# Degenerative marrow (modic) changes on cervical spine MRI scans: prevalence, inter- and intra-examiner reliability and link to disc herniation

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Abstract: ABSTRACT: Study Design. A prevalence and reliability study of Modic changes in the cervical spine.Objective. To assess the prevalence and reliability of diagnosing and classifying Modic changes and their relationship to disc herniations in the cervical spine.Summary of Background Data. Degenerative marrow (Modic) changes in the spine can be seen on MRI with some evidence linking them to pain. Many studies have been published on Modic changes in the lumbar spine, but only 1 small prevalence study focusing on Modic changes in the cervical spine has been reported.Methods. The cervical MRI scans of 500 patients over the age of 50 were retrospectively evaluated for the prevalence, type and location of Modic changes and disc herniations. 200 of these same scans were independently analyzed by a second observer to evaluate interobserver reliability of diagnosis with 100 re-evaluated by the same observer 1 month later to assess intraobserver reliability. The SPSS program and Kappa statistics were used to assess prevalence and reliability. The risk ratio comparison of DH and MC was calculated.Results. 426 patients (85.2 %) met the inclusion criteria. Modic changes were observed in 40.4% of patients (14.4% of all motion segments). 4.3% were type 1 and 10.1% were type 2. Disc herniations were seen in 78.2% of patients (13.3% of motion segments). Both MC and DH were most frequently observed at C5/6 and C6/7. Disc extrusions were positively associated with MC (RR = 2.4). The reliability demonstrated an upper moderate interobserver (k = 0.54) and an almost perfect intraobserver agreement (k = 0.82).Conclusions. A high prevalence of Modic changes was observed with type 2 predominating. The C5/6 and C6/7 levels are most effected. Patients with MC are more likely to have a disc herniation at the same level. MC type 2 predominates. The classification is reliable.

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# Degenerative Marrow (Modic) Changes on Cervical Spine MRI Scans: Prevalence, Inter- and Intra-examiner Reliability and Link to Disc Herniation.

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Because this was a retrospective study using data routinely collected, and because patients signed informed consent prior to their procedures, specific ethics approval for this study was not required according to a waiver issued by the ethics committee.

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**Abstract**

**Study Design.** A prevalence and reliability study of Modic changes in the cervical spine.

**Objective.** To assess the prevalence and reliability of diagnosing and classifying Modic changes and their relationship to disc herniations in the cervical spine.

**Summary of Background Data.** Degenerative marrow (Modic) changes in the spine can be seen on MRI with some evidence linking them to pain. Many studies have been published on Modic changes in the lumbar spine, but only 1 small prevalence study focusing on Modic changes in the cervical spine has been reported.

**Methods.** The cervical MRI scans of 500 patients over the age of 50 were retrospectively evaluated for the prevalence, type and location of Modic changes and disc herniations. 200 of these same scans were independently analyzed by a second observer to evaluate interobserver reliability of diagnosis with 100 re-evaluated by the same observer 1 month later to assess intraobserver reliability. The SPSS program and Kappa statistics were used to assess prevalence and reliability. The risk ratio comparison of DH and MC was calculated.

**Results.** 426 patients (85.2 %) met the inclusion criteria. Modic changes were observed in 40.4% of patients (14.4% of all motion segments). 4.3% were type 1 and 10.1% were type 2. Disc herniations were seen in 78.2% of patients (13.3% of motion segments). Both MC and DH were most frequently observed at C5/6 and C6/7. Disc extrusions were positively associated with MC (RR = 2.4). The reliability demonstrated an upper moderate interobserver (k = 0.54) and an almost perfect intraobserver agreement (k = 0.82).

**Conclusions.** A high prevalence of Modic changes was observed with type 2 predominating. The C5/6 and C6/7 levels are most effected. Patients with MC are more likely to have a disc herniation at the same level. MC type 2 predominates. The classification is reliable.

**Keywords:**

Modic change, bone marrow, vertebrae, cervical spine, prevalence, disc herniation, bone marrow edema.

**Mini Abstract / Précis**

A high prevalence of Modic changes was observed in the cervical spine with motion segments C5/6 and C6/7 most commonly involved. Type 2 predominates. There is a link with disc herniation at the same level. The classification is reliable and reproducible.

**Key points:**

- Modic changes in the cervical spine showed a high prevalence, seen in 40.4% of patients or 14.4% of vertebral motion segments, most frequently in segments C5/6 and C6/7.
- MC type 2 predominates.
- The classification is reliable and reproducible, and applicable for specialists with varying clinical experience.
- Patients with Modic changes are 2.42 times more likely to have a disc herniation at the same level compared to patients without Modic changes.



**Introduction**

Degenerative endplate and marrow changes surrounding a dehydrated lumbar intervertebral disc were identified and classified by Modic *et al.* (1-3*)*. He described three types of bone marrow changes. Modic type 1 changes (hypointense signal on T1-weighted sequences and hyperintense signal on T2-weighted sequences) were seen in 4% of patients and are associated with vascular granulation tissue within the subchondral bone (4) (figure 1). Type 2 changes (hyperintense signal on T1 sequences and hyper- or isointense signal

on T2 sequences) appear to be more common (figure 2) and reflect fatty replacement of the adjacent marrow (1,5-7). Type 3 changes (hypointense signal on T1 and T2 sequences) appear to be much less frequent and corresponded to subchondral sclerosis seen on plain radiographs (2). Modic changes have been linked with low back pain and are therefore clinically relevant findings seen on lumbar MRI scans (8,9).

Most of the literature on Modic marrow changes focuses on the lumbar spine, with only one small study found reporting strictly on the prevalence of Modic changes in the cervical spine (10). Therefore the objectives of the present study were to further evaluate the prevalence, type, location and gender distribution of Modic changes in the cervical spine on a larger number of subjects and compare this Swiss patient sample with the findings from the previous study (10). In addition, investigating whether or not there is an association between disc herniations (DH) and MC was desired, since they are both parts of the degenerative process in the spine and this has not been evaluated previously in the cervical region. Finally, the current literature identifies no reliability studies on identifying and classifying MC in the cervical spine, whereas at least 8 reliability studies have been carried out for lumbar spine (3,9-16). Therefore, the present study also aimed to evaluate the reliability and reproducibility of identification and classification of MC in the cervical spine.



**Materials and Methods**

Because this was a retrospective study using data routinely collected, and because patients signed informed consent prior to their procedures, specific ethics approval for this study was not required according to a waiver issued by the ethics committee.

The retrospective study group consisted of 500 patients over the age of 50 with available cervical MR images as listed in the computer database of our orthopedic university hospital, starting from 2002 and including up to early 2004. For the prevalence study, cervical

MRI scans of 500 consecutive patients were evaluated by one observer. Two hundred of these patients' MRI scans were independently evaluated by a second observer to assess the inter-observer reliability. Additionally, 100 of these patients were reevaluated by the same observer one month later to assess the intra-observer reliability. The T1- and T2-weighted sagittal and axial cervical spine images of the patients were retrospectively and independently evaluated by two individuals, one radiologist and one medical intern who had special instruction on interpretation of cervical MRI images. Imaging characteristics were standardized based on the literature and agreed by consensus. Prior to study initiation, the two observers evaluated a sample set of images and held an in-person meeting to review them and refine the standardized definitions.

Exclusion criteria, as obtained from the imaging reports or noted on the MRI scans, comprised recent acute vertebral fractures, surgical fusions, acute traumatic Schmorl's nodes, spinal infections or tumors, inflammatory spondyloarthropathy, haemodialysis spondyloarthropathy, congenital block vertebrae, scoliosis involving a vertebral column curvature of greater than 15° as well as patients who had undergone radiotherapy. Each patient was assigned a number, and data were collected for patient age, gender, presence or absence of MC, dominant MC-Type if present and the respective segmental level. Given the fact that MC type 3 is usually a very rare finding, only MC types 1 and 2 were considered in the present study. Only the motion segments C3/4, C4/5, C5/6 and C6/7 were considered due to the fact that Modic changes are rare in the other cervical segmental levels (10). For disc herniations (DH), the presence or absence, the type, and the segmental disc level were recorded. DH classification was based on the original interpretation that radiologists registered in the reports. DH type 1 consisted of a diffuse or broad-based disc protrusion, usually without spinal cord or nerve root compromise, usually called a disc 'bulge' in English-speaking areas; DH type 2 was identified as a focal protrusion, herniation or extrusion,

usually with spinal cord or nerve root compromise (17,18). The type and location of DH was assessed by using a combination of axial and sagittal MRI scans.

SPSS program (Version 16.0, SPSS, Chicago, IL) was used for the statistical evaluation. The prevalence rates of MC and DH were reported in relation to the number of patients and/or in relation to the number of affected segmental disc levels. The prevalence rates were studied in relation to MC and DH type, mean age and gender. Two-by-two or three-by-two tables were created to evaluate the associations between MC and DH and presented as risk ratios (RR) with 95% confidence intervals (CI 95%). A positive association was defined as CI 95% limits above the value of one. Cohen's Kappa statistics (19,20) were calculated for the reliability study. K-value of 0.81-1.00 indicates an almost perfect agreement; 0.61-0.80, substantial agreement; 0.41-0.60, moderate agreement; 0.21-0.40, fair agreement; and 0.20 or lower, poor agreement.

**Results**

Four hundred twenty six patients (85.2%) of 500 patients enrolled met the inclusion criteria (Table 1). The patients' ages ranged from 50 to 89 years with the mean age of 61.7 years (SD +/- 9.12) and a fairly equal male:female ratio (48.4% : 51.6%). Modic changes were observed in 172 of the 426 patients (40.4%), with 51% of them seen in females. Of 1704 motion segments evaluated, 245 segments demonstrated Modic changes (14.4%), 74 of these 1704 were MC type 1 (4.3%) and 171 of the 1704 were MC type 2 (10.1%). Of patients with MC, 30% (74 patients) had type 1 and 70% (171 patients) type 2. Sixty-one patients (35.5%) had MC in more than one segmental level. Modic changes were most frequently found at C6/7, where they were observed in 84 cases (34.3% of all 245 MC cases observed). The second most common level to show MC was C5/6 with 82 cases (33.5% of all 245 MC cases observed). No significant gender differences were seen.

**DH Prevalence:** Disc herniations (bulge and extrusion) were detected in 333 patients (78.2%). Of those, 242 (56.8%) had DH at more than one level. Of the 1704 motion segments evaluated, 226 (13.3%) appeared to have a broad-based disc protrusion (bulge), and in 493 segments (28.9%) a disc herniation (extrusion) was detected. The most common motion segments were C5/6 with 79 bulges and 169 disc herniations, and C6/7 with 68 bulges and 143 disc herniations (table 1).

**Association between MC and DH:** The risk ratio (RR) calculation comparing the presence of Modic changes (both types combined) with the presence of a disc extrusion at the same segmental level resulted in a RR of 2.42 (95% CI = 1.93 – 3.04) Table 2 reports the risk ratios of having Modic changes and disc herniation at each segmental level evaluated.

**Reliability of diagnosis:** One hundred seventy MRI scans (30 did not meet the inclusion criteria) were independently assessed by both readers who were blinded towards each others' findings. The overall inter-observer agreement achieved in the current study was upper moderate with 73% agreement and k = 0.54 (CI 95% = 0.43-0.65). The intra-rater reliability was 89% (k = 0.82) with a confidence interval of 0.72 – 0.92, indicating almost perfect agreement.

## Discussion

A high proportion of the patients in this study demonstrated Modic changes in the cervical spine, with the C5/6 and C6/7 levels most commonly affected. This prevalence is similar to other studies involving the lumbar and cervical regions and is likely due to the fact that only patients over the age of 50 were included (10,21). No significant gender differences were found for the prevalence of Modic changes nor was there a significant age difference between those with and without Modic changes. Because this study used an older population, Modic type 2 changes predominated over type 1. The only other study reporting on

the prevalence and type of Modic changes for the cervical spine found that type 1 changes were more prevalent and that Modic changes were more common in older individuals. This previous study included a much wider age range with a significantly younger mean patient age (10). Therefore, it is likely that more Modic type 1 changes, which tend to precede Modic type 2, would have been found had a wider age range of patients been included in this current study (22).

A high prevalence of disc bulges and herniations was also observed in this study as 78.2% had either bulge or DH. This can also be explained by the high mean age of the patients included as well as by the fact that the hospital where this research took place is a specialized orthopedic and rheumatologic institution, where people with more complex problems are referred. The most common motion segments where DH of both types was detected were C5/6 and C6/7. These findings are in line with the majority of prevalence studies for DH in this spinal region.

The risk ratio calculations that compared the presence of both types of Modic change with the presence of disc herniation (excluding disc bulges) for all motion segments pooled revealed that patients with Modic changes are nearly 2 1/2 times more likely to have a disc herniation at the same segmental level compared to patients without Modic changes. The RR estimates for each motion segment in particular (table 2) showed a similar tendency although with wider confidence intervals due to smaller sample sizes. Although the majority of the patients had no Modic changes and no disc herniation at each segmental level, due to the high number of patients included in the study, a relationship between Modic changes and disc herniation at the same segmental level was found. These findings are consistent with the recent study by Jensen et al. (23) who also found a link between the development of new MC (mostly MC type 1) and disc bulges or herniations (extrusions) in the lumbar spine. The question as to why some patients with disc herniation also have

Modic changes at the same level while others do not may be explained by recent research suggesting a genetic predisposition in this subgroup of patients (24,25).

The reliability results for detecting and classifying Modic changes obtained in this study are good and similar to those obtained for the lumbar spine when using a similar study design (12). These results are particularly encouraging considering that one of the evaluators was a novice at reading MRI scans and only received a couple of targeted tutorials on the subject as well as extensively reading the relevant literature. This suggests that clinicians, in addition to radiologists and orthopedic surgeons, can quickly learn to recognize the features of MC and begin to evaluate their effects.

**Limitations:** Possible limitations of the present study could be the inclusion bias. First, the high mean age of 61.7 years could be seen as a confounder or an effect modifier, reducing the number of MC type 1 identified. However, it was a deliberate measure to achieve a higher prevalence of pathologies within the sample. Second, the university hospital where the study was conducted is a special orthopedic/rheumatology institution where complex patients are referred. Additionally, certain limitations could have been introduced by the inhomogeneity of image acquisition methods as well as by inconsistency of use of terminology on imaging reports, which is especially relevant for evaluation of DH.



**Conclusions**

A high prevalence of Modic changes was observed in the cervical spine in patients over the age of 50, with type 2 predominating. The reliability of identifying and classifying Modic changes in this spinal region is good and a definite link between Modic changes and disc herniations at the same segmental level was found. Further prevalence studies on Modic changes in the cervical spine should be conducted with samples from clinical, occupational and general populations, including patients below the age of 50. An association of

Modic changes with neck pain or radiculopathy should be a further subject of investigation.

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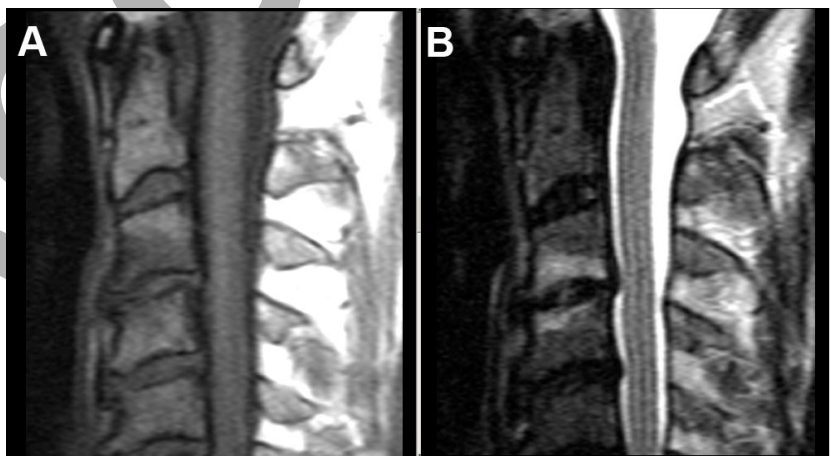


**Figure 1**

A, B. End plate marrow changes Modic type 1 in the motion segment C3/4 seen as low signal in T1-weighted and a high signal in T2- weighted sequences. Disc bulges are noted at the C3/4 and C4/5..

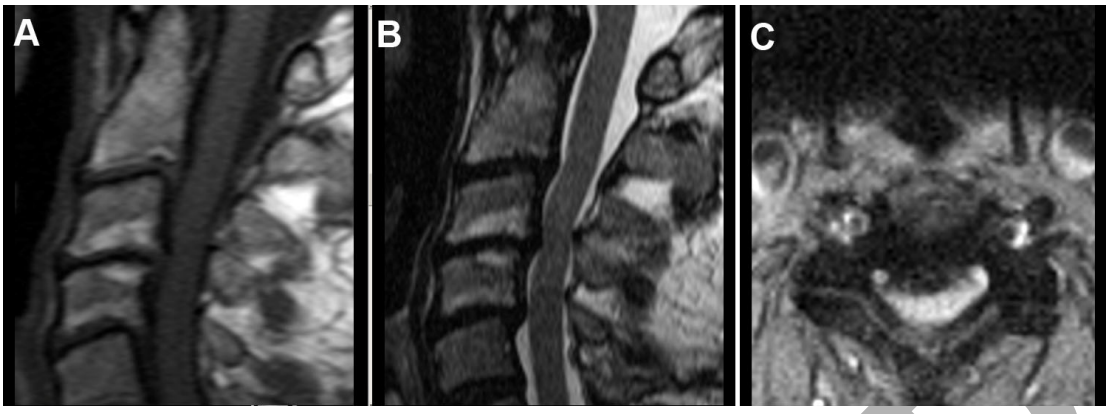


**Figure 2**

A, B. Modic type 2 in the motion segments C3/4 and C4/5 seen as high signal in both T1- and T2- weighted sequences. C. The axial slice shows a significant posterior disc extrusion, slightly more on the left.

Table 1: **Prevalence of Modic changes (MC) and disc herniations (DH) in the cervical spine**

| Abnormality | No. of Patients/Total Patients | No. of Cervical Motion Segments/Total Motion Segments |
|---|---|---|
| **Modic Change** | | |
| **MC (both types)** | | |
| n (%) | 172/426 (40.4%) | 245/1704 (14.4%) |
| Age: AM +/- SD | 61.84 +/- 9.15 | |
| m:f (%) | 84:88 (49%:51%) | |
| **MC type 1:** | | |
| n (%) | 63/426 (14.8%) | 74/1704 (4.3%) |

| | | |
|---|---|---|
| Age: +/- SD | 60.94 +/- 9.41 | |
| **MC type 2:** | | |
| n (%) | 121/426 (28.4 %) | 171/1704(10.1%) |
| Age: +/- SD | 62.14 +/- 8.99 | |
| **Patients** with MC in more than one segment: n (% of total sample) (% of patients with MC) Age: +/- SD m:f (%) | 61/426 (14.3%) (35.5%) 61.90 +/- 8.06 30:31 (49:51%) | na |
| Most common cervical **motion segment** with MC MC (both types): n | na | C6/7 84/1704 |
| MC type 1: n | | 26/1704 |
| MC type 2: n | | 58/1704 |
| 2nd most common cervical **motion segment** with MC MC (both types) | na | C5/6 82/1704 |
| MC type 1: n | | 26/1704 |
| MC type 2:n | | 56/1704 |
| **Disc Herniation** | | |
| DH (both types) n (%) | 333/426 (78.2%) | 719/1704 (42.2%) |
| DH type 1: n (%) | -- | 226/1704 (13.3 %) |
| DH type 2: n (%) | -- | 493/1704(28.9 %) |
| **Patients** with DH in more than one motion segment: n (%) | 242/426 (56.8 %) | na |

| | | | |
|---|---|---|---|
| Most common cervical **motion segment** with DH | DH (both types): n | na | C 5/6<br>248/1704 |
| | DH type 1: n | | 79/1704 |
| | DH type 2: n | | 169/1704 |
| 2nd most common cervical **motion segment** with DH | DH (both types): n | na | C 6/7<br>211/1704 |
| | DH type 1: n | | 68/1704 |
| | DH type 2: n | | 143/1704 |

**Table 2**

Risk ratios of disc herniation in motion segments with Modic changes

| **Motion segment** | **RR** | **$CI_{95\%}$ of RR** |
|---|---|---|
| C3/4 | 2.89 | 1-61 – 5.06 |
| C4/5 | 3.30 | 1.80 – 6.05 |
| C5/6 | 1.58 | 1.07 – 2.31 |
| C6/7 | 2.27 | 1.55 – 3.32 |
| Pooled (C3/4 – C6/7) | 2.42 | 1.93 – 3.04 |

Only DH type 2 (herniation/extrusion) were included in this calculation. MC types were pooled.

MC = Modic change; DH = disc herniation; RR = risk ratio; CI 95% = 95% confidence interval