

# Prevalence of annular tears and disc herniations on MR images of the cervical spine in symptom free volunteers

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## Abstract

*Study design:* Prospective MR analysis of the cervical spine of 30 asymptomatic volunteers.

*Objectives:* To evaluate the prevalence of annular tears, bulging discs, disc herniations and medullary compression on T2-weighted and gadolinium-enhanced T1-weighted magnetic resonance (MR) images of the cervical spine in symptom free volunteers.

*Summary of background data:* Few studies have reported the prevalence of cervical disc herniations in asymptomatic people, none have reported the prevalence of cervical annular tears on MR images of symptom free volunteers.

*Materials and methods:* Thirty symptom-free volunteers (no history or symptoms related to the cervical spine) were examined using sagittal T2-weighted fast spin-echo (SE), sagittal gadolinium-enhanced T1-weighted SE imaging and axial T2\*-weighted gradient echo (GRE). The prevalence of bulging discs, focal protrusions, extrusions, nonenhancing or enhancing annular tears and medullary compression were assessed.

*Results:* The prevalence of bulging disk and focal disk protrusions was 73% (22 volunteers) and 50% (15 volunteers), respectively. There was one extrusion (3%).

Eleven volunteers had annular tears at one or more levels (37%) and 94% of the annular tears enhanced after contrast injection. Asymptomatic medullary compression was found in four patients (13%).

*Conclusion:* Annular tears and focal disk protrusions are frequently found on MR imaging of the cervical spine, with or without contrast enhancement, in asymptomatic population. The extruded disk herniation and medullary compression are unusual findings in a symptom-free population.

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*Keywords:* Gadolinium/magnetic resonance (MR); Contrast enhancement/spine, Intervertebral discs/spine; MR

## 1. Introduction

The cervical and lumbar spine are among the first areas of the human body to show demonstrable imaging evidence of degenerative joint disease [1] but the relation between abnormalities in the cervical (and lumbar) spine and neck pain (or low back pain) is frequently controversial.

Annular tears are frequently identified on magnetic resonance (MR) images in patients with neck pain or brachialgia. The annulus fibrosis is innervated by the recurrent meningeal nerve and by the small branches from the ventral ramus of the

somatic nerve [2]. Annular tear, therefore, can be responsible for neck pain or brachialgia.

A history of neckpain or brachialgia can also be related to discogenic pain produced by disc herniation. On the other hand, the high prevalence of disc protrusions in symptom-free populations has been reported in lumbar spine studies (e.g., Stadnik et al. [5], Jensen et al. [3]). The relation between the discovered disk herniation and trauma remains one of the most important problems in insurance claims.

Previous studies [1,4] already reported the prevalence of asymptomatic degenerative disc disease of the cervical spine, however, no attempt was made to categorize the discovered disc herniations. The prevalence of annular tears in the cervical spine of asymptomatic subjects was never reported.

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We examined the prevalence of abnormal findings on magnetic resonance images of the cervical spine in people without neck pain and without history of trauma.

## 2. Materials and methods

Thirty volunteers (20 male and 10 female subjects) aged 19–69 years (median age 44 years) were included in our study. The volunteers were recruited from patients who were referred for head MR imaging and who received injection of contrast material. The declaration of Helsinki principles was followed for the study. Informed consent was obtained from all participants. The inclusion criteria were absence (including the history) of neck pain or cervical radiculopathy. The anamneses and standard questions were obtained from all volunteers in order to exclude the history of cervical pain and/or trauma.

All MR images were obtained with a 1.5-T unit (magnetom Vision; Siemens Medical Systems, Erlangen, Germany). The participants first underwent brain MR imaging with intravenous injection of 0.1 mmol/kg gadopate meglumine (Dotarem; Guerbet, Aulnay-sous-Bois, France), and immediately afterward cervical spine MR imaging.

The following sequences were performed: (a) sagittal gadolinium-enhanced T1-weighted fast spin-echo (SE) sequence (840/12 [repetition time ms/echo time ms], three signals acquired, 3-mm section thickness, echo train length of three 182 × 512 matrix, 130 × 260-mm field of view) performed within 15 min after injection of gadopate meglumine; (b) sagittal T2-weighted fast SE sequence (5500/128, two signals acquired, 3-mm section thickness, echo train length of 23, 180 × 512 matrix, 130 × 260-mm field of view); and (c) axial T2\*-weighted GRE sequence (680/25.8, two signals acquired, 4-mm section thickness, echo train length of 23, 154 × 256 matrix, 120 × 160 mm field of view) with seven slabs parallel to the disks at the level of pathological findings discovered on sagittal T2, T1 weighted SE images.

All images were interpreted by two experienced neuroradiologists (T.W.S., E.P.). When disagreement arose as to the presence or absence of pathologic findings, a third neuroradiologist (C.E.) adjudicated.

An annular tear was defined as a focal hyperintensity of the annulus on the T2-weighted SE image or on the gadolinium-enhanced T1-weighted SE image, or on both images, without focal protrusion or extrusion. The extension of the abnormal signal through the annuloligamentous complex was also evaluated for each discovered annular tear.

For bulging, protrusion and extrusion the classification introduced by Jensen et al. [3] was used. Bulging was defined as circumferential symmetric extension of the disk beyond the end plates. Protrusion was defined as focal or asymmetric protrusion of the disk beyond the end plates but in connection with the parent disk and with the base of protrusion (measured on axial images in our study) broader than any other dimension. Extrusion was defined as focal protrusion of the

disk beyond the endplates without connection with the parent disk or in connection with the parent disk but with the base of protrusion (measured on axial images in our study) narrower than the diameter of the protrusion itself.

Degeneration of a disk was graded as mild: hypointense nucleus pulposus on T2-weighted images or severe: hypointense nucleus pulposus with narrowing of the disk space.

The criteria for medullary compression were obliteration of the subarachnoidal space associated with change of form or position of the spinal cord.

## 3. Results

### 3.1. Annular tears

The prevalence of annular tears in our population of asymptomatic volunteers was 36.7% (i.e., 11 of 30 patients had annular tears [ $n = 18$ ] at one or more levels). Of 18 tears in 11 volunteers, two (11%) were located at the level C3–C4, two (11%) at the C4–C5 level, nine (50%) at the C5–C6 level and five (28%) at level C6–C7. The higher levels were not involved.

Only one (16.7%) of the six volunteers aged 30 years or younger had an annular tear. The prevalence of annular tears increased with age (Table 1) although a decrease was seen at the age of 61 and older with one only of the three volunteers (33%) having an annular tear.

Contrast material enhancement (generally faint and localized) in the central part of the annular tear (Fig. 1) was recognized in 17 (94%) of the 18 discovered annular tears (30 volunteers). In six cases (33%) the annular tears were recognised only after Gd-injection (no hyperintensity on T2 weighted SE images).

### 3.2. Bulging disk

The prevalence of bulging disk in our sample of volunteers was 73% (i.e., 22 of 30 volunteers had bulging of the disk at one or more levels).

Three (50%) of the six volunteers aged 30 years or younger already showed at least one annular bulge. Still there was a fairly marked increase in prevalence with age (Table 1); all 12 volunteers older than 45 years had at least one bulging disk.

In total, 42 bulging disks were found in 22 volunteers. The C5–C6 disk space was involved in 14 cases (33%), C6–C7 in 11 cases (26%), C4–C5 in 9 cases (21%) and the other levels were involved in 8 cases (20%).

### 3.3. Disk herniation

#### 3.3.1. Protrusion

Protrusions were also frequently found in our population of asymptomatic volunteers (i.e., 15 [50%] of the 30 volunteers had at least one protrusion).

Table 1  
On MR images in an asymptomatic population ( $n = 30$ ) as a function of age

Population (years)	Number of volunteers with one or more			
	Annular tears	Bulging discs	Protrusions	Severe degeneration of one or more discs
<31	1/6 (17)	3/6 (50)	2/6 (33)	1/6 (17)
31–45	4/12 (33)	7/12 (33)	5/12 (42)	1/12 (8)
46–60	5/9 (56)	9/9 (100)	7/9 (78)	5/9 (56)
>61	0/3 (0)	3/3 (100)	1/3 (33)	3/3 (100)
19–69	10/30 (33)	22/30 (73)	15/30 (50)	10/30 (33)

Note: Data are the number of volunteers with at least one disorder (annular tear, bulging disc, protrusion or severe degeneration of at least one disc)/total number for a given age group. Numbers in parentheses are percentages.

The frequency of protrusions increased as a function of age upto 60 years (Table 1). In total, 22 protrusions were found in 20 volunteers. Fifteen protrusions (68%) were lateralised (left or right) (Fig. 2) and seven (32%) were median protrusions.

The disk space C5–C6 was involved in seven cases (32%), C3–C4 in six cases (27%), C4–C5 in five cases (23%) and the other levels in four cases (18%).

### 3.3.2. Extrusion

One extrusion (3.3%) was found at level C5–C6 in a 43 years old volunteer. This extrusion was lateralised to the right and presented as a small retrocorporeal migration of disc material (disc C5–C6) on sagittal T2-weighted and sagittal T1-weighted images and as a small hyperintens mass on axial T2\*-weighted images (Fig. 3).

### 3.4. Disk degeneration

The different stages of disk degeneration are very frequently found in an asymptomatic population. Mild disk degeneration was found in three (50%) of the six volunteers aged 30 years or younger, in eight (75%) of the 12 volunteers

aged 31–45 years and in 12 (100%) of the 12 volunteers older than 45 years.

Severe disk degeneration (defined by hypointense nucleus pulposus and narrowing of the disk height) was found in only one (16.6%) of the six volunteers aged 30 years or younger, and also in one (8.3%) of the 12 volunteers aged 31–45 years; this prevalence increases to 55.5% (five of the nine volunteers) in those between 46 and 60 years and than to a 100% (three of three) in those older than 60 years (Table 1).

### 3.5. Medullar compression

The prevalence of medullar compression in our sample of volunteers was 13.3% (i.e., 4 of 30 volunteers). One (8.3%) of the 12 volunteers between 31 and 45 years and three (33.3%) of the nine volunteers between 46 and 60 years had radiological signs of medullar compression (obliteration of the subarachnoidal space associated with change of form or position of the spinal cord, Fig. 4). There was no abnormal signal on T2 weighted SE or abnormal enhancement on T1 weighted SE of the spinal cord in these cases.

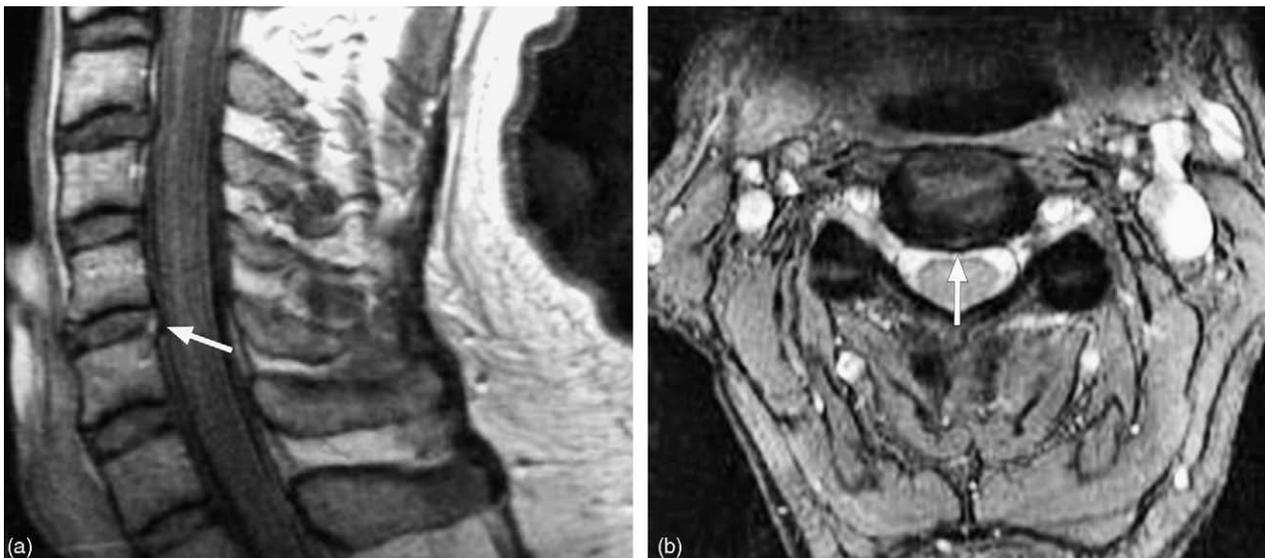


Fig. 1. Sagittal (a) gadolinium-enhanced T1-weighted fast SE and axial (b) T2\*-weighted GRE images in an asymptomatic volunteer show an annular tear (arrow) without clear protrusion.

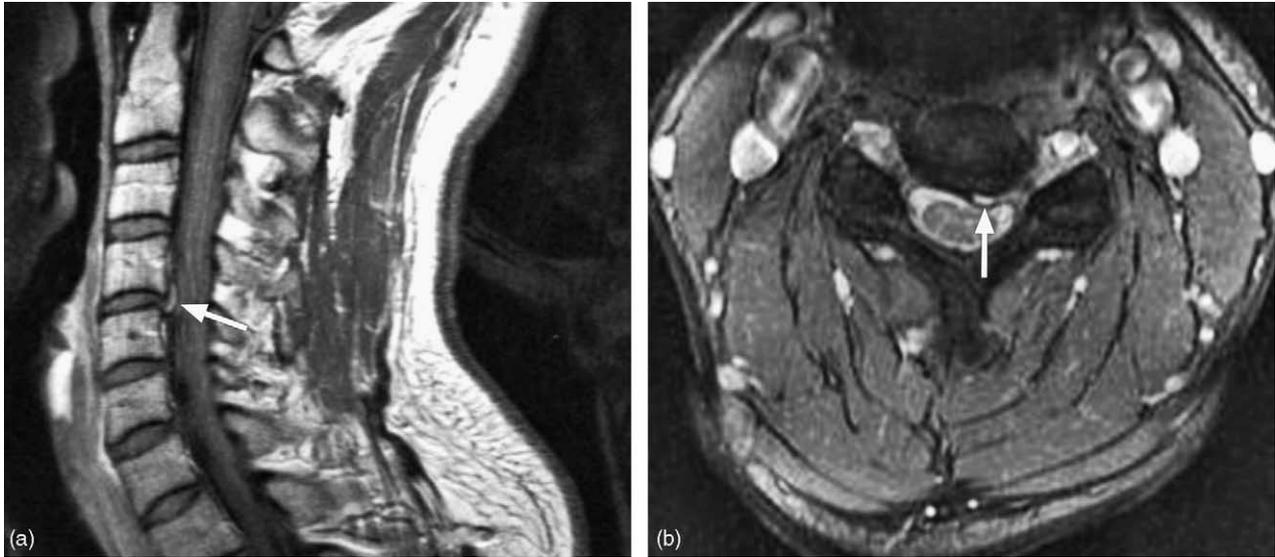


Fig. 2. Sagittal (a) gadolinium-enhanced T1-weighted fast SE and axial (b) T2\*-weighted GRE images in an asymptomatic volunteer classified as a focal protrusion at C4-5 (arrow) that appears hyperintense with both sequences.

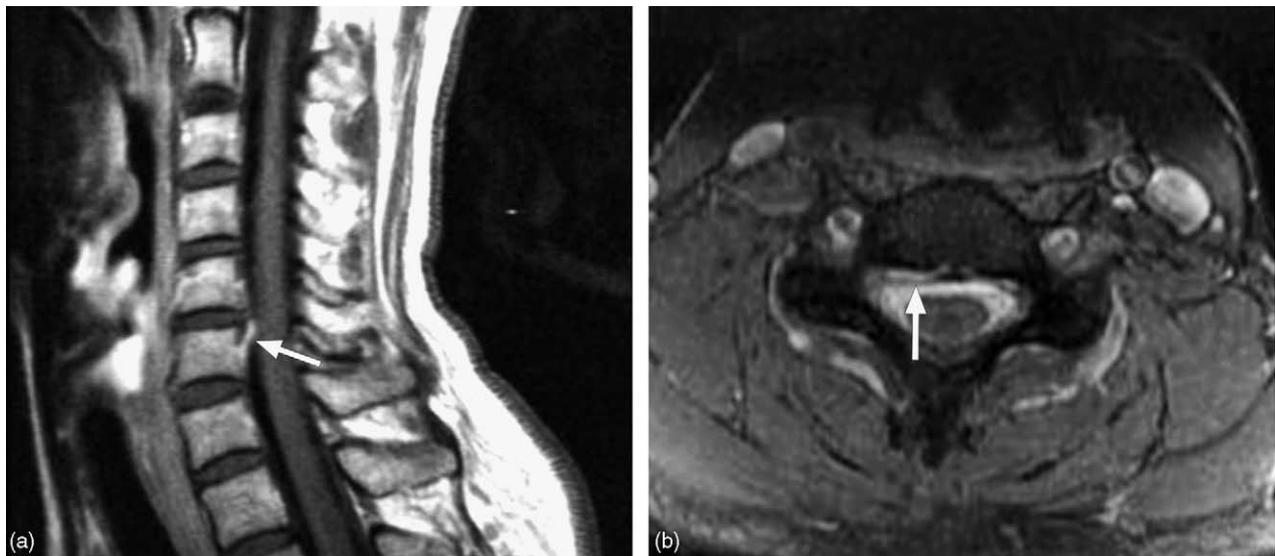


Fig. 3. Sagittal (a) gadolinium-enhanced T1-weighted fast SE and axial (b) T2\*-weighted GRE images in an asymptomatic volunteer show a small retrocorporal migration of disc material at C5-6 (arrow) that appears hyperintense with both sequences.

## 4. Discussion

### 4.1. Annular tears

The prevalence of annular tears in the cervical spine of asymptomatic subjects was never reported. On the other hand, the prevalence of annular tears in the lumbar spine of the symptom free population was reported on post-mortem studies or using MRI [6,3,5].

The reported prevalence of posterior radial tears at autopsy in asymptomatic people is 40% for those between the ages of 50 and 60 years and 75% for those between 60 and 70 years [6].

Jensen et al. [3] found 14% of annular defects (disruption of the outer fibrous ring of the disc) in 98 asymptomatic volunteers examined with axial and sagittal T1-weighted images and sagittal T2-weighted images.

Stadnik et al. [5] examined 36 asymptomatic volunteers with sagittal and axial T2-weighted images and sagittal gadolinium-enhanced T1-weighted images and found 28 annular tears (focal intensity of the annulus on the T2-weighted images or/and on the gadolinium-enhanced T1-weighted image) in 20 patients (56%).

In our asymptomatic population we also found a relative high prevalence (11 [37%] of 30 volunteers) of one or more hyperintense annular tears on T2-weighted images.

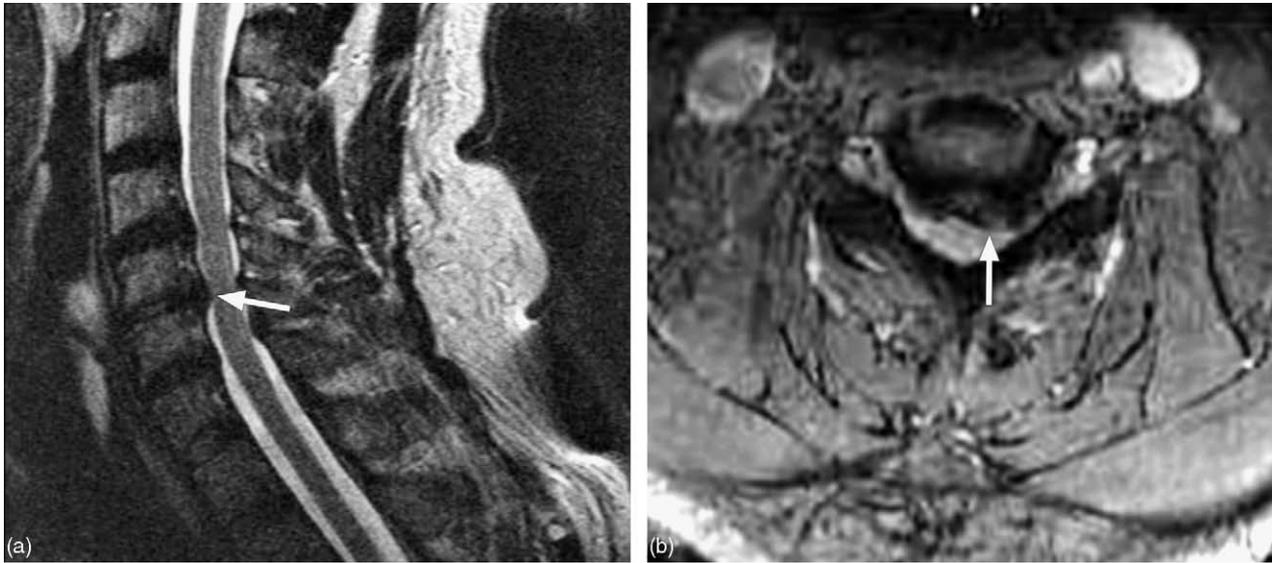


Fig. 4. Sagittal (a) T2-weighted fast SE and axial (b) T2\*-weighted GRE images in an asymptomatic volunteer show important degenerative changes with obliteration of the subarachnoid space at C5–6 (arrow).

The incidence of annular tears in our population was relatively similar to that seen in lumbar spine by Stadnik et al. with exception for the age-group of 61 years and older where the incidence is remarkably lower in our study (33% in our study, 100% in the study of Stadnik et al.). The small amount of volunteers, only three, in this age group could be a possible reason for this discrepancy.

Enhancement of annular tears is frequently found in symptomatic patients with neck pain or brachialgia. In our study, contrast enhancement in the central part of the annular tear was recognized in 94% of the 18 discovered annular tears (96% in the study of Stadnik et al.). Therefore, the discovery of this sign in symptomatic patients is likely to be an incidental finding.

The abnormal hyperintensity on T2 SE or contrast-captation on T1 weighted SE in the outer fibers of the annuloligamentous complex was never discovered in the 18 annular tears. Therefore, this finding, if present, may be more closely correlated with symptoms. However, this remains speculative.

#### 4.2. Bulging disc

Seventy-three percent of our asymptomatic patients had symmetrical central bulging (non-herniated) discs. The prevalence of disc bulges increased with age, up to a 100% in the volunteers aged 46 years and older.

Jensen et al. [3] also reported an increasing prevalence of disk bulging with age in the lumbar spine of an asymptomatic population.

Stadnik et al. [5] and Boden et al. [7] reported an erratic prevalence of bulging in the lumbar spine as a function of age (Stadnik et al.: 100% and 80% in the 46–60 years and >60-year age groups, respectively; Boden et al.: 54% and 50% in

the 20–39 years and 40–59-year age groups, respectively). Our results agree with the previously reported frequency of bulging disc in an asymptomatic population by Jensen et al. [3].

#### 4.3. Disc herniation

##### 4.3.1. Protrusion

For definition of disc herniation we used the classification introduced by Jensen et al. This definition was used in previous studies dealing with this subject and the comparison with our data is more consistent. We also found a high prevalence (50%) of protrusions in our 30 asymptomatic volunteers. The previously discussed significant correlation between age and the prevalence of bulging disc is less clear for protrusion. Since protrusions are less common than bulges, a larger study is needed to assess the possibility of similar association between age and protrusions.

Our results confirm previously reported prevalence of protrusions [1,4] in the cervical spine of asymptomatic populations. Healy et al. [1] reported a 63% prevalence of protrusions in the cervical spine of asymptomatic older male lifelong athletes. Teresi et al. [4] study revealed 20% of patients aged 45–54 years and 57% of patients older than 64 to have cervical disc protrusion (identification of protruded disc material beyond the posterior vertebral line). In these studies no attempt was made to categorize the discovered disc herniations.

##### 4.3.2. Extrusion

In our population, we found only one (3%) extruded disc in a 43 years old asymptomatic volunteer. These findings may support the hypothesis that the prevalence of extrusions is substantially lower in people without symptoms and

that extruded disc herniations are much better correlated with neckpain and radiculopathy than protrusions.

## 5. Conclusion

An asymptomatic population demonstrates a high (37% in our study) prevalence of annular tears on MR-images. In our study, the contrast enhancement in the central part of the annular tear was recognized in 94% of the 18 discovered annular tears. Therefore, the discovery of this sign in symptomatic patients is likely to be an incidental finding.

The enhancement of the outer annuloligamentous complex was not seen in our study and on T2-weighted images this complex was never interrupted. Therefore, the lesions involving completely the annuloligamentous complex may be more closely correlated with neckpain or brachialgia. This remains speculative, however, and needs to be studied further.

Our results confirm previously reported prevalence of bulging discs (73%) [3] and protrusions (50%) in a asymptomatic population [1,4].

In our population, we found only one (3%) extruded disc. These findings may support the hypothesis that extruded discs are well correlated with neckpain or brachialgia but need further investigation.

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