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MRI changes of cervical spine in asymptomatic and symptomatic young adults

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Abstract Several work-related, psychosocial and individual factors have been verified as being related to neck and shoulder pain, but the role of pathology visualized by magnetic resonance imaging (MRI) remains unclear. In this study, the relationship between neck and shoulder pain and cervical high-field MRI findings was investigated in a sample of persons in a longitudinal survey. The study aimed to determine whether subjects with persistent or recurrent neck and shoulder pain were more likely to have abnormal MRI findings of cervical spine than those without neck and shoulder pain. A random sample of 826 high-school students was investigated initially when the students were 17–19 years, and again when they had reached 24–26 years of age. Eighty-seven percent participated in the first survey in 1989, of whom 76% took part in the second survey, in 1996. The validated Nordic Musculoskeletal Questionnaire was used to collect data about neck and shoulder symptoms. Two groups were chosen for the MRI study: the first group (n=15) consisted of the participants who had reported no neck and shoulder symptoms in either of the inquiries, while the second group (n=16) comprised those who were suffering from neck and shoulder symptoms once a week or more often at the time of both surveys. The degrees of disc degeneration, anular tear, disc herniation and protrusion were assessed by two radiologists. The differences between the two study groups were evaluated. The study found that abnormal MRI findings were common in both study groups. Disc herniation was the only MRI finding that was significantly associated with neck pain. These findings indicate that pathophysiological changes of cervical spine verified on MRI seem to explain only part of the occurrence of neck and shoulder pain in young adults.

Keywords MRI · Neck and shoulder pain

Introduction

Neck and shoulder pain is a commonly encountered complaint in medical practice. In population studies, 20–65% of women and 15–40% of men have reported having experienced neck and shoulder symptoms during their lives [1, 29]. The symptoms are also fairly common in adolescents, and may predict morbidity in adulthood [8]. It has been demonstrated that 15% of adolescents suffer from weekly neck and shoulder symptoms [19, 28], the prevalence increases with age [28] and the symptoms among adolescents have increased during the last decade [21]. Neck and shoulder pain is thought to be multietiological. There is evidence to show that various work-related factors, such as repetitive tasks and working with the arms raised or the neck bent forward, are related to neck and shoulder pain [5, 7]. Several psychosocial and individual factors, such as high requirements [26] or low personal control of work [2], work-related psychosocial stress [30],

psychosomatic stress symptoms [14, 20] and depressive symptoms [13, 20], are also associated with neck and shoulder symptoms. Although several factors have been shown to be related to neck and shoulder pain in cross-sectional studies, it is still unclear how the changes are manifested in spinal structures.

It has been established that discs, ligaments, muscles, joints and dura are capable of eliciting pain in cervical spine when irritated or inflamed [6]. Discogenic pain is thought to originate from anular tears [18, 22] or disc degeneration (DD) [16, 23], although it has also been postulated that DD is a normal age-related change [17, 25]. A facet joint block may relieve neck pain, which indirectly indicates the facet joint to be a possible source of idiopathic neck pain [4]. Histochemical studies have shown that neck pain is associated with local hypoxia and decreased energy metabolism in tissues, but the changes are not specific to any pathophysiological change of cervical spine [11, 15]. Magnetic resonance imaging (MRI) is the most sensitive technique for showing early pathologic changes in cervical spine [9]. Only a few MRI studies of cervical spine have been carried out among subjects with neck pain. According to the study by Schellhas et al. [24], abnormal MR morphology of cervical spine was a more common finding in a group of subjects with chronic head/neck pain than among asymptomatic subjects [24]. Lehto and his co-workers found that abnormalities were rare in asymptomatic volunteers aged less than 30 years [12]. However, DD has been shown to be a fairly common finding among asymptomatic subjects in their 20s (17% of men and 12% of women) [17], and even in the population aged less than 40 years 25% of the discs have been found to be degenerated or narrowed [3]. Tertti et al. found DD of lumbar spine to be a common finding in a 15-year-old population with or without low back pain [27]. Their study found only disc protrusion and Scheuerman-type changes to be associated with low back pain. As far as we know, no studies of MRI findings relating to the subjects's neck and shoulder symptoms in a young population have been made. The aim of the present study was to examine whether symptomatic young adults had more pathological MRI changes in cervical spine than asymptomatic subjects of the same age.

Materials and methods

In 1989, a total of 2212 students attended 11 high schools in the city of Oulu in Finland (100,000 inhabitants). Five of the high schools, with a total of 826 students, were randomly selected for a 7-year follow-up study concerning neck and shoulder symptoms and associated factors (Fig. 1). Of these 826 students, 718 (87%) completed a questionnaire, which was a modified version of the well-standardized and validated Nordic Musculoskeletal Questionnaire, including questions on the presence, frequency, and duration of neck and shoulder symptoms [10]. After 7 years, the same subjects filled in the same questionnaire concerning neck and shoulder symptoms as a postal inquiry. The response rate in the second survey was 66% (*n*=547).

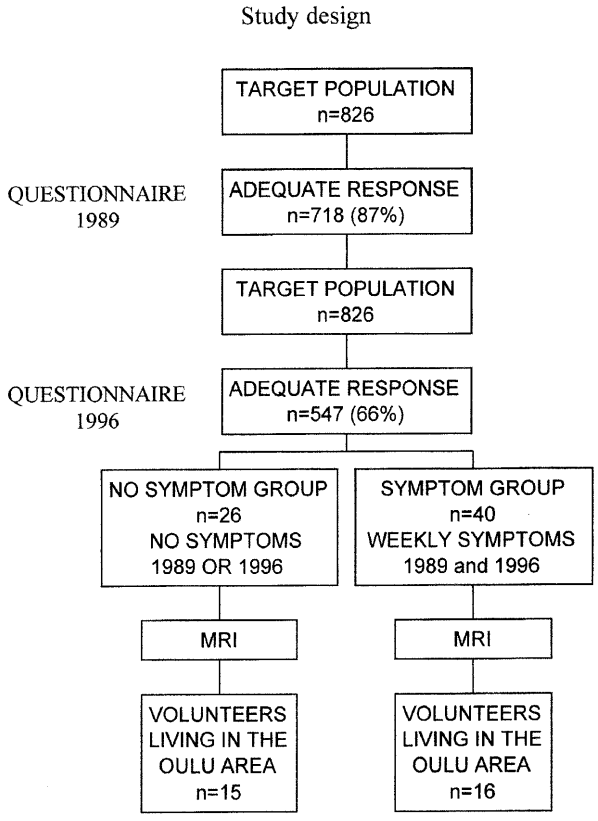

Fig. 1 Study design

Two groups were chosen from the follow-up study for MRI scanning. The first group consisted of the participants who had reported no neck and shoulder symptoms in either of the inquiries (no symptom group=NSG). The other group comprised those who had been suffering from neck and shoulder symptoms once a week or more often at the time of both surveys, in 1989 and 1996 (recurrent or persistent symptom group=SG). According to these criteria, 26 NSG subjects and 40 SG subjects were found. Since the MRI study was carried out in the Oulu University Hospital, participants living outside the Oulu area were excluded, after which the NSG consisted of 23 and SG of 33 subjects. Thirty participants, 15 from each group, were randomly chosen for MRI study. Since one symptomatic participant signed up for the study after the deadline, the final number of SG subjects was 16. Written informed consent was obtained from all subjects.

The MRI study comprised 31 subjects, 24–27 years of age. The NSG comprised 8 female and 7 male subjects (mean age 25.7 years) and the SG comprised 13 female and 3 male subjects (mean age 25.4 years). During their visit for the MRI examination, the participants filled in a pain drawing and questionnaire concerning the frequency, duration, severity, location and inconvenience of their neck and shoulder symptoms. The severity of the neck and shoulder symptoms was estimated on a visual analogue scale (VAS). The mean VAS value for the SG was 38.4 mm, with 13 subjects reporting pain during the past week. In the NSG the mean VAS value was 0 mm.

The imaging was performed with a 1.5-T imaging system (Signa, General Electric, Milwaukee, Wis.) and a standard phased-array spine coil. The imaging consisted of sagittal spin echo (SE) T1-weighted (TR=500 ms, TE=14 ms, 3 excitations average, 256×224 matrix) and sagittal fast spin echo (FSE) T2-weighted

images (TR=4000 ms, effective TE 105 ms, 8 echo train length with 15 ms echo spacing, 3 excitations, 256×224 matrix, 16 kHz bandwith), with a 26 cm field of view (FOV) and 3 mm slice thickness with no interslice gap, and oblique axial SE T1-weighted (TR=500 ms, TE=14 ms, 3 excitations average, 256×224 matrix) and T2*-weighted gradient echo images (GRE) (TR=600 ms, TE=20 ms, flip angle 25°, 3 excitations average, 256×192 matrix) with 22 cm FOV and 4 mm slice thickness with 1 mm interslice gap. The sagittal imaging planes were placed on a prior coronal scout image to cover the whole spine, and the oblique axial image planes, oriented along the plane of the intervertebral discs, were located on a midline T2-weighted sagittal image to cover the planes from the caudal end plate of the C2 vertebra to the cranial end plate of the T1 vertebra. The imaging was approved by the institutional ethical committee.

Two radiologists (O.T., E.I.) assessed the MR images cooperatively through discussion, unaware of the participants' pain history. The MR images were reanalyzed separately by both radiologists for calculation of Kappa coefficients. The morphology of cervical spine was categorized as showing either no anomaly or anomaly. The posture of cervical spine was evaluated as normal, slightly straightened lordosis, straightened or kyphotic. The degrees of disc degeneration, anular tear, herniation and protrusion were assessed separately. The degree of DD was classified by change in signal intensity in sagittal T2-weighted FSE images as follows: 0=normal high signal in the central anulus comparable with cerebrospinal fluid, 1=a decrease in disc signal intensity without other morphological changes, 2=a decrease in signal intensity and end plate osteophyte, and 3=a decrease in signal intensity and disc space narrowing. Anular tear was classified on T2*-weighted oblique axial images as follows: 0=high signal intensity in the central disc only, 1=high-intensity signal extending to the inner anulus area, 2=high-intensity signal extending to the outer anulus area, and 3=herniation. The degree of herniation was classified as: 1=slight, only visible in the sagittal image, 2=herniation filling half of the ventral liquor space in the sagittal and axial directions, 3=herniation reaching out to the spinal cord, 4=herniation reaching out to the spinal cord and classified as contained or non-contained. Protrusion was analyzed in the oblique axial T2*-weighted images as follows: 0=no protrusion, 1=slight protrusion, presented as straightening of the dorsal concave shape of the posterior disc margin, 2=protrusion filling half of the ventral liquor space in the sagittal and axial directions, 3=protrusion reaching out to the spinal cord. The facet joints were analyzed by assessing hydrops, osteophytes and narrowing of cartilage. The muscles of the spinal area were graded as normal or atrophied.

The proportions of DD, anular tear, herniation and protrusion were calculated for the NSG and SG. The results were analyzed by cross-tabulation. A chi-square test and Fisher's exact test were used to determine the statistical significances between proportions. The reliability of the MR images was estimated by Kappa statistics.

Results

Altogether, 186 discs were analyzed on the MR images. No MR image was excluded due to inadequate visibility or artifacts. One anomaly of the cervical spine was found in each study group (a blocked vertebra and a developmental variation of vertebra with lowered sagittal height). The postures of 26 subjects (84%) were evaluated as abnormal, a slightly straightened cervical spine being the most common finding (*n*=12). There were no statistically significant differences in the abnormal posture findings between the SG and the NSG. No abnormal findings were detected in the facet joints or muscles of the spinal area.

Table 1 Subjects with abnormal magnetic resonance imaging (MRI) findings in the no symptom group (NSG) and recurrent or persistent symptom group (SG)

	NSG subjects (*n*=15)	SG subjects (*n*=16)	*P*
Disc degeneration	11	9	0.46
Anular tear	10	8	0.47
Disc protrusion	13	11	0.39
Disc herniation	–	4	0.10
No finding	2	4	0.27

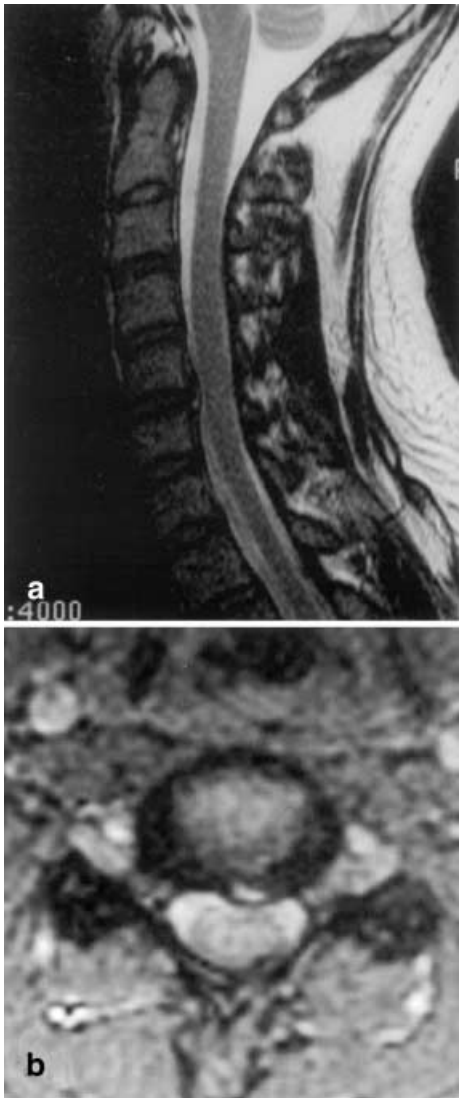

Fig. 2A, B Magnetic resonance (MR) images of a 25-year-old man with weekly neck and shoulder pain. **A** T2-weighted sagittal scan; **B** T2-weighted axial scan. The images show a central herniation at level C5-C6. The herniated disc is also moderately degenerated

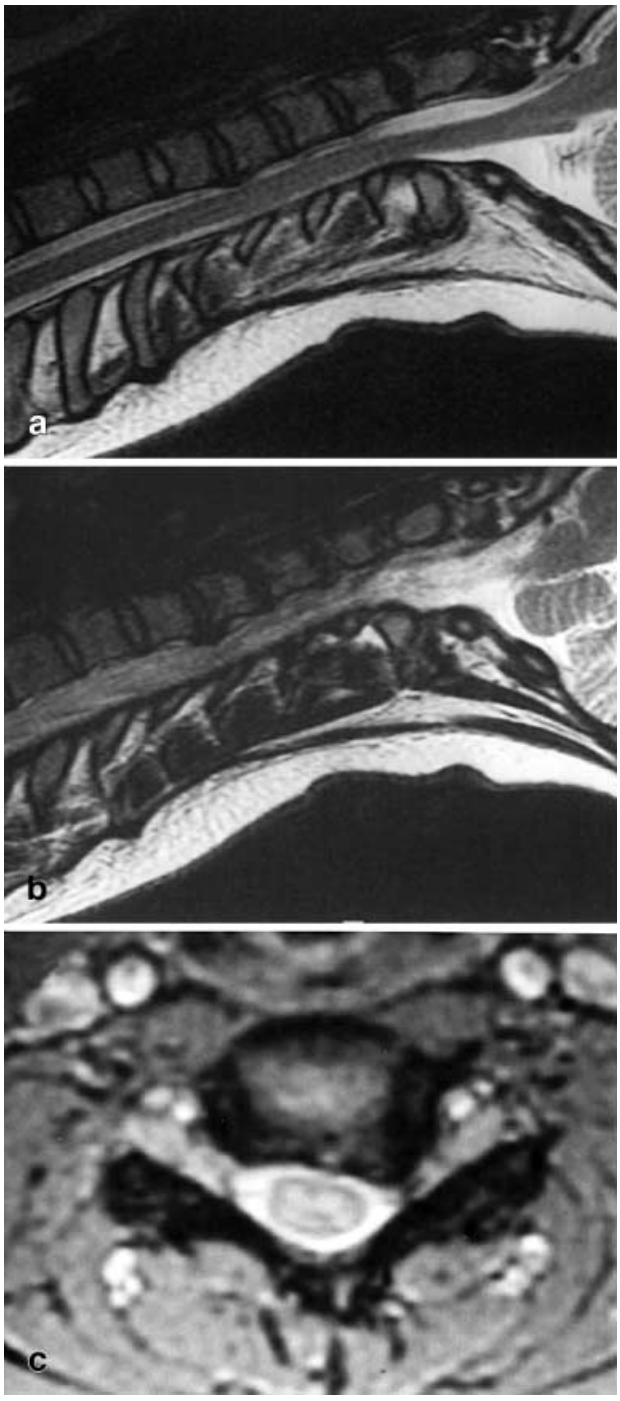

Fig. 3 MR images of a 24-year-old symptomatic woman with central (**A**) and lateral (**B,C**) disc herniation at level C5-C6

The numbers of subjects with abnormal MRI findings are presented in Table 1. The Kappa scores for the two radiologists were 0.67 for DD, 0.44 for anular tears, 0.52 for disc protrusions, and 1.0 for hernias. These show fair to strong agreement. There were four disc herniations visible in the images, all of which were in the SG (Fig. 2, Fig. 3). According to the pain drawing, one of the four subjects suffered from radicular pain in the upper arm. The difference between the study groups in the proportion of herniated discs was statistically significant (Table 2).

Altogether, 46 discs (25%) were degenerated, of which 38 (83%) were classified as slightly degenerated (grade 1) and 8 (17%) as moderately degenerated (grade 2) (Fig. 4). The SG subjects had 20 and the NSG subjects 26 degenerated discs (Table 2). Thirty-two anular tears (17%) were found, of which 21 (66%) were slight, 9 (28%) moderate and 2 (6%) severe. Fourteen of the tears were in the SG and 18 in the NSG. Forty-seven disc protrusions were detected, 37 (79%) of which were classified as slight and 6 (21%) as moderate. The SG subjects had 18 and the NSG subjects 29 disc protrusions.

Discussion

The results showed that pathological changes of cervical spine in a 24- to 27-year-old population were equally common in symptomatic and asymptomatic subjects. Disc herniation was the only finding significantly associated with neck pain. The finding is in agreement with the study by Schellhas et al. [24], in that abnormal MRI findings are also common in asymptomatic subjects. However, Schellhas et al. found pathological findings to be more common in symptomatic participants; 73% of the discs were morphologically abnormal in the pain group. The main interest in their study was to assess the accuracy of MRI and discography in identifying the sources of cervical discogenic pain. The age variation was wider (21–48 years) and the mean age higher (34.1 years) than in our study. The criterion of neck pain was also different, as the participants with cervical symptoms had been suffering from pain for a minimum of 6 months before referral for discography. The classification of abnormalities of cervical spine was analyzed dichotomously as morphologically normal/abnormal. The age variation of the study population and the criterion of neck pain may have caused the discrepancy in the results. As far as we know, no other MRI studies concerning subjects with neck and shoulder pain have been done so far.

All the four disc herniations detected were found in symptomatic subjects, which indicates that possibly only severe pathophysiological changes of discs are associated with neck pain. We could not, however, ascertain the causality between herniation and neck pain in this study.

DD and disc protrusion were the most common abnormalities. The prevalences of DD and disc protrusion were higher than those reported by Lehto et al. [12], who found DD in 3 (14%) of the 21 asymptomatic 20- to 23-year-old young adults. No disc protrusions were detected. Matsumoto et al. [17] also found the prevalence of DD and disc protrusion in a 20- to 29-year-old population to be

Table 2 Proportions of abnormal disc findings on MRI in the NSG and SG

	NSG (*n*=90)		SG (*n*=96)		Total (*n*=186)		*P*-value
	n	%	*n*	%	*n*	%	
Disc degeneration	26	29	20	21	46	24	0.20
Degree 1	19	19	19		38		0.07
Degree 2	7	7	1		8		
Anular tear	18	20	14	15	32	17	0.33
Degree 1	13	13	8		21		
Degree 2	5	5	4		9		
Degree 3	–		2		2		
Disc protrusion	29	32	18	19	47	25	0.03
Degree 1	24		13		37		
Degree 2	5		4		9		
Degree 3	–		1		1		
Disc herniation	–		4	4	4	2	0.05

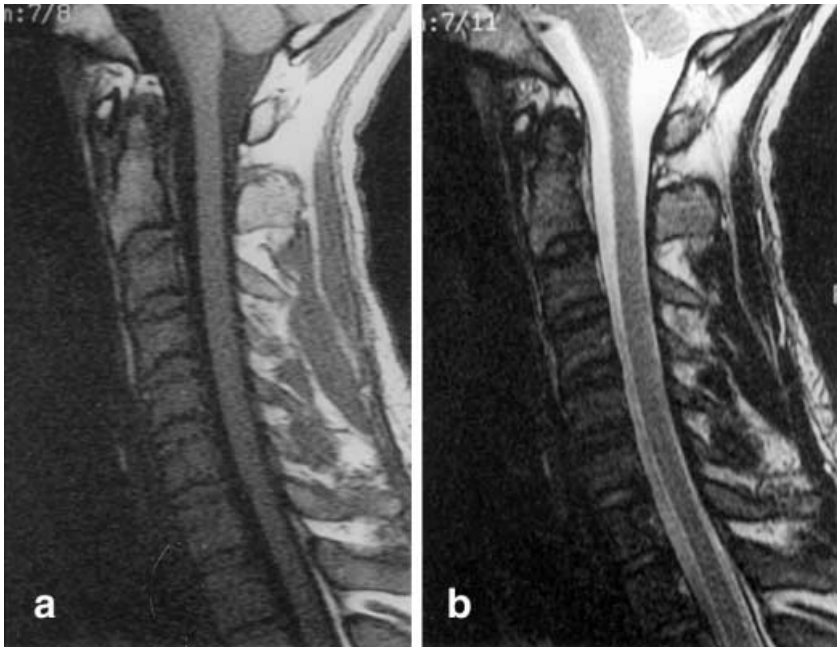

Fig. 4A, B MR images of a 25-year-old asymptomatic man with moderate disc degeneration at level C5-C6 and slight disc degeneration at levels C2-C3, C3-C4 and C4-C5

lower than in our study. Since DD and disc protrusion were more common findings in the NSG than the SG, the difference between the study populations concerning cervical symptoms does not explain the discrepancy between the results. Instead, the difference in the imaging system and the classification of DD and disc protrusion may have caused the different results.

The limitation of the study is the fairly small sample. However, the study groups were carefully selected based on neck pain history. The study groups were originally derived from a large population consisting of 718 high school students. On the basis of the results of the 7-year follow-up survey, we chose subjects at the two extremes of the population for MRI study: a group of subjects who had reported never having had neck and shoulder pain in both surveys and another group of subjects who had reported suffering from neck and shoulder pain at least weekly at both times. Moreover, the remarkable difference in VAS score between the NSG and SG supports the notion of a difference between the study groups as far as neck and shoulder pain is concerned.

In conclusion, pathophysiological changes of cervical spine verified on MRI seem not to explain any remarkable part of the occurrence of neck and shoulder pain in young adults. The results of our study indicate that pathophysiological changes, such as DD and disc protrusion, are surprisingly common findings in cervical spine even among young adults. However, it is possible that only severe

changes are associated with neck and shoulder pain. It seems that other factors, such as a heavy workload, dysfunction of muscle metabolism and psychosocial factors, may also contribute to neck and shoulder pain. Because of the small study sample, the finding has to be considered as preliminary and its findings need to be verified in a larger population.

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