



## FOLLOW-UP OF THE DEGENERATIVE PROCESS WITH MRI AFTER ANTERIOR CERVICAL DISC SURGERY

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**Received:** 19th November, 2018.

**Accepted:** 22th February, 2019.

### ABSTRACT

**Objective:** Anterior cervical discectomy is a common procedure in neurosurgery. MRI can be used for the diagnosis of the disease and follow up. This study aimed to evaluate postoperative period and adjacent segment disease with MRI after the anterior cervical disc surgery.

**Material and Methods:** Thirty consecutive patients include 44 segments with anterior cervical discectomy from 2014-2015 were invited to follow-up and investigated with preoperative and postoperative MRI. Median follow-up was 19 months.

**Results:** Prevalence of Modic changes and uncovertebral hypertrophy were higher in the postoperative period ( $P < 0.001$ ). Degeneration of the adjacent segments were seen 22.7% postoperatively. The adjacent segments degeneration was higher in blade-peek cage than peek cage ( $P = 0.026$ ). All patients showed type 3 Modic changes after 30 months and uncovertebral hypertrophy was detected after 36 months in the postoperative period.

**Conclusion:** After the anterior cervical disc surgery, degenerative endplate changes and uncovertebral hypertrophy increase in course of time. Type 3 Modic changes and uncovertebral hypertrophy occur in all patients at the end of the 3 years after the surgery. Degeneration of the adjacent segment is seen almost 1/5, which has a higher prevalence in used blade-peek cage.

**Key Words:** Anterior cervical discectomy, Modic Change, Uncovertebral hypertrophy, Adjacent segment degeneration, Peek cage, Blade-Peek cage.

**Level of Evidence:** Retrospective clinical study, Level III.

### INTRODUCTION

Cervical vertebrae degeneration includes disc herniation, spondylosis and end plate changes. This entity can present with neck pain, radiculopathy and myelopathy. Decompression and stabilization techniques are used when patients do not benefit from medical or physical therapies<sup>(25)</sup>. Anterior microdiscectomy and fusion are the most preferred types of procedures for cervical disc herniation treatment. Anterior cervical discectomy (ACD) is a common procedure in neurosurgery practice upon and is also adequately documented. Complication rates are slightly low<sup>(27)</sup>.

MRI, CT and X-ray can be used for the diagnosis of the disease, treatment and

follow up. AP-lateral X-rays, as well as oblique X-ray can show bony narrowing of the foramen. CT scans can evaluate bony structures, disc and vertebrae degeneration, width of the foramen and spinal canal<sup>(25)</sup>. MRIs are used to assess preoperative diagnosis, postoperative follow up to the nerve roots, spinal cord and end plates. MRI is preferred because not use any ionizing radiation and it has high soft tissue resolution<sup>(4)</sup>.

In this study we aimed to compare pre- and postoperative end plate changes, uncovertebral joint (UV) and adjacent segment degeneration and to help understand the postoperative period. The relation between end plate changes and uncovertebral hypertrophy (UVH)

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was specifically discussed in order to evaluate cervical fusion with a different point of view.

## MATERIALS AND METHODS

This is a retrospective study. 30 consecutive patients, who had been operated for 44 segments in total between December 2014 and 2015, were reviewed. Pre- and postoperative cervical MRIs and X rays were done. Operated segments and the adjacent segments (one segment above and below of the operated segment) were evaluated for end plate changes and hypertrophy of uncial joint. Patients operated via posterior approach, trauma patients, oncology patients were excluded from the study.

### Evaluation Criteria

Ethical committee of GOP Taksim Training and Research Hospital (27.01.2016 / 54) gave approval prior to the study. Informed consent taken from patients. Radiological imaging domains were accepted as: end plate changes, degeneration of uncovertebral joint and disc degeneration. Operated segment and adjacent segments were compared pre- and postoperatively with MRI. Modic classification was used to assess end plate degenerations on MRI <sup>(12-13)</sup>.

Modic changes: (type 0) normal, (type 1) hypointense in T1-weighted (W) images and hyperintense in T2-W images, (type 2) hyperintense in both T1-W and T2-W images, (type3) hypointense in both T1-W and T2-W images. MRI and X-ray findings were correlated for uncovertebral joint degeneration, which was classified as no degeneration, low grade degeneration and high grade degeneration, visually. Disc degeneration was recorded according with Miyazaki Grading System, pre- and postoperatively <sup>(11)</sup>. All radiological evaluations were made by an experienced musculoskeletal radiologist.

MRI imaging; 1.5 T MR Unit (Signa HDxt; GE, USA) and body surfacecoil were used. Sagittal T1W FSE, T2W FSE and an axial T2W FSE (3680/128 repetition time/echo time, 256x256 matrix, 280-mm field of view and 4-mm section thickness, NEX 2) was used for imaging.

Surgical procedure; all patients underwent same surgical procedure and different fusion materials were used. The fusion materials to be used were decided on case-by-case basis. 2 patients have undergone simple discectomy, 22 patients have undergone peekcage (PC), 19 patients have undergone blade-peekcage (BPC) and disc prosthesis was used in 1 patient. Anterior cervical discectomy via microsurgical technique was used in all patients. Anulus fibrosus and endplates were shaved with curette. After adequate decompression, selected fusion material was placed. Hydroxyapatite filling were put inside

cages and then placed in the disc space. No complications were faced during pre- and postoperative period and there was not any blood transfusion. Patients were discharged in 3 +/- 1 days.

Our data were presented as mean, median frequency and percentage values. Categorical variants were compared by Fisher's exact test. Pre- and postoperative Modic and UVH changes were evaluated by McNemar-Bowker test. Median follow up time for Modic and UVH were calculated by Kaplan Meier survival analysis. Age and sex factors, which were thought to be effective on degeneration, were assessed by cox regression analysis. Two tailed significance level was accepted to  $p < 0.05$ . NCSS10 software (2015 NCSS, LLC, Kaysville, Utah, USA) was used for all statistical analyses.

## RESULTS

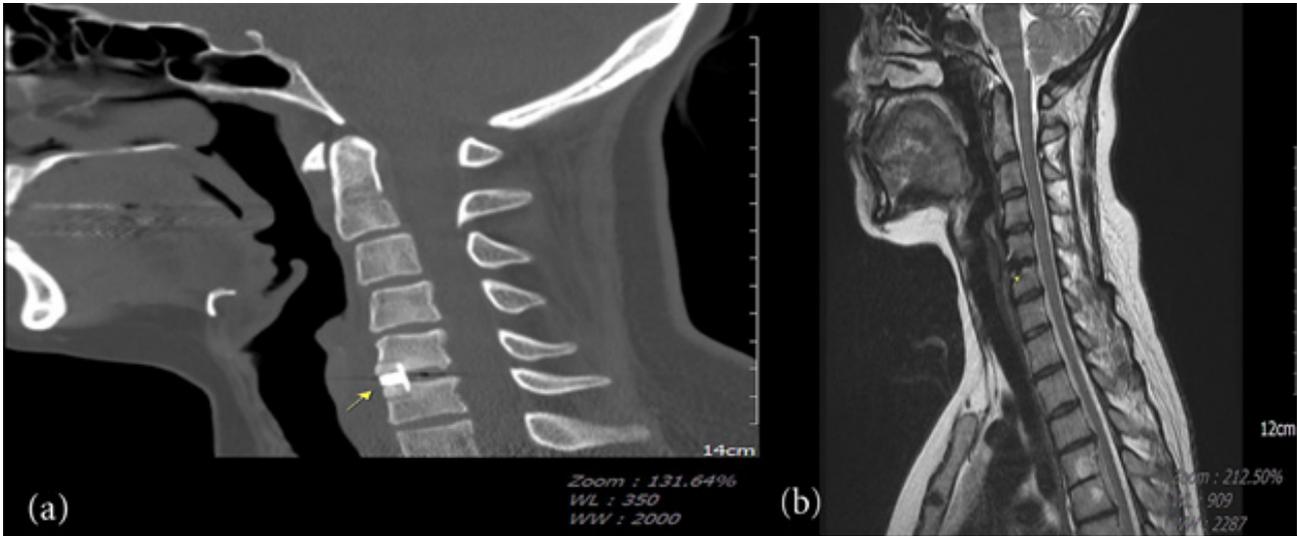
30 patients (24 women, 6 men) with 44 different operation segments were included in the study. Mean age was  $45.86 \pm 8.5$ , mean follow-up time was  $18 \pm 7.4$  months.

4 C4-5 intervertebral segments, 25 C5-6 segments, 15 C6-7 segments were operated. Operated segments and the procedures were checked from the operation reports of every patient.

Preoperative cervical vertebrae MRI evaluation: 36 (81.8 %) of 44 segments didn't show any Modic changes. Modic type 1 changes were detected in 5 segments (11.4 %), while type 2 changes were found in 2 segments (4.5 %) and type 3 in 1 segment (2.3 %). Evaluation for UVH didn't show any degeneration in 10 segments (22.7 %). 33 segments (75 %) showed slight hypertrophy whereas 1 segment (2.3%) was high degenerated.

Postoperative cervical vertebrae MRI evaluation: Only 1 patient (2.3 %) showed no signs of Modic degeneration, while type 1 changes were found in 4 segments (9.1 %), type 2 changes in 15 segments (34.1 %) and type 3 changes in 24 segments (54.5 %). 2 patients, in whom no UVH was found preoperatively also showed no signs of UVH postoperatively. Slight hypertrophy was found in 20 patients (45.5 %) and high grade hypertrophy was found in 22 patients (50 %). (Figure-1)

Postoperative adjacent segment evaluation: In 10 segments (22.7 %) were found to have new changes such as Modic changes, disc degeneration and UVH. Postoperative Modic degeneration rates on adjacent segment were higher than preoperative rates significantly ( $P < 0.001$ , McNemar-Bowker test). Statistically, UVH was higher postoperatively than preoperatively ( $p < 0.001$ , McNemar-Bowker test).



**Figure-1.** 37-years-old female patient after the anterior cervical discectomy (a) on the midsagittal 2D reformate CT, the cage material at C5-C6 level is shown (arrow). (b) In the same patient is detected negligible signal loss and magnetic susceptibility artefacts in the operated segment on midsagittal T2-W MRI image.

Evaluation of the operation material: Adjacent segment degeneration was frequent in patients operated with BPC compared to the patients operated with PC ( $p=0.026$ , Fisher's exact test). Simple discectomy and prothesis procedures couldn't be compared due to lack of patients.

Time-dependent degeneration analysis in postoperative period: As the follow up periods differed from patient to patient, Modic changes and UVH were assessed according to the follow up period (Kaplan-Meier survey analyses, Table-1).

**Table-1.** 'Evaluation of postoperative Modic changes related to time' shows increase in Modic changes rates in the follow up period.

Time table (month)	the rate of Modic in time	Standard error
7	10%	0.04
12	33%	0.07
18	45%	0.07
24	77%	0.06
30	100%	0

Patients with preoperative type 3 Modic changes and high grade UVH were excluded from this evaluation, considering that these degenerations would not progress. Degenerative changes that were stable were coded "0" while progressing degeneration was coded "1". Median follow-up was nearly 19 months and the longest follow up period was 36 months, standard error  $\pm 0.65$  (95 % confidence interval 17.72-20.28).

With this evaluation we found that 10 % patients showed newly onset or progressing Modic changes at 7th month, as well as type 3 Modic changes were found in all patients at 36 months postoperatively (Figure-2).

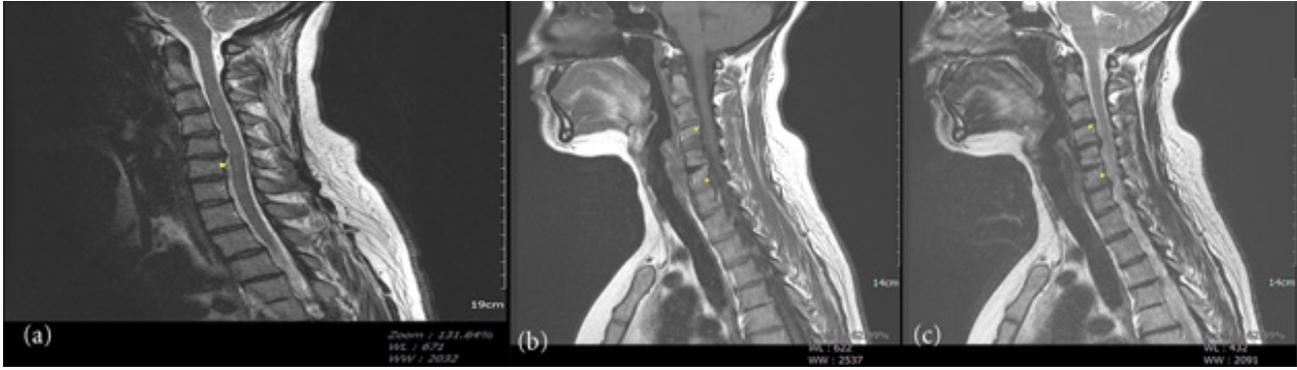
Similar assessments for UVH showed in the postoperative 7th month only 5 % of the patients have UV degenerations whereas in the 36th month nearly all patients have high grade degeneration (Table-2).

Effect of age and sex on Modic changes: Evaluated separately, age and sex have no effect on Modic changes (Age:  $P=0.173$ ,  $HR=1.045$ , Sex:  $P=0.07$ ,  $HR=0.003$ , Cox regression test). However, age and sex are evaluated together, it is effective on MC ( $P=0.041$ ,  $HR=1.142$ , Cox regression test).

Effect of age and sex on UVH: Separately, age and sex also have no effect on UVH (Age  $P=0.237$ , Sex  $P=0.141$ , Cox regression test). Also, age and sex are evaluated together, they were not effective on UVH ( $P=0.092$ , Cox regression test).

**Table-2.** 'Evaluation of uncovertebral joint degeneration related to time' shows an increase in UV degeneration during follow-up

Time table (month)	the rate of UV degeneration in time	Standard error
7	5%	0.03
12	20%	0.06
18	26%	0.07
24	51%	0.09
36	100%	0



**Figure-2.** 37-years-old female patient, preoperative cervical MRI evaluation **(a)** on midsagittal T2-W image is shown that there is signal loss and central protrusion on C5-C6 intervertebral disc but no end-plate degeneration (arrow). Degenerative signal loss is detected on C4-C5, C6-C7 intervertebral disc space, too. She has also foraminal disc protrusion (not shown). 18 months after the surgery **(b)** On midsagittal T2-W image is shown that hypointensity and vertical high loss in the C5-C6 intervertebral disc due to anterior cervical discectomy are detected. Hyperintense signal due to type 2 Modic change is also detected on the same level (long arrow). Additionally, the hypointense signal due to type 3 Modic change is detected on the end-plates of C4-C5 level (arrow head). The increase in disc degeneration on the other levels is remarkable. **(c)** Band-shaped hyperintensities on C5-C6 end-plates and the hypointensities on C4-C5 end-plates are seen on sagittal T1-W MRI.

## DISCUSSION

Cervical anterior procedure is used to neurosurgery practice, consists of decompression and fusion <sup>(1)</sup>. There are many studies discussing the operation material, arthrodesis and arthroplasty. Recently, otologue bone grafts and plate-screw systems were used in anterior cervical discectomy with fusion <sup>(11,21-23)</sup>. Fusion aims to prevent abnormal motion and to maintain stability. However, range of motion is limited in the adjacent segment as well as the operated segment due to fusion. Fusion and stability are still accepted worldwide, on the other hand, protecting the motion to operated segment is more highlighted. That is why, material such as PC and disc prothesis are replacing bone grafts <sup>(5,7)</sup>. There are studies claiming that hydroxyapatite, known as composite graft and osteoconductive, is procuring fusion equivalent to otologue bone grafts <sup>(2,10,16)</sup>. In our series, mainly PCs and BPCs are used.

X-rays, CTs and MRIs can be used for postoperative imaging in patients with ACD. In our study, we used MRI for defining changes in the operated and adjacent segments. We detected negligible signal loss and artefacts in all operated segments (Figs 1a, b). In the literature, it is also revealed that MRI is the most suitable technique for follow up of ACD <sup>(14,24)</sup>. Also, studies which are evaluating anterior discectomy without fusion, emphasize that the most common postoperative sign is signal loss in intervertebral space in T2-weighted images <sup>(24)</sup>.

Arunkumar and Rajshekhar <sup>(1)</sup> showed in their 2-patient case series that postoperative microparticle in the operation area

can cause hypointensity due to susceptibility artefact. In the literature, it is noted that besides signal loss and artefacts, asymptomatic kyphosis, adjacent segment degeneration and new disc herniation are the most common findings <sup>(6,17,19-20)</sup>. Adjacent segment degeneration is believed to be a result of spondylolysis rather than fusion <sup>(17)</sup>. We showed in our study, MD and UVD is progressive in the adjacent segment as well as the operated segment in the postoperative period. Adjacent segment degeneration developed in every one of five patients. In our study, we found that age is not effective on MD and UVH in the operated and adjacent segments. Due to, adjacent segment degeneration might be a result of operative trauma, sagittal balance problems and damage of the functional motion unit besides spondylolysis. Also, we found in our study that the adjacent segment degeneration is related to the type of the operation materials. Adjacent segment degeneration was significantly higher BPC than used PC ( $p=0.026$ , Fisher's exact test).

Different studies have evaluated the postoperative MRI changes in the operated segments. Li et al <sup>(8)</sup> reported that type 2 Modic changes in the operated segments are not effective on fusion. Van de Kelft et al <sup>(24)</sup> claimed that the T2 weighted signal loss in the intervertebral space is referring to bone fusion. In cervical disc herniation surgery, end plates are curated in order to help to maintain fusion. It is possible to follow the post-operative process by evaluated the end plate signal on MRI. End plate inflammation, lipid degeneration and sclerosis are continuing processes and these could define

the healing process. In our studies, from the 7th month after the operation, Modic changes begin to emerge (10 %) and 30 months later all patients showed type 3 Modic changes. Are type 3 Modic sclerotic bands, which are determined terminal changes, showing fusion? This question can be answered by new studies that type 3 Modic changes together with functional X-rays or postmortem analyses.

Uncovertebral joint is first defined by Luschka<sup>(9)</sup>. Some authors claimed that this entity is not a real joint but a degenerative change<sup>(15,18)</sup>. Facets and uncovertebral joints are restricting sliding and extreme movement while permitting a little flexion and extension<sup>(26)</sup>. Our study showed that postoperative UVH rates are significantly higher than the preoperative period ( $P < 0.001$ , McNemar-Bowker test). 7 months later in the follow-up period, only 5 % of the patients showed UVH, while all patients showed high grade degeneration at the 36th months postoperatively. Age and sex factors have no effect on UVH (respectively  $P = 0.237$ ,  $P = 0.141$ , Cox regression test). On this basis, we can claim that uncovertebral joint is quite sensitive to disc and end plate degeneration as well as UVH may develop due to deterioration of the sagittal imbalance in postoperative period, and thus it can aggravate clinical symptoms.

Our limitation, despite small patient group, statistical evaluation in terms of MD and UVH was possible for the entire study. However, use of different materials in the operations are our limitation. Since simple discectomy and pro techniques was not performed adequately, these techniques could not be compared postoperatively. Lastly, dynamic imaging could not be added to the study to evaluate fusion since retrospective study.

## Conclusions

In postoperative period after the anterior cervical discectomy, end plate changes and uncovertebral degeneration are increasing by time. Approximately 3 years after the surgery, all patients show type 3 Modic changes and high grade UVH. Also, adjacent segment degeneration is developing in 1/5 of the patients. Adjacent segment degeneration is more common in patients operated with BPC than PC.

**Acknowledgement:** Thanks to Sevim Purisa for statistical evaluation.

**Conflict of interest:** None. In this study, no funds were obtained from any organization.

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