MRI evaluation of the characteristics of the cervical spine intervertebral disc in subjects with and without minor vertebral contusion.

Poster No.:	C-1992
Congress:	ECR 2018
Type:	Scientific Exhibit
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Keywords:	Musculoskeletal spine, MR, Diagnostic procedure, Hernia
DOI:	10.1594/ecr2018/C-1992

Aims and objectives

To determine the magnetic resonance imaging (MRI) characteristics of normal and pathologic cervical discs and adjacent vertebral bodies in young patients with non-traumatic cervical pain and patients who suffered from a minor vertebral contusion.

Methods and materials

Cervical spine MRI examinations of patients with neck pain without trauma (n=86) and after a minor trauma (n=506) were investigated (Table 1 on page 4). Investigated parameters were: Modic changes, uncovertebral joint arthrosis, disc herniation, annular fissures, high intensity zones (HIZs), the position of the center of the nucleus pulposus, disc height, signal intensity of the nucleus pulposus (Table 2 on page 5 , Fig. 1 on page 4).

Images for this section:

Non-trauma group	Trauma group
86 patients	506 scans / 283 patients
38 men / 48 women	168 men / 115 women
Mean age: 27,4 y	Mean age: 41,5 Y
Range 18-36 y	Range 13-80 y

Table 1: Characteristics of the trauma and non-trauma group.

Fig. 1: Mid-sagittal T2-weighted image of the cervical spine with measurements of the disc height and signal intensity of the nucleus pulposus.

	Finding	Details
Vertebral body	Modic changes	Type I, II or III or combination
	Uncovertebral joint arthrosis	Left / right / bilateral
Disc space	Extrusion or protrusion	Location is described (median, paramedian, foraminal, extraforaminal, sequestration)
	Annular fissures	Presence or absence of fissures and HIZs
	Position of the NP	Anteriorly / middle / posteriorly
Other	Scoliosis	Presence or absence and side of the convexity

Table 2: Overview of the different recorded parameters. NP: nucleus pulposus, HIZ: high intensity zone.

Results

Signal intensity of the nucleus pulposus

In the non-traumatic group (age 18-36 y) the SI of the NP decreased at all levels with increasing age (Fig. 2 on page 10). This finding was significant at levels C2-C3, C6-C7 and C7-T1.

In the trauma group, the SI of the NP decreased significantly at all levels with increasing age.

Literature supports that disc dehydration and degeneration is common in young and asymptomatic patients [1-4].

Disc height

In the non-traumatic group, the height of the disc space increased from C2-C3 to C6-C7, with exception of C3-C4, which was higher than C2-C3 and C4-C5. C7-T1 was lower than C6-C7. The mean height of C5-C6 and C6-C7 was higher than in the trauma group.

In the trauma group, the mean height of the disc space was the lowest at C5-C6. The disc space between C3 and C4 was higher than C2-C3 and C4-C5 (Fig. 3 on page 10).

The height of the discs decreased significantly with increasing age at levels C5-C6 and C6-C7 and we reported a higher disc space at level C5-C6 and C6-C7 in the younger non-traumatic group compared to the trauma group. This can be explained by the fact that degeneration sets in first at level C5-C6 [4-7].

Annular fissures and HIZ

Of 3036 reviewed discs in the trauma group, 340 (11.20%) had an annular fissure or HIZ. Annular fissures were most present at level C5-C6 and C6-C7 (Table 3 on page 10). HIZs were most prevalent at levels C4-C5 and C5-C6.

All HIZ were found at the caudal part of the annulus (Fig. 4 on page 11). This could be due to traction forces, which are stronger at the caudal part of the annulus in a hyperflexion trauma.

Discs with HIZs had a higher mean height than discs without HIZs in the trauma group (not significant). This may suggest that discs can tear first and degenerate later. This does not exclude that sometimes discs dehydrate without fissure of the annulus. It can also raise the question whether higher discs are more susceptible for annular fissures.

Herniation

In the trauma group, an extrusion was present in 9.4% of all discs and in 117 (41.34%) patients at the time of their first scan. Protruded and extruded discs were most prevalent at level C5-C6 and C6-C7. Paramedian extrusions occured most frequently (64.5%), followed by median extrusions (24.4%), foraminal extrusions (9.8%) and sequestrations (1.3%) (Table 3 on page 10 , Fig. 5 on page 12).

The database contained 6 cases without extrusion or protrusion on the first MRI examination after the trauma, and in which a disc extrusion developed between 2 and 107 months after the trauma.

We are to our knowledge the first to report that the height of extruded discs was not significantly different compared to discs without extrusion. We assume the volume of expulsed content in an extruded disc is too low to provoke a decrease in height.

There was no relation between scoliosis and the location of an extrusion. Out of 13 patients, 46.15% had an extrusion at the side of the convexity of their scoliosis, 30.77% had an extrusion at the concave side and 30.77% had a median extrusion. It is our opinion that in scoliosis the extrusion can occur at the convex part where extrusion forces might be higher but can also occur at the concave part where compression forces may extrude the nucleus pulposus.

Sixteen patients (18 imaging studies, some patients had multiple follow-up imaging studies) (age: 26-55y), representing 6.27% of all extruded discs, showed volume decrease of the extruded part of the disc (Fig. 6 on page 12). In only 4 patients (age: 40-49y) there was a complete resorption of the extruded part .

Modic changes in adjacent vertebrae

In the trauma group, Modic changes were most prevalent at level C5-C6 and C6-C7 (Table 3 on page 10 , Fig. 7 on page 13).

The height of discs with adjacent Modic I changes was significantly lower at levels C3-C4 and C6-C7 compared to discs without Modic I changes. The height of discs with adjacent Modic II changes was significantly lower at levels C4-C5 and C5-C6 compared to discs without Modic II changes.

We found a lower disc height in adjacent Modic I and II changes than without Modic changes. Two studies [8, 9] described a correlation between Modic changes and

degeneration but to the best of our knowledge, no other study performed precise measurement of disc height in patients with Modic changes.

The age of the patients with Modic changes (mean= 43.9y) was significantly higher than patients without Modic changes (mean= 41.5y).

Uncovertebral arthrosis

In the trauma group, uncovertebral arthrosis was most prevalent at levels C5-C6 and predominantly bilaterally (Table 3 on page 10).

The age of patients with uncovertebral arthrosis (mean= 44.6y) was significantly higher than those without uncovertebral arthrosis (mean= 39.7y).

The height of the disc with uncovertebral arthrosis was lower than without uncovertebral arthrosis at all levels and significant at levels C3-C4 to C6-C7. To our knowledge, no other study ever measured disc height on MRI imaging in the presence of uncovertebral arthrosis and our finding can be explained by frequent combination of disc degeneration and uncovertebral arthrosis [10, 11].

Position of the nucleus

In both non-traumatic and trauma group, the most prevalent position of the center of the nucleus pulposus was in the middle at all levels. At levels C2-C3 and C3-C4, the second most prevalent position was posteriorly to this middle point and anteriorly at the other levels (Fig. 8 on page 14).

We did not encounter any study describing the position of the center of the nucleus in the cervical spine. Our study revealed minor cervical trauma does not influence the position of the center of the NP.

Images for this section:

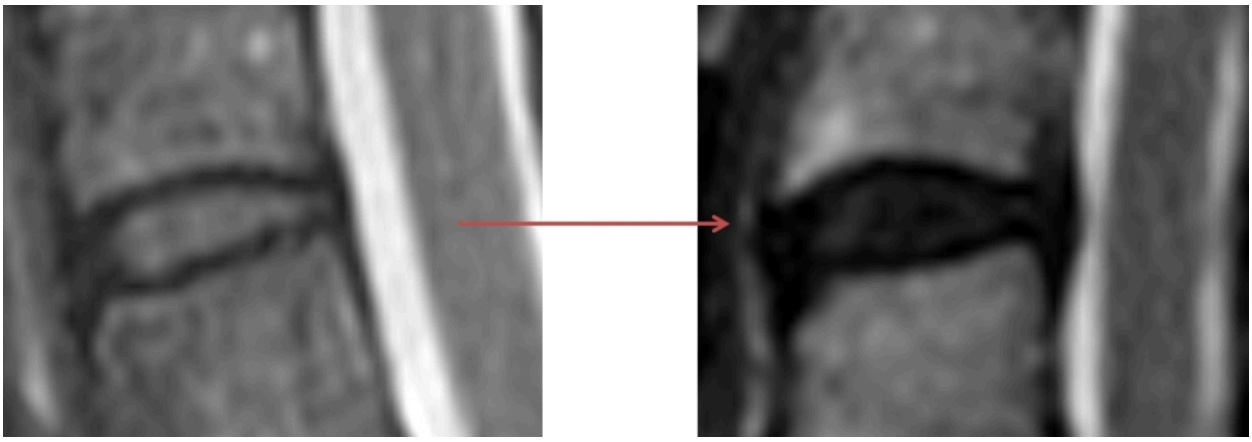

Fig. 2: a) Hydrated disc. b) Dehydrated disc. Sagittal T2-weighted images.

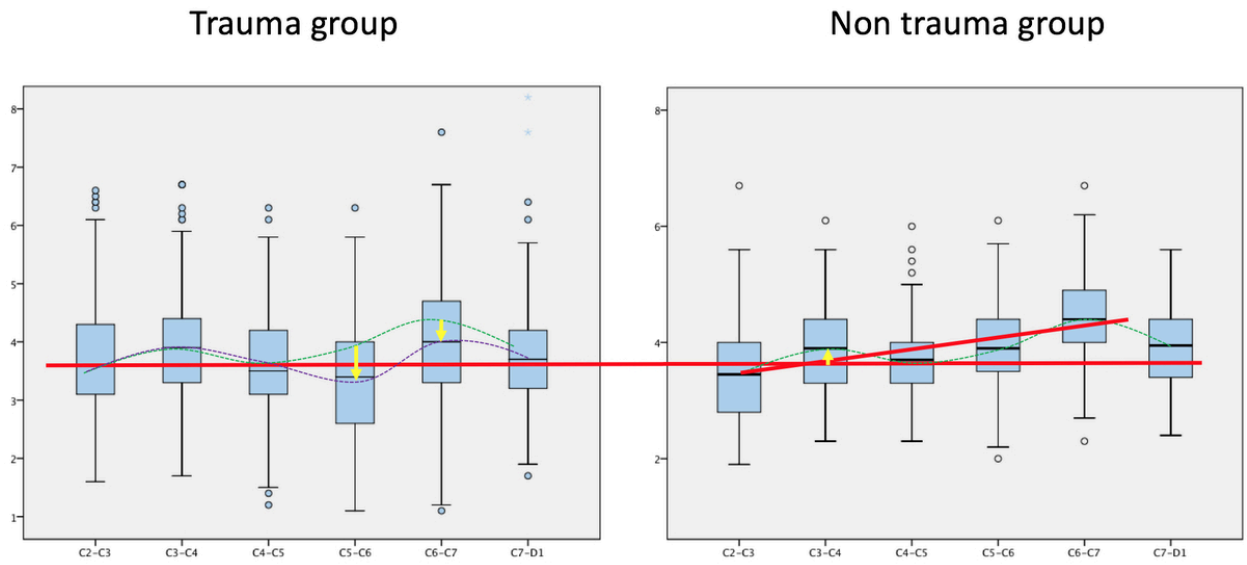

Fig. 3: Mean disc height in the trauma group (left) and the non-traumatic group (right). The height of the disc space increased from C2-C3 to C6-C7, with exception of C3-C4, which was higher than C2-C3 and C4-C5 (green line). In the trauma group level C5-C6 is lower due to degeneration (purple line).

		C2-C3 N (%)	C3-C4 N (%)	C4-C5 N (%)	C5-C6 N (%)	C6-C7 N (%)	C7-T1 N (%)	*Total N*
AF and HIZ	Fissure	2 (0.4%)	28 (5.5%)	54 **(10.7%)**	149 **(29.5%)**	76 **(15.0%)**	2 (0.4%)	311
	HIZ caudally		1 (0.2%)	12 (2.4%)	12 (2.4%)	3 (0.6%)		28
Protrusion		1 (0.2%)	28 **(5.5%)**	37 **(7.3%)**	43 **(8.5%)**	42 **(8.3%)**		*151*
Extrusion		**2 (0.4%)**	**25 (5%)**	**49 (9.7%)**	**136 (26.8%)**	**73 (14.4%)**	**2 (0.4%)**	287
	Median		11 (2.2%)	22 (4.3%)	27 (5.3%)	10 (2.0%)		*70*
	Foraminal right			1 (0.2%)	4 (0.8%)	9 (1.8%)		*14*
	Foraminal left			3 (0.6%)	9 (1.8%)	2 (0.4%)		*14*
	Paramedian right	2 (0.4%)	11 (2.2%)	14 (2.8%)	53 **(10.5%)**	26 **(5.1%)**	2 (0.4%)	*108*
	Paramedian left		3 (0.6%)	9 (1.8%)	41 **(8.1%)**	24 **(4.7%)**		*77*
	Sequestration				2 (0.4%)	2 (0.4%)		*4*
Modic changes	Modic I		6 (1.2%)	2 (0.4%)	32 **(6.3%)**	17 **(3.4%)**	2 (0.4%)	59
	Modic II			3 (0.6%)	18 **(3.6%)**	6 **(1.2%)**		27
	Modic III			2 (0.4%)	3 (0.6%)			5
	I and II				3 (0.6%)	2 (0.4%)		5
Uncovertebral arthrosis	Bilateral	3 (0.6%)	35 (6.9%)	41 (8.1%)	112 **(22.1%)**	72 **(14.2%)**		263
	Right	5 (1.0%)	22 (4.3%)	12 (2.4%)	29 (5.7%)	13 (2.6%)		81
	Left		7 (1.4%)	10 (2.0%)	30 (5.9%)	11 (2.2%)		58

Table 3: Prevalence of annular fissures (AF), high signal intensity zone (HIZ), protrusion, extrusion, Modic changes and uncovertebral arthrosis in the cervical spine.

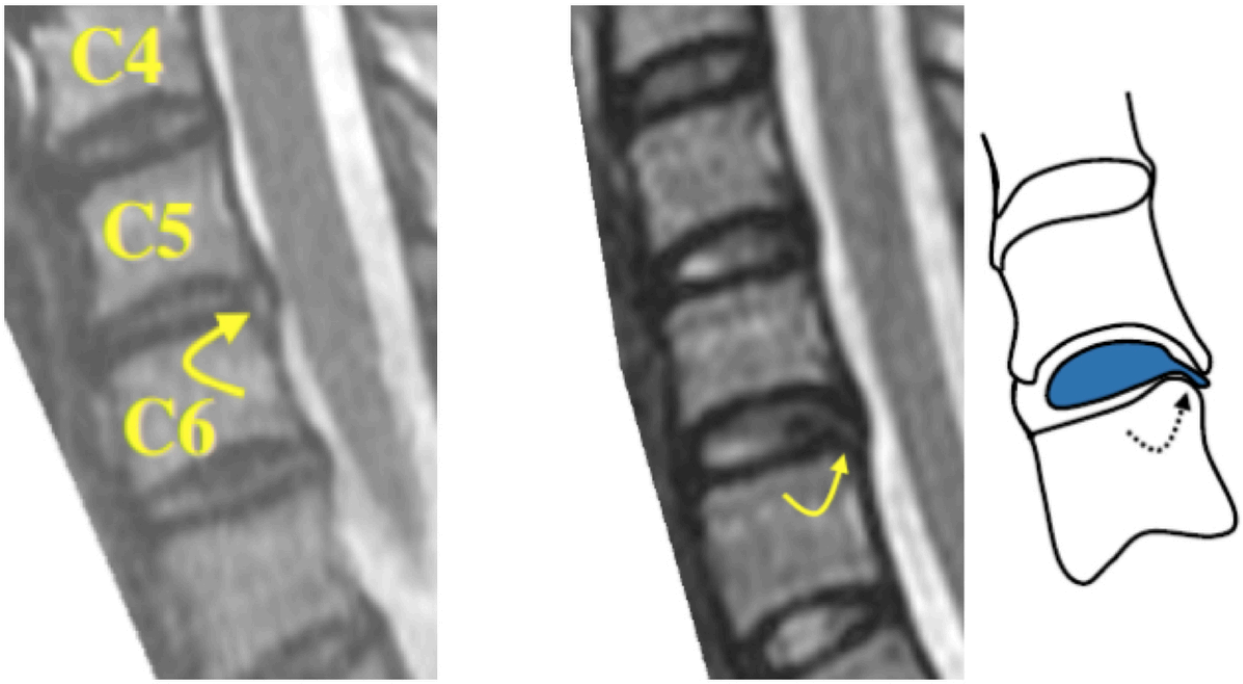

Fig. 4: a) HIZ at level C5-C6 b) Annular fissure at level C6-C7. Sagittal T2-weighted images.

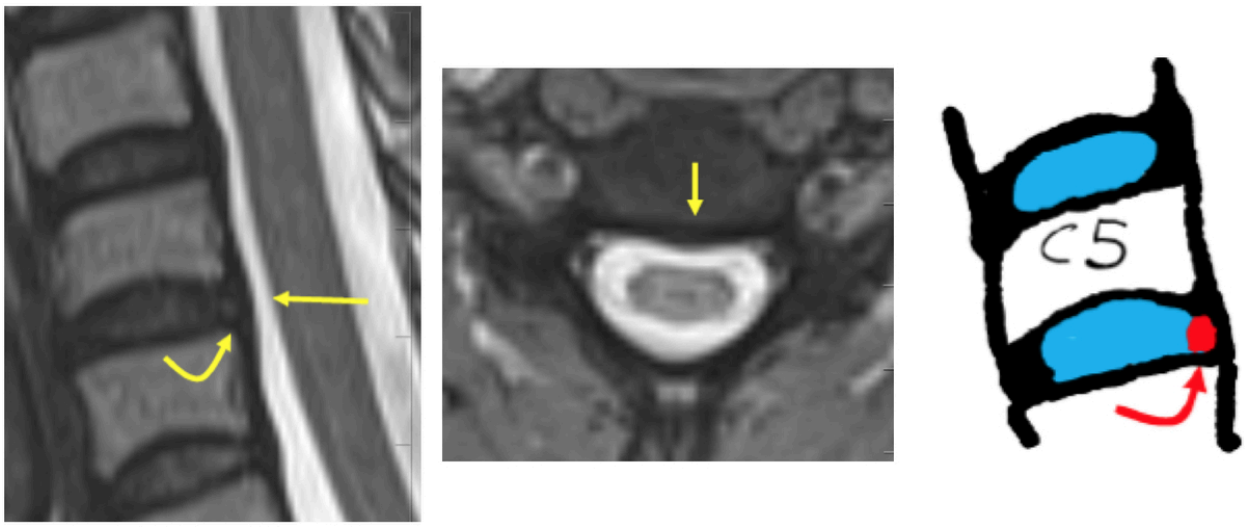

Fig. 5: Median protrusion at level C5-C6. Axial and sagittal T2-weighted images.

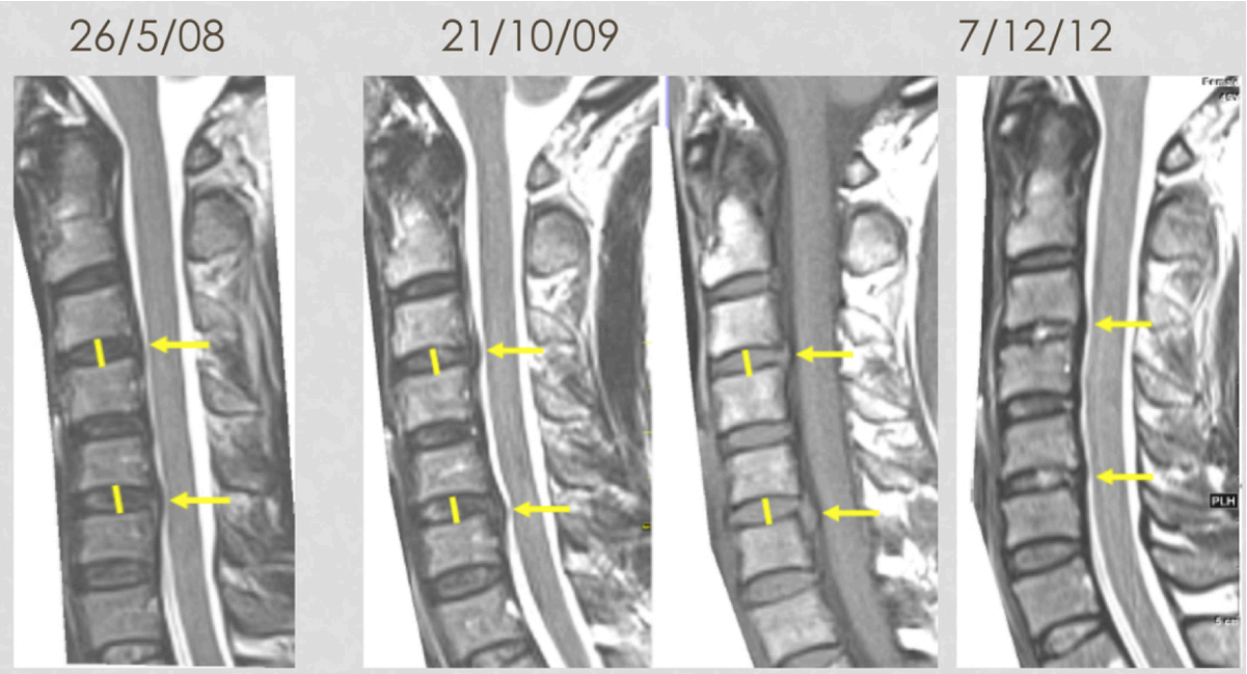

Fig. 6: Evolution of a herniated disc at level C3-C4 and C5-C6 over several years.

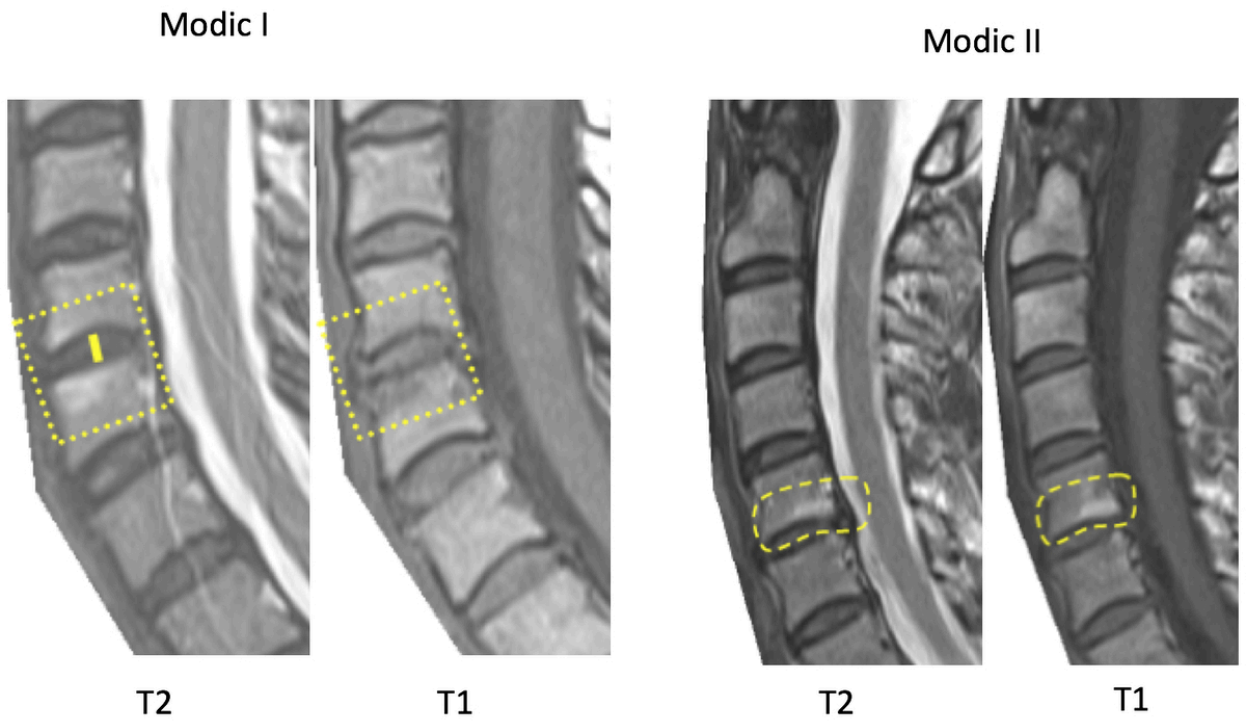

Fig. 7: a) Modic I. b) Modic II. Sagittal T2-weighted and T1-weighted images.

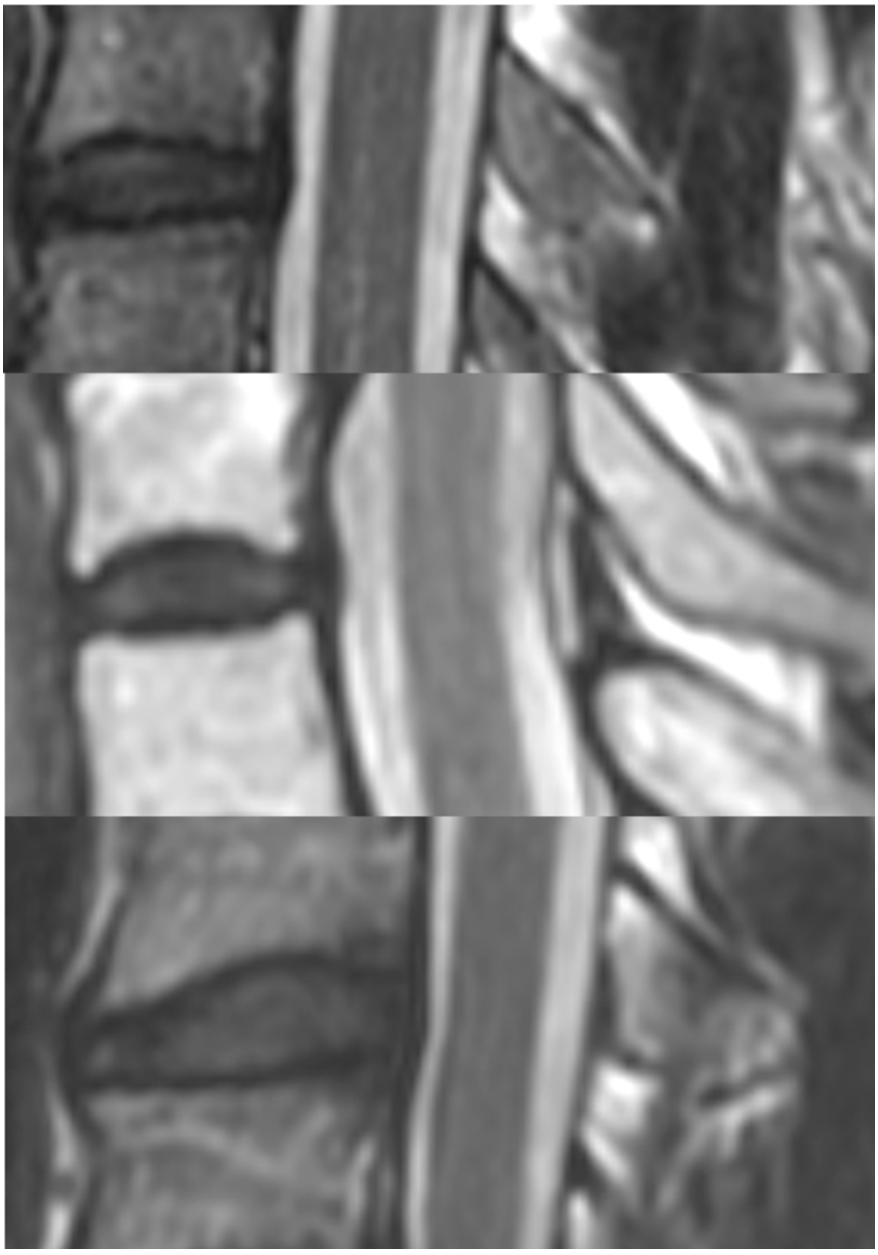

Fig. 8: a) Anterior position of the center of the nucleus pulposus, b) Median position of the center of the nucleus pulposus, c) Posterior position of the center of the nucleus pulposus.

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Conclusion

We found previously unreported findings:

- All HIZs are present at the caudal part of the annulus
- Discs with a HIZ have no reduced height
- There is no correlation between scoliosis and the location of extrusions
- Discs with uncovertebral arthrosis or adjacent Modic changes have reduced height
- Extrusion does not influence the disc height
- Minor cervical trauma has no influence on the position of the center of the nucleus pulposus

We also confirm previously published findings:

- The signal intensity of the nucleus pulposus decreases with aging, even in young and healthy patients
- Degenerative pathology is most prevalent at level C5-C6.

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