digital radiograph covering the lower part of the skull, the cervical spine and the upper part of the chest. Scans were obtained from the base of the skull to the top of the C3 vertebral body in the neutral and the rotated positions. The hard palate was included in the examination whenever possible to use as a reference point to determine the orientation of the skull. In the head-rotated position two slices were obtained at the level of the first thoracic vertebra. A line was drawn parallel to the posterior border of first thoracic vertebra to represent the frontal plane. The difference in angles between the nasal septum and the first thoracic vertebra represented the degree of skull rotation. The difference in angles between nasal septum and the first thoracic vertebra was accepted as total cervical spine rotation owing to the complete absence of rotation between occiput and atlas. Bone and soft-tissue windows were obtained in all examinations. Osteophytes in the AOJ and erosions of the odontoid process were noted.

Fig. 2 **a** Dynamic CT scan of the atlantoaxial region with head in maximal rotation. The maximal head rotation is limited. The angle between atlas and axis is 5°. CT shows the odontoid locking in the left lateral articular mass of C1 due to osteophytes originating from the left side of odontoid. **b** The odontoid is circumscribed by osteophytes



We used the method described by Li and Pang for calculation of normal and abnormal angles of C1–C2 rotation [5]. Quantification of the degree of AAJ rotation was performed by measuring the angle between the anteroposterior axes of the atlas (line connecting the anterior tubercle to the spinous process) and the axis (line connecting the base of odontoid to the spinous process). The angle formed by the intersection of the two anteroposterior lines through the midline of each vertebra represents the relation between atlas and axis (Fig. 1).

Statistical calculations were performed using Systat 5.02 for Windows (Systat Inc., Evanston, IL, USA). The appropriate statistical evaluations of data were made by variance analysis (ANOVA), Student's *t*-test and Pearson's correlation coefficient. Values were expressed as the mean \pm SD. *p* values <0.05 were considered to be statistically significant.

Results

The mean duration of the disease was 6.1 years (range 1–26 years). Thirty of the patients had been treated with disease-modifying antirheumatic drugs, including methotrexate (MTX). The mean duration of MTX treatment was 5.1 years (range 3.1–6.4).

Twelve patients had complaints of suboccipital headache and 3 of these had also limited head rotation. Only one (4%) control subject had mild degenerative changes in the AOJ. CT examination revealed that 9 patients (24%), with a mean disease duration of 5.8 years, had degenerative features in the AOJ. All 9 were on long-term MTX treatment. The degenerative findings included osteophyte(s) of the odontoid in 7 patients. In 3 patients the osteophytes were surrounding the dens (Fig. 2). Four patients had obliteration of the AOJ space (Fig. 3). One patient had vacuum phenomenon in the AOJ (Fig. 4) and another had transverse ligament calcification. Erosions of the dens were observed in 5 (13%) of 38 patients. All erosions were superficial and in 3 patients were accompanying AOJ osteophytes.

Fig. 3 Axial CT scan of the atlantoaxial region with head in neutral position **a**. The atlantoodontoid joint space is obliterated with sclerosis **b**. CT shows another patient with prominent osteophytes in the AOJ

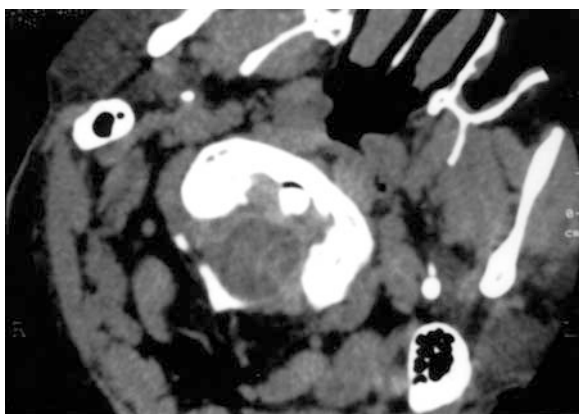
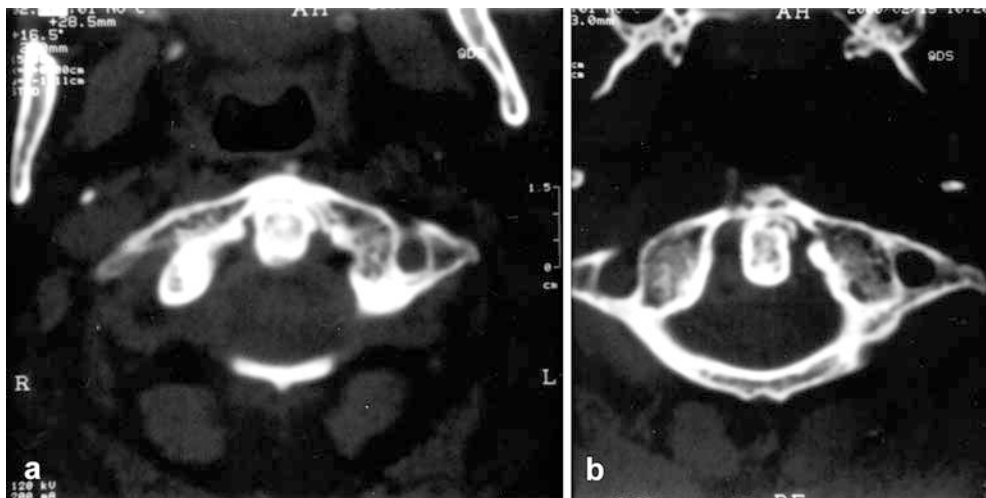


Fig. 4 Axial CT scan of the atlantoaxial region in soft tissue window. Vacuum phenomenon is seen in the atlantoodontoid joint

In the patient group (including those with limited motion) the difference between the right and left rotation angles was insignificant ($p = 0.45$). In normal subjects the total rotation of the cervical spine and the average rotation in AAJ were significantly greater than in the patient group (Table 1). Two patients with osteophytosis of the odontoid had 1° and 5° AAJ rotation.

The ratio of AAJ rotation to the total rotation of the cervical spine was significantly higher in normal subjects ($54 \pm 3\%$) than patients ($38 \pm 12\%$). The degree of AAJ rotation was significantly lower in the patient group with degenerative features in the AOJ ($20.9 \pm 8.4^\circ$) than in patients without degenerative features ($28.5 \pm 7.4^\circ$).

The ratio of AAJ rotation to the total rotation of the cervical spine ($32 \pm 13\%$) was significantly less in patients with degenerative features in AOJ than in patients without degenerative findings ($41 \pm 10\%$) (Table 2).

Discussion

Studies of physiological atlantoaxial rotation to date have employed either plain radiography or CT of

Table 1 The average rotation at the cervical spine and atlantoaxial joint in normal subjects and rheumatoid arthritis patients

	Total cervical rotation ($^\circ$)	AAJ rotation ($^\circ$)	AAJ/total cervical rotation
Control group	$78.7 \pm 5.1(69-87)$	$42.4 \pm 5.5(37-45)$	0.54 ± 0.03
Patient group	$68.3 \pm 8.1(49-79)$ $p < 0.0001$	$25.7 \pm 8.5(1-42)$ $p < 0.001$	0.38 ± 0.12 $p < 0.02$

Table 2 The average rotation at the cervical spine and atlantoaxial joint in rheumatoid arthritis patients with and without degeneration in the atlanto-odontoid joint

	Total cervical rotation ($^\circ$)	AAJ rotation ($^\circ$)	AAJ ^b /total cervical rotation
Patients with AO OA ^a	$66.5 \pm 8.7(49-79)$	$20.9 \pm 8.4(1-32)$	0.32 ± 0.13
Patients without AO OA	$69.4 \pm 7.7(52-79)$ $p < 0.3$	$28.5 \pm 7.4(15-42)$ $p < 0.006$	0.41 ± 0.10 $p < 0.02$

^aAtlanto-odontoid osteoarthritis

^bAtlantoaxial joint

normal volunteers [2, 6, 7, 8]. Both techniques are limited by the radiation dose involved, and therefore most studies have measured rotation in one direction only [9]. Although MRI has the advantages of no ionizing radiation, multiplanar imaging capacity and excellent depiction of the soft tissues, CT was reported to be the best choice in demonstration of the bony structures. MRI seemed to be the radiological technique of choice in diagnosing peridental pannus formation and cervical cord compression [10]. Dynamic CT study obtained with maximal voluntary contralateral rotation of the head was recommended to demonstrate the motion of the atlas on the axis [9, 11].

The facet joints between the atlas and axis are almost horizontal, allowing excellent rotation at the expense of bony stability [9]. There is a wide range of rotation to either side in the literature of between 25° and 53° [6, 8, 12]. The principal motion at the AAJ is rotation, and 40%–70% of total neck rotation occurs here [6, 13].

Limitation in AAJ rotation may have different causes. A synovial fold, a disrupted capsule, a segment of the transverse ligament or a cartilaginous or bony particle may impinge on the joint [6, 14]. Our results revealed both limited AAJ rotation and decreased contribution of AAJ to total cervical rotation in RA patients. The average degree of AAJ rotation and the ratio of AAJ rotation to the total rotation of the cervical spine were significantly less in RA patients with AO OA than in patients without AO OA.

Degenerative changes at the AOJ are frequently related to suboccipital neck pain. These changes were seen in 49% of patients undergoing CT of the brain or sinuses for a variety of indications, and 42% of the patients reported pain in the suboccipital region [15]. Although there are previous reports about the degenerative changes in lateral AAJ [16, 17], AO OA has been reported to receive little scientific attention. Halla and Hardin reported that symptomatic lateral AO OA mainly occurs in elderly patients who have osteoarthritis at other sites [17]. These degenerative changes were reported to show a roughly linear progression with advancing age [1]. In an MRI study of AO OA the mean age of the patients studied was reported to be 72 years [2]. Degenerative changes at the AAJ had been reported in 76% of RA patients [10]. It was reported that odontoid process osteophytosis occurred more frequently with increased duration of the disease [18]. We did not observe a relationship between the degenerative changes and the duration of the disease. Two of our patients who had almost locked AAJ (1° and 5°) were 32 and 38 years old, respectively, and both were on a high-dose MTX regimen for rapid progression of the RA. The mean age of our patients and the control group was about 50 years. This finding may reveal that factors other than age have an effect on the development of degenerative changes. The prevalence of rheumatoid cervical involvement was reported to be affected not only by disease duration, but also by disease activity [19].

A likely explanation for the relatively high frequency of AOJ degenerative changes may be radiological healing phenomena reported in the AAJ and other joints of RA patients [10, 20]. Sclerosis of the subchondral bone and the formation of osteophytes (secondary osteoarthritis) were described as examples of healing phenomena [21, 22]. The term ‘secondary osteoarthritis’ has been used to describe degenerative joint disease as a consequence of inflammatory joint disease, implying an arrest of inflammation. Examples of healing phenomena have been described in RA patients during long-term treatment with disease-modifying antirheumatic drugs since the early 1980s, and images of these findings have been repeatedly described [22, 23]. A decrease in the number

of joints with ‘active erosions’ and an increase in the number of joints with ‘inactive’ changes during MTX treatment has been described [24]. Clinical trials where radiologic changes have been carefully scored were reported to involve patients with long-standing destructive disease, where it can be extremely difficult to see change and decide whether reparative processes have occurred [20].

RA patients with a history of long-standing disease and treatment with antirheumatic drugs may develop AO OA. Although secondary OA was described as healing phenomena in the joints of RA patients, it can limit rotation in the AAJ and cause suboccipital neck pain. A regular check-up of the AAJ and AOJ by means of dynamic CT in all RA patients is proposed to avoid possible antirheumatic drug complications.

References

- Zapletal J, Hekster REM, Straver JS (1995) Atlanto-odontoid osteoarthritis. Appearance and prevalence at computed tomography. *Spine* 20:49–53
- Zapletal J, Hekster RE, Treurniet FE (1997) MRI of atlanto-odontoid osteoarthritis. *Neuroradiology* 39:354–356
- Harata S, Tohno S, Kawagishi T (1981) Osteoarthritis of the atlanto-axial joint. *Int Orthop* 5:277–282
- Genev BM, Willis JJ, Lowrey CE (1990) CT findings of degenerative arthritis of the atlanto-odontoid joint. *AJR* 154:315–318
- Li V, Pang D (1995) Atlanto-axial rotatory fixation. In: Pang D, ed. *Disorders of the pediatric spine*. Raven Press, New York, pp 531–553
- Iai H, Moriya H, Goto S (1993) Three-dimensional motion analysis of the upper cervical spine during axial rotation. *Spine* 18:2388–2392
- Penning L (1978) Normal movements of the cervical spine. *AJR* 130:317–326
- Penning L, Wilmink T (1987) Rotation of the cervical spine. A CT study in normal subjects. *Spine* 12:732–738
- Roche CJ, King SJ, Dangerfield PH (2002). The atlanto-axial joint: physiological range of rotation on MRI and CT. *Clin Radiol* 57:103–108
- Castro S, Verstraete K, Mielants H (1994) Cervical spine involvement in rheumatoid arthritis: a clinical, neurological and radiological evaluation. *Clin Exp Rheumatol* 12:369–374
- Kowalski HM, Cohen WA, Cooper P (1987) Pitfalls in the CT diagnosis of atlantoaxial rotary subluxation. *AJR* 149:595–600
- Dvorak J, Hayek J, Zehnder R (1987) CT-functional diagnostics of the rotatory instability of the upper cervical spine. Part 2. An evaluation on healthy adults and patients with suspected instability. *Spine* 12:726–731
- White AA, Panjabi MM (1978) Kinematics of the spine. In: White AA, Panjabi MM, eds. *Clinical biomechanics of the spine*. JB Lippincott, Philadelphia, pp 87–125
- Mihara H, Onari K, Hachiya M (2001) Follow-up study of conservative treatment for atlantoaxial rotatory displacement. *J Spinal Disord* 14:494–499
- Zapletal J, Hekster RE, Straver JS (1996) Relationship between atlanto-odontoid osteoarthritis and idiopathic suboccipital neck pain. *Neuroradiology* 38:62–65
- Ghanayem AJ, Leventhal M, Bohlman HH (1996) Osteoarthritis of the atlanto-axial joints. Long-term follow-up after treatment with arthrodesis. *J Bone Joint Surg Am* 78:1300–1307
- Halla JT, Hardin JG Jr (1987) Atlantoaxial (C1-C2) facet joint osteoarthritis: a distinctive clinical syndrome. *Arthritis Rheum* 30:577–582

18. Wolfe BK, O'Keeffe D, Mitchell DM (1987). Rheumatoid arthritis of the cervical spine: Early and progressive radiographic features. *Radiology* 165:145–148
19. Yamashita T, Yoshino S, Nagashima M (2000) Prevalence of cervical lesions in rheumatoid arthritis: cross-sectional study on 263 patients. *Mod Rheumatol* 10:211–215
20. Rau R, Vassenberg S, Herborn G (2001) Identification of radiologic healing phenomena in patients with rheumatoid arthritis. *J Rheumatol* 28:2608–2615
21. van der Heijde D, Boonen A (1999) Reading radiographs in chronological order, in pairs or as single films has important implications for the discriminative power of rheumatoid arthritis clinical trials. *Rheumatology* 38:1213–1220
22. Fuchs HA, Sargent SJ (1997) Rheumatoid arthritis: The clinical picture. In: Koopman WJ, ed. *Arthritis and allied conditions*. Williams & Wilkins, Philadelphia, pp 1041–1070
23. Rau R, Herborn G (1996) Healing phenomena of erosive changes in rheumatoid arthritis patients undergoing disease-modifying antirheumatic drug therapy. *Arthritis Rheum* 39:162–168
24. Rau R, Herborn G, Karger T (1991) Retardation of radiologic progression in rheumatoid arthritis with methotrexate therapy: a controlled study. *Arthritis Rheum* 34:1236–1244