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Clinical Study

Association between cervical degeneration and self-perceived nonrecovery after whiplash injury

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Abstract

BACKGROUND CONTEXT: Pre-existing radiological degenerative changes have not previously been considered a risk factor for nonrecovery from neck pain due to motor vehicle accidents (MVA). Results from previous studies are however often based on assessment of plain radiography or MRI and little consideration has been given to facet joints. Furthermore, previous studies have often lacked a validated scoring system for degenerative changes.

PURPOSE: To investigate the association between cervical degeneration on computed tomography (CT) and nonrecovery after whiplash trauma.

STUDY DESIGN: Longitudinal cohort study.

PATIENT SAMPLE: One hundred twenty-one patients attending the Emergency Department because of neck pain after MVA, 2015−2017, with a valid CT-scan of the cervical spine and completion of follow up after 6 months.

OUTCOME MEASURES: The primary outcome measure was self-perceived nonrecovery (yes/no) after 6 months. A secondary outcome measure was self-reported pain level (Numeric Rating Scale).

METHODS: Baseline data regarding demographics and health factors were gathered through a web-based questionnaire. Degeneration of facet joints and intervertebral discs was assessed on CT-scans according to a validated scoring system. Binary logistic regression was used to study the association between cervical degeneration and nonrecovery.

RESULTS: Moderate facet joint degeneration was associated with nonrecovery. In the group with moderate degree of facet joint degeneration, 69.6% reported nonrecovery compared with 23.6% among patients without any signs of degeneration (adjusted odds ratio 6.7 [95% confidence interval: 1.9−24.3]). There was no association between disc degeneration and nonrecovery. Combined facet joint degeneration and disc degeneration were associated with nonrecovery (adjusted odds ratio 6.2 [2.0−19.0]).

CONCLUSIONS: These results suggest that cervical degeneration, especially facet joint degeneration, is a risk factor for nonrecovery after whiplash trauma. We hypothesize that whiplash trauma can be a trigger for painful manifestation of previously asymptomatic facet joint degeneration.

Keywords: Whiplash injuries; Neck pain; Cervical spondylosis; Cervical osteoarthritis; Degeneration; Computed tomography; Radiology; Risk factors; Facet joints; Zygoapophyseal joints

Introduction

The etiology of whiplash associated disorders (WAD) is thought to be multifactorial [1]. Psychosocial risk factors are known to include post-traumatic stress, catastrophizing, and medicolegal involvement but these alone cannot predict the outcome after whiplash trauma [2,3]. Neither can motor

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vehicle accident (MVA) related factors such as high-speed and rear-end impact collisions satisfactorily predict the outcome [4,5]. Initial level of pain after MVA is thought to be the most accurate prognostic factor for outcome [3].

The cervical spine is one of the most common localizations for chronic pain, regardless of etiology [6], and 20% of patients suffering from chronic neck pain report a traumatic onset [7]. To a large extent nonspecific neck pain and traumatic onset neck pain (WAD) share similar clinical manifestations [7,8], with local neck pain and stiffness as the main symptoms [6,9,10]. The recovery rate after whiplash trauma is about 50% [1], similar to the recovery rate for nonspecific neck pain [11]. Baring this in mind, it could be argued that patients with self-reported traumatic onset of chronic neck pain do not differ from patients without a history of whiplash trauma [8].

The terminology describing degenerative disease of the spine is unfortunately imprecise. The terms spondylosis, degenerative disc disease, arthrosis, and osteoarthritis are often used synonymously [12] and may refer to mechanical, radiological or clinical manifestations related to the vertebral column [13]. In this paper we define cervical degeneration as degeneration of the facet joints and discs as shown radiologically [14].

The facet joints (zygoapophyseal joints) have been reported to be the origin of pain in 60% of neck pain patients [15]. An equivalent frequency has been documented in WAD patients [16]. The mechanism of facet joint pain after whiplash trauma is suggested to be capsular strain and hypermobility. Furthermore, facet joint mensicoid injuries have been suggested as a possible source of pain among WAD-patients [17]. These mechanisms are however derived from in vitro studies and currently have no bearing on clinical practice [18].

Facet joints are biomechanically linked to the intervertebral discs and facet joint degeneration is often explained by the "degenerative cascade-theory," that is, primary loss of inherent structural integrity in the intervertebral discs, secondary biomechanical malalignment, and an alteration of the axial load toward the facet joints [19−21]. However, being synovial joints, the facet joints can also manifest primary osteoarthritis [14,22]. The frequency of isolated, primary osteoarthritis in the cervical facet joints without corresponding radiologic disc degeneration in the same segment is not described and the understanding of neck pain origins and the joints´ contribution is limited [23].

Degenerative radiological changes of the cervical spine have been considered of no or limited prognostic value after whiplash injury [3,4]. Neither has radiological cervical degeneration been accepted as a risk factor for nonspecific neck pain [24].

Previously, disc degeneration has been the focus of attention when investigating the association between cervical degeneration and outcome after whiplash trauma. Several studies have reviewed disc degeneration (on either magnetic resonance imaging [MRI] or plain x-ray) as a possible risk factor for nonrecovery [4,25−28]. No evidence of the prognostic value of pre-existing disc degeneration, "spondylosis" or traumatic disc injury has been shown [26,29,30].

To our knowledge, only plain x-ray has previously been used to study facet joint degeneration as a possible risk factor for poor recovery from WAD. Additionally, these studies have been conducted without validated scores for degeneration [31,32].

Computed Tomography (CT) is often the initial radiology investigation carried out in the Emergency Department after a MVA when skeletal injuries cannot be ruled out according to clinical guidelines, such as Canadian C-spine rules [33]. Additionally, CT is considered superior to MRI and plain x-ray in detecting facet joint degeneration, especially early signs of degeneration [34]. It is also reported to have a higher level of inter-rater agreement in the assessment of facet joint degeneration compared with the assessment on MRI [35]. However, previous research indicating that cervical degeneration is not a risk factor for persisting neck pain, is based only on assessment with MRI or plain x-ray [36].

In summary, previous studies conclude that radiological degeneration of the cervical spine is not a risk factor for post-traumatic neck pain. The aim of this prospective study was to investigate associations between cervical degeneration and self-perceived nonrecovery after whiplash injury, using CT-scans assessed with a validated scoring system of the cervical spine, and addressing both disc degeneration and facet joint degeneration.

Material and methods

Study population

All patients were recruited from a randomized clinical trial (RCT) evaluating the effect of a patient information-video on patients suffering from an acute whiplash trauma (NCT02570659). The ledger of the Emergency Department of Södersjukhuset, Stockholm, Sweden was checked daily for patients with neck pain after a MVA. Inclusion criteria for the original study were adults 16−70 years of age reporting neck pain after MVA to the medical doctor at the Emergency Department, and injuries being of WAD grade I−III [37]. Exclusion criteria were: non-Swedish speakers, cervical fractures or dislocations (WAD grade IV), other accompanying injuries caused by the index MVA, hospitalization for more than 2 days due to the index MVA (according to self-reports), residence outside of Sweden, and no persisting neck pain when interviewed by the research nurse at inclusion.

For this study we included patients with CT scans of the cervical spine performed at admission. Inadequate CT scans failing to visualize all cervical segments were excluded. Participants who had not undergone a CT scan of the cervical spine initially were offered one as an outpatient within

10 days after the index accident. The patients concerned were contacted by telephone by the study team and were given information about the study. The index accident was defined as the accident generating the symptoms the patient sought care for (Figure). The time from the index accident to inclusion was always shorter than 10 days.

Radiology evaluation

All patients were examined in a Philips Brilliance 64-slice CT scanner. The scans were analyzed by a senior spine surgeon according to a previously published protocol [38]. The protocol has been shown to have a "good" inter-rater reproducibility (0.54−0.75) and "moderate" inter-rater agreement (kappa 0.52 for facet joint degeneration and kappa 0.47 for disc degeneration). For total cervical degeneration the protocol has exhibited an "excellent" inter-rater reproducibility of 0.73−0.82 and "substantial" kappa-value of 0.70 [38,39]. All scans were anonymized. The spinal segments with the worst disc degeneration and facet joint degeneration respectively were chosen and assessed.

The facet joints were examined for joint space narrowing, irregularity of the articular surface and osteophytes. Disc degeneration was assessed regarding disc height, anterior osteophytes, and end plate sclerosis (Table 1).

We defined total degeneration score as the sum of the facet joint degeneration score and disc degeneration score, in accordance with previous research [38].

Data acquisition at baseline

Patients reported data in a web-based questionnaire. Reminders were sent out after 2 weeks and any remaining nonresponders were subsequently contacted by telephone by the study nurse who offered assistance with the questionnaire. Data was collected regarding age, gender (male/female), highest level of education (university/ <university), sick-leave secondary to the MVA (yes/no) and self-reported presence of neck pain the month before the MVA (yes/no).

Patient reported levels of pain, stiffness, and distress were indicated on a numeric rating scale (NRS) [40] from 0 to 10 (0 = no pain/stiffness/distress, 10 = worst possible pain/stiffness/distress) (Table 2). These factors were chosen because previous reports have suggested them as risk factors for non-recovery [1,5,41−43]. Additionally, intervention in form of an information video was included, due to the fact that the study population was selected from the previous RCT evaluating the effect of this video on outcome.

Follow-up

At 6 months the participants received a follow-up questionnaire regarding recovery. The primary outcome measure was self-reported nonrecovery as assessed by the question "Do you feel recovered from the neck injury obtained from the MVA?" (Yes = recovered, No = nonrecovered). They were also asked to grade their level of remaining neck pain on a scale from 0 to 10 according to NRS.

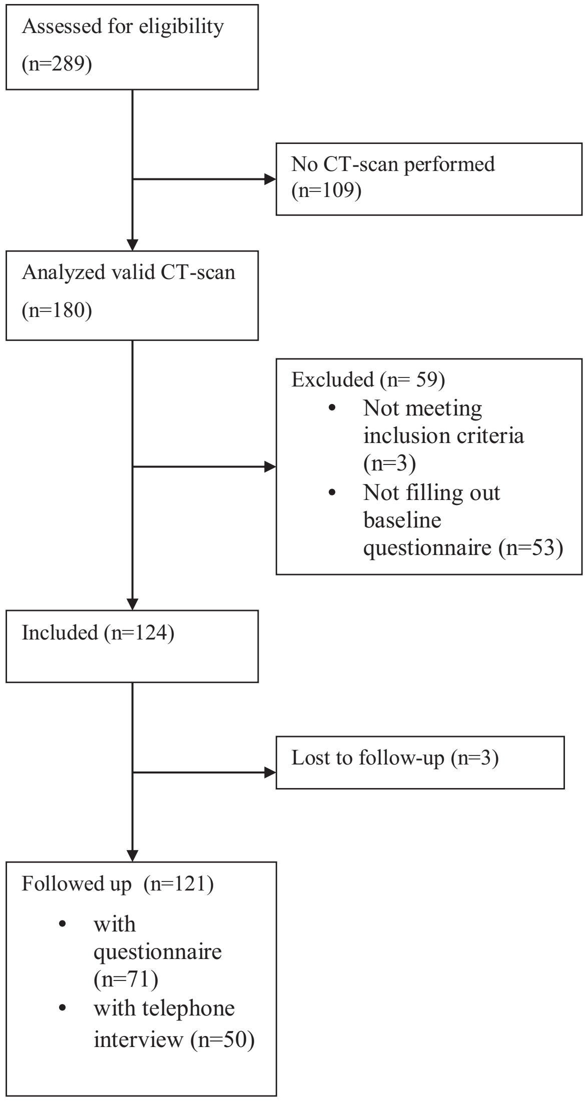

Fig. Flow chart of the inclusion process and follow-up.

The study team contacted participants who had failed to reply to two reminders, for a brief interview (Figure).

Statistical analysis

IBM SPSS Statistics, version 22 (SPSS Inc., Chicago, IL, USA) was used to perform all statistical analyses. For the analyses, we categorized age as 16−25, 26−40, and 41−65 years (analogous with previous studies [44]). Level of pain was categorized as NRS <4, 4, <6, and ≥6 and the level of distress was categorized as NRS <1, 1−5, and >5 corresponding to previous studies [44]. For the variable "initial level of neck stiffness" no previous NRS

Table 1
Scoring system of cervical disc and facet joint degeneration

Facet joint degeneration		
1. Joint space narrowing	Normal	0 points
	Narrowed	1 point
2. Osteophytes	No osteophytes	0 points
	Yes	1 point
3. Irregularity of articular surface	Normal	0 points
	Irregular	1 point
Overall degree of facet joint degeneration (1+2+3)	0 points (no degeneration)	0 points
	1 point (mild degeneration)	1 point
	2 points (moderate degeneration)	2 points
	3 points (severe degeneration)	3 points
Disc degeneration		
1. Height loss	0 %	0 points
	≤25%	1 point
	>25- ≤50%	2 points
	>50%- ≤ 75%	3 points
	>75%	4 points
2. Anterior osteophytes	No osteophytes	0 points
	≤1/8 AP diameter	1 point
	>1/8 - ≤1/4 AP diameter	2 points
	>1/4 AP diameter	3 points
3. Endplate sclerosis	No sclerosis	0 points
	Detectable	1 point
	Definite	2 points
Overall degree of disc degeneration (1+2+3)	0 points (no degeneration)	0 points
	1-3 points (mild degeneration)	1 point
	4-6 points (moderate degeneration)	2 points
	7-9 points (severe degeneration)	3 points

AP, anteroposterior.

Table 2
Demographics and baseline categorizations of the included patients (N=121)

		N	%
Facet joint degeneration grade	0 (no degeneration)	54	44.6%
	1 (mild degeneration)	25	20.7%
	2 (moderate degeneration)	25	20.7%
	3 (severe degeneration)	17	14.0%
Disc degeneration grade	0 (no degeneration)	66	54.5%
	1 (mild degeneration)	34	28.1%
	2 (moderate degeneration)	16	13.2%
	3 (severe degeneration)	5	4.1%
Age group (years)	16−29	51	42.1%
	30−45	37	30.6%
	46−65	33	27.3%
Gender	Male	63	52.1%
	Female	58	47.9%
Highest level of education	Not university	69	57.0%
	University	52	43.0%
Sick leave because of index trauma	No	96	79.3%
	Yes	25	20.7%
Level of pain at baseline (NRS)	0−3	41	33.9%
	4−6	51	42.1%
	7−10	29	24.0%
Level of neck stiffness (NRS)	0−2	33	27.3%
	3−6	59	48.8%
	7−10	29	24.0%
Level of mental distress (NRS)	0−3	38	31.4%
	4−6	52	43.0%
	7−10	31	25.6%
Previous neck pain*	No	106	89.8%
	Yes	12	10.2%
RCT intervention	No	53	43.8%
	Yes	68	56.2%

NRS, numeric rating scale; RCT, randomized clinical trial.
* Missing values = 3.

categorization was found. We assessed neck stiffness using the clinical experience of the authors. To test differences between proportions (nominal or ordinal factors), Fisher exact test was used. To compare mean values, we used independent samples *t* test or analysis of variance. For the post hoc analysis, Dunnettes *t* test (2-sided) was used because of the consideration of absence of degenerative findings (=no degeneration) being a control group. A p value of <.05, 2-sided, was considered statistically significant in all analyses.

We used binary logistic regression to study the association between cervical degeneration and nonrecovery (outcome) and previous suggested risk factors for nonrecovery. A 2-step model strategy was used. First, crude association between nonrecovery and each of the factors was calculated. Second, adjusted association was calculated through adjustment for level of pain, cervical stiffness distress, sick leave, age, gender, highest level of education, self-reported consistent neck pain, and video intervention.

Results

The total follow-up rate for 6 months follow-up by either web questionnaire or telephone interview was 97.6% (121 of 124) (Figure).

The demographics and baseline categorizations are shown in Table 2.

The prevalence of notable facet joint degeneration was 45.5% (55 of 121), with C6−C7 as the most commonly affected level (20.7%). The prevalence of disc degeneration was 56.2% (68 of 121), with C5−C6 as the most commonly affected level (22.3%). The prevalence of any detectable degeneration, disc, and facet joint included, was 66.9% (81 of 121) (Table 3). The degree of disc and facet joint degeneration was associated with age. No other associations were found (Tables 4 and 5).

There was an association between joint degeneration and nonrecovery (Table 6). In the group with moderate degree of facet joint degeneration, 69.6% reported nonrecovery compared with 23.6% among patients without any degeneration (adjusted odds ratio [OR] 6.7 [95% confidence interval: 1.9−24.3]). No associations between other degrees of facet joint degeneration or disc degeneration and nonrecovery were observed.

Table 3
Descriptive table of the most degenerated cervical segments with corresponding number of identified subjects. 0 = no detectable degeneration

		Most degenerated disc level					
		0	C4−C5	C5−C6	C6−C7	C7−T1	Total
Most degenerated facet joint level	0	40	2	5	7	1	55
	C2−C3	2	0	2	0	0	4
	C3−C4	3	0	1	3	0	7
	C4−C5	5	**0**	3	0	0	8
	C5−C6	5	0	**6**	1	0	12
	C6−C7	6	2	9	**8**	0	25
	C7−T1	7	0	1	1	**1**	10
	Total	68	4	27	20	2	121

There was also an association between total cervical degeneration (facet joint degeneration + disc degeneration) and nonrecovery (adjusted OR 6.2 [95% confidence interval: 2.0−19.0]) (supplementary table 1).

Additionally, the mean pain level was associated with facet joint degeneration (p=.01) and disc degeneration (p=.01) at follow up, using one-way analysis of variance analysis (supplementary table 2). When performing a post hoc analysis, moderate facet joint degeneration remained associated with level of pain. There was no association between disc degeneration and level of pain (supplementary table 2).

The overall nonrecovery rate was 38.0% (46 of 121). In the group followed up with the questionnaire, the nonrecovery rate was 39.4% (28 of 71) and in the group followed up with telephone interview 36.0% (18 of 50) (p=.70). The baseline variables were also similar between the groups regarding facet joint degeneration, disc degeneration, gender, pre-existing neck pain, level of pain, level of distress, level of neck stiffness, level of education, initial sick leave, or video intervention (p=0.19−0.88). The overall mean age at inclusion was 37.0 years (SD 12.5), however, the group followed up by questionnaire had a higher mean age at inclusion (40.2 vs. 33.3 years) (p<.05).

Discussion

This study demonstrates an increased risk for nonrecovery after whiplash trauma for patients with moderate facet

Table 4
Facet joint degeneration in relation to studied factors

		Facet joint degeneration group				
		0 Count (%)	1 Count (%)	2 Count (%)	3 Count (%)	p Value
Age group	16−29	26 (48.1%)	16 (64.0%)	8 (32.0%)	1 (5.9%)	<.05
	30−45	19 (35.2%)	6 (24.0%)	8 (32.0%)	4 (23.5%)	
	46−65	9 (16.7%)	3 (12.0%)	9 (36.0%)	12 (70.6%)	
Gender	Male	24 (44.4%)	13 (52.0%)	14 (56.0%)	12 (70.6%)	.30
	Female	30 (55.6%)	12 (48.0%)	11 (44.0%)	5 (29.4%)	
Highest level of education	No university	30 (55.6%)	16 (64.0%)	14 (56.0%)	9 (52.9%)	.90
	University	24 (44.4%)	9 (36.0%)	11 (44.0%)	8 (47.1%)	
Sick leave because of index trauma	No	43 (79.6%)	22 (88.0%)	18 (72.0%)	13 (76.5%)	.54
	Yes	11 (20.4%)	3 (12.0%)	7 (28.0%)	4 (23.5%)	
Level of pain at baseline (NRS)	0−3	23 (42.6%)	8 (32.0%)	5 (20.0%)	5 (29.4%)	.18
	4−6	24 (44.4%)	9 (36.0%)	12 (48.0%)	6 (35.3%)	
	7−10	7 (13.0%)	8 (32.0%)	8 (32.0%)	6 (35.3%)	
Level of neck stiffness (NRS)	0−2	19 (35.2%)	5 (20.0%)	4 (16.0%)	25 (9.4%)	.39
	3−6	26 (48.1%)	14 (56.0%)	12 (48.0%)	7 (41.2%)	
	7−10	9 (16.7%)	6 (24.0%)	9 (36.0%)	5 (29.4%)	
Level of distress (NRS)	0−3	20 (37.0%)	8 (32.0%)	4 (16.0%)	6 (35.3%)	.09
	4−6	26 (48.1%)	11 (44.0%)	11 (44.0%)	4 (23.5%)	
	7−10	8 (14.8%)	6 (24.0%)	10 (40.0%)	7 (41.2%)	
Previous neck pain*	No	49 (90.7%)	22 (91.7%)	21 (91.3%)	14 (82.4%)	.77
	Yes	5 (9.3%)	2 (8.3%)	2 (8.7%)	3 (17.6%)	
RCT intervention	No	25 (46.3%)	8 (32.0%)	14 (56.0%)	6 (35.3%)	.32
	Yes	29 (53.7%)	17 (68.0%)	11 (44.0%)	11 (64.7%)	

NRS, numeric rating scale; RCT, randomized clinical trial.

* Missing values = 3.

Table 5
Disc Degeneration in relation to studied factors

		Disc joint degeneration group				
		0 Count (%)	1 Count (%)	2 Count (%)	3 Count (%)	p Value
Age group	16−29	42 (63.6%)	9 (26.5%)	0 (0.0%)	0 (0.0%)	<.05
	30−45	20 (30.3%)	11 (32.4%)	6 (37.5%)	0 (0.0%)	
	46−65	4 (6.1 %)	14 (41.2%)	10 (62.5%)	5 (100%)	
Gender	Male	31 (47.0%)	17 (50.0%)	11 (68.8%)	4 (80.0%)	.26
	Female	35 (53.0%)	17 (50.0%)	5 (31.3%)	1 (20.0%)	
Highest level of education	No university	42 (63.6%)	17 (50.0%)	7 (43.8%)	3 (60.0%)	.38
	University	24 (44.4%)	17 (50.0%)	9 (56.3%)	2 (40.0%)	
Sick leave because of index trauma	No	52 (78.8%)	26 (76.5%)	13 (81.3%)	5 (100.0%)	.84
	Yes	14 (21.2%)	8 (23.5%)	3 (18.8%)	0 (0.0%)	
Level of pain at baseline (NRS)	0−3	25 (37.9%)	8 (23.5%)	5 (31.3%)	3 (60.0%)	.60
	4−6	27 (40.9%)	15 (41.1%)	7 (43.8%)	2 (40.0%)	
	7−10	14 (21.2%)	11 (32.4%)	4 (25.0%)	0 (0.0%)	
Level of neck stiffness (NRS)	0−2	21 (31.8%)	5 (14.7%)	4 (25.0%)	3 (60.0%)	.08
	3−6	34 (51.5%)	15 (44.1%)	8 (50.0%)	2 (40.0%)	
	7−10	11 (16.7%)	14 (41.2%)	4 (25.0%)	0 (0.0%)	
Level of distress (NRS)	0−3	21 (31.8%)	9 (26.5%)	6 (37.5%)	2 (40.0%)	.98
	4−6	29 (43.9%)	15 (44.1%)	6 (37.5%)	2 (40.0%)	
	7−10	16 (24.2%)	10 (29.4%)	2 (25.0%)	1 (20.0%)	
Previous neck pain*	No	58 (90.6%)	28 (84.8%)	15 (93.8%)	5 (100.0%)	.82
	Yes	6 (9.4%)	5 (15.2%)	1 (6.3%)	0 (0.0%)	
RCT intervention	No	30 (45.5%)	16 (47.1%)	6 (37.5%)	1 (20.0%)	.71
	Yes	36 (54.5%)	18 (52.9%)	10 (62.5%)	4 (80.0%)	

NRS, numeric rating scale; RCT, randomized clinical trial.
* Missing values n=3.

joint degeneration (grade 3 of 4) as demonstrated on CT-scans performed shortly after trauma. These findings contradict the previous dogma stating that pre-existing cervical degeneration does not affect the outcome for neck pain after MVA. However, only moderate facet joint degeneration showed a significant association with nonrecovery, unlike mild and severe degeneration. In contrast, no association was seen between disc degeneration and nonrecovery. This finding supports previous research with MRI-scans and plain radiography concluding the lack of such association. However, when facet joint degeneration and disc degeneration were included in a total score of degeneration the remained robustly significant. This reflects the facet joints impact on the total score.

Previous research has been based on unvalidated radiological assessment of degenerative changes of the facet joints using either plain radiography or MRI-scans. To our knowledge these analyses have been carried out without using a validated scoring system of degeneration and/or with primary focus on disc degeneration. This, in combination with the benefits of detecting early degenerative changes with CT, could have led to a failure to reveal the true association between degeneration and nonrecovery.

The fact that only moderate facet joint degeneration is associated with nonrecovery could partly be explained by the natural course of osteoarthritis. The degenerative process of the aging spine is thought to be less painful when the degeneration is more advanced and the range of motion is limited by ankylosis [45]. However, the degeneration process is not entirely linked to biological age and the variety of radiological findings within an age group is vast [46]. One could speculate that an early, rapid onset of osteoarthritis may be more painful than a slow, late development. To our knowledge however, no such evidence exists. Further, no association between mild degenerative changes in the facet joints and nonrecovery was seen. It could be argued that this negative finding is due to the difficulty in assessing radiologic findings of this subtle nature. However, previous agreement analysis [38] has shown acceptable correspondence even within this mild degree of degeneration.

Given that facet joint degeneration appears to be associated with nonrecovery after whiplash trauma the question can be posed as to whether whiplash trauma represents a catalyst for manifestation of symptoms of the degenerative processes that would otherwise have appeared spontaneously at a later stage. This would be analogous with the debut of symptoms of degenerative change in the event of trauma in for example the knee joint [47].

There is a clinical conviction that cervical degeneration starts in the disc and initiates a “degenerative cascade” [48]. If the degenerative cascade is the exclusive explanation for cervical degeneration, one might expect that the most advanced degeneration of disc and facet joints occur at the same segmentary level due to the load transfer from

Table 6
Association between nonrecovery and degeneration and other factors. Logistic regression analysis

		Count	Nonrecovery	p Value	Crude OR	95% CI	Adjusted OR[†]	95% CI
Facet joint degeneration	0	54	13 (23.6%)	<.05	Ref		Ref	
	1	25	10 (41.7%)		2.3	0.8−6.4	2.1	0.6−7.3
	2	25	16 (69.6%)		7.4	2.5−21.8	6.7	1.9−24.3
	3	17	7 (38.9%)		2.1	0.7−6.4	1.1	0.2−5.6
Disc degeneration	0	66	21 (32.3%)	.20	Ref		Ref	
	1	34	18 (52.9%)		2.5	1.0−5.5	1.8	0.5−6.4
	2	16	5 (31.3%)		1.0	0.3−3.1	0.92	0.2−5.8
	3	5	2 (40.0%)		1.4	0.2−9.0	3.04	0.2−46.9
Age groups	16−29	51	17 (33.3%)	.36	Ref		Ref	
	30-45	37	13 (37.1%)		0.6	0.2−1.4	0.8	0.2−3.8
	46−65	33	16 (47.1%)		0.7	0.3−1.7	1.3	0.3−5.3
Gender	Male	63	21 (33.9%)	.35	Ref		Ref	
	Female	58	25 (43.1%)		1.5	0.7−3.1	2.0	0.7−5.5
University education	No	69	26 (37.7%)	1.00	Ref		Ref	
	Yes	52	20 (39.2%)		1.1	0.5−2.3	1.0	0.4−2.7
Sick leave	No	96	36 (37.9%)	.82	Ref		Ref	
	Yes	25	10 (40.0%)		0.9	0.4−2.3	1.1	0.4−3.6
Level of pain (NRS)	0−3	39	5 (12.8%)	<.05	Ref		Ref	
	4−6	52	22 (42.3%)		5.0	1.7−14.8	3.4	0.7−16.8
	7−10	29	19 (65.5%)		12.9	3.9−43.4	6.9	1.0−46.2
Level of stiffness	0−2	33	5 (15.2%)	<.05	Ref		Ref	
	3−6	59	25 (42.4%)		4.1	1.4−12.1	1.6	0.3−8.1
	7−10	29	16 (57.1%)		7.5	2.2−25.1	1.34	0.2−9.5
Level of distress	0−3	38	9 (24.3%)	<.05	Ref		Ref	
	4−6	52	19 (35.8%)		1.7	0.7−4.4	1.0	0.3−3.1
	7−10	31	18 (60.0%)		4.7	1.6−13.3	2.3	0.6−9.6
Previous neck pain*	No	106	37 (34.6%)	<.05	Ref		Ref	
	Yes	12	9 (69.2%)		4.3	1.2−14.8	3.6	0.8−16.0
RCT intervention	No	68	17 (32.1%)	.26	Ref		Ref	
	Yes	53	29 (42.6%)		1.5	0.7−3.3	2.3	0.9−6.2

CI, confidence interval; NRS, numeric rating scale; RCT, randomized clinical trial.
* Missing values n=3.
† Adjusted for all 11 variables in Table 6.

the disc to the joint. Our findings partially contradict the degenerative cascade theory, as only 27.3% (15 of 55) of the most prominent facet joint degeneration was detected at the same level as the most pronounced disc degeneration.

The finding of C6−C7 being the facet joint with the highest frequency of degeneration supports the biomechanical theory of whiplash trauma, suggesting the inferior cervical levels are subject to the most pronounced extension forces [49]. These findings contradict previous reports of higher prevalence of degeneration in the upper part of the cervical spine [50].

The outcome measure of self-reported nonrecovery was chosen because of its simplicity and validity [51], as well as because its importance as self-perceived outcome. When mean level of pain at follow-up was used as an outcome measure (continuous), we found differences between mean pain between patients with different grades of degeneration with respect to both facet joint and disc degeneration. That is in contrast to the binary (yes/no) analysis with nonrecovery as outcome measure. However, the perception of not being recovered is complex and not exclusively equivalent to reporting high level of pain [52]. It could also be debated whether a disability score, such as Neck Disability Index, would better reflect the outcome and make the results more compatible with previous studies. However, there are considerable downsides to all outcome measures in this field [2] and work is in progress to establish a core outcome set for WAD [53].

Strengths and limitations

The high follow-up rate is the strength of this study. Further, all patients were enrolled with the same criteria and the cohort should be considered homogeneous. The methodology, where we have used a validated score for the assessment of the CT-scans is unique. Previous validated scoring systems are made on plain radiography [54] or MRI [55] and the facet joints have often been neglected.

This study also has some limitations. Our patients are selected from an existing RCT which makes our cohort rather small and therefore the CIs are wide, especially because some categories for the included factors have few patients.

The follow-up was carried out in 2 separate ways either by questionnaire or by telephone interview. Despite the absence of differences between the groups, it would have been preferable if the outcome had been measured in the same way. It is for example conceivable that the interview with the study nurse was influenced by expectations or that the patients were reluctant to report disappointing results. Further, it is possible that patients without remaining symptoms at follow-up were reluctant to fill out a questionnaire.

Another limitation is the fact that the uncovertebral joints have not been assessed. The reason for this is the difficulty in assessing them on CT-scans and the lack of validated scoring systems. It has however been proposed that the uncovertebral joints play a role in the development of chronic neck pain [56].

Finally, only the spinal segment with the worst disc degeneration and facet joint degeneration for each patient was chosen for our analysis. Nonetheless, we cannot exclude the possibility of other segments, then the most degenerated, being symptomatic. It can be hypothesized that a patient with degenerative changes in several cervical segments, of different stages, may experience pain from a moderately degenerated segment while being included in the severely degenerated group in our analysis. This would increase the nonrecovery rate in the severely degenerated group and subsequently disadvantage any comparison of nonrecovery in the moderately degenerated group. However, our analysis shows a significant association in the moderate degeneration group, despite any possible occurrence of pain from any other than the analyzed cervical segment.

Conclusions

To our knowledge, this is the first study with a standardized, validated scoring system that has found an association between facet joint degeneration and nonrecovery after whiplash trauma. These findings not only contradict the clinical consensus that outcome after whiplash injuries is not associated with pre-existing degeneration of the cervical spine, but also highlight the heterogeneity in cervical degeneration and the occurrence of isolated facet joint osteoarthritis without corresponding degenerative discs. We suggest that one of the underlying mechanisms of WAD may be that trauma triggers a painful clinical manifestation of underlying, previously asymptomatic, cervical facet joint degeneration. These findings should be confirmed by future research before implementation in clinical practice.

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Supplementary materials

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.spinee.2019.07.017.

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