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Original paper

Influence of whiplash injury on cervical spine stability

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The aim of this study was to define the influence of whiplash injury on cervical spine stability. The study involved 72 patients who had suffered from sprain injury to cervical spine of 0º–IIIº according to QTF. To verify the results the authors examined the control group whose representatives have never suffered from any cervical spine injury and met all the exclusion criteria. Conventional plain radiographs in both groups showed three lateral views: maximum flexion, neutral (resting) position and maximum extension view. The results of image studies were subjected to roentgenometric analysis to find mechanical symptoms of instability according to radiological criteria: AADI, anterior translation and regional angulation. The authors demonstrated that there was no influence of whiplash injury on mechanical stability of cervical spine measured on radiograms in static-functional lateral views.

Key words: *spine, whiplash injury, stability*

1. Introduction

In 1995, Canadian body of experts – *The Quebeck Task Force on Whiplash-Associated Disorders* officially proposed a definition of "whiplash injury": "acceleration–deceleration mechanism of energy transfer to the neck" which may result from rear-end, front or side impact collisions of motor vehicle [1]. This type of injury happen in 4 out of 1000 individuals. In most cases, there is no fracture of cervical spine. The variety of manifestations leads to a number of pathomechanical and pathophysiological theories on the nature of this type of injury [2]–[4]. Based on biomechanical studies on cervical spine during whiplash injury (in vivo), a model of cervical column function was presented [3]–[7]. The studies demonstrated that during movement cycle initiated by collision, the cervical spine experiences a temporary loss of intervertebral joint congruency, an increase of tension in articular capsules and anterior longitudinal ligament, an increased opening of intervertebral space of the motor segment C5–C6 and a pathological decrease of the dimensions of intervertebral foramens at this level as well as an axial attrition of the intervertebral disc in its posterior–superior area [7]–[11]. The injury to those structures increases and exceeds normal values in this area, depending on the impact force, which is a multiple of acceleration of gravity (G) [9], [12]. Until now, clinical studies did not give any information about the cause of symptoms and manifestations in patients who suffered from whiplash injury. One of potential theories states that the disorders in biomechanical stability of cervical spine are the consequence of this type of injury [13].

The goal of this article was to define the influence of whiplash injury on cervical spine stability.

2. Material and methods

Study involved 72 patients who had suffered from sprain injury of cervical spine of 0º–IIIº ac-

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cording to QTF and were treated in the Departament of Orthopaedic and Traumatology of Medical University in Wrocław between 2003 and 2006 [2], [14]. The group included 34 (47.2%) men and 38 (52.8%) women aged between 24 and 66 (mean of 36 ± 10.1). To verify the results the authors examined the control group whose representatives have never suffered from any cervical spine injury and met all the exclusion criteria. The control group consisted of 31 individuals: 14 men (42.5%) and 17 women (54.8%) aged between 23 and 78 (mean of 41 ± 16.5). The patients who had previously suffered from cervical spine or head injury, with diagnosed rheumatoid arthritis, diagnosed instability at any level of spine and of any etiology, diagnosed lupus erythematosus, or individuals who used any type of cervical spine collar were excluded from the study. The first follow-up was held 6 months after injury at a minimum, while mean follow-up in the patient group – after 29.25 months.

• For C2–C3 segment – Roy–Camille's criteria which include anterior translation (A.T.) and regional angulation (R.A.). Anterior translation values higher than 2 mm and regional angulation exceeding 5° were acknowledged as pathological [17].

• For C3–C7 segment – the White and Panjabi criteria which include anterior translation (A.T.) and regional angulation (R.A.). Anterior translation values higher than 3.5 mm, regional angulation exceeding 11° and the coverage of the inferior articular process with the superior articular process less than 50% were acknowledged as pathological (figure 4) [18], [19].

Data was analysed statistically with STATISTICA program, version 7.0. All the analysed parameters evaluated in all patient groups were subjected to preliminary assessment which gave mean values, standard deviation, median and minimum and maximum values. Nonparametrical alternatives of Student's *t*-test were used to calculate the relevance of the obtained results between the compared groups. The relationship between the chosen parameters was checked using the Goodman–Kruskal index. Statistical significance was taken at $p < 0.05$.

A B C

Fig. 1. The series of functional radiograms: A) flexion, B) neutral position, C) maximum extension (our own material)

Conventional plain radiographs in both groups showed three lateral views: maximum flexion, neutral (resting) position and maximum extension (figure 1) [15]. In patient group, the analysis included functional radiographs taken shortly after the injury (2–4 weeks) and during the last follow-up.

The results of image studies were subjected to roentgenometric analysis to find mechanical symptoms of instability according to the following radiological criteria:

• For C1–C2 segment – AADI (*anterior atlatnodentiale diameter index*) which is the distance between the posterior border of anterior arch of atlas and the anterior surface of the dens (odontoid process) of axis (figure 2). The distance exceeding 3 mm was acknowledged as pathological [16].

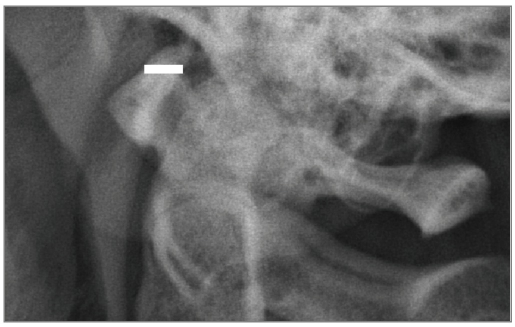

Fig. 2. AADI distance (our own material)

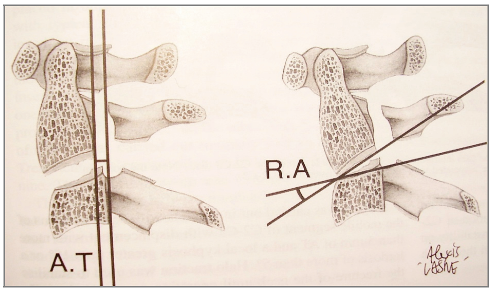

Fig. 3. Assessment of C2–C3 segment instability according to Roy–Camille [16]

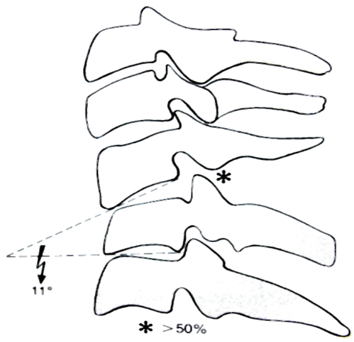

Fig. 4. Assessment of articular processes coverage [17]

3. Results

The analysis of the number and proportion of patients in the last follow-up and in the control group, where AADI parameter in lateral neutral view was normal, did not show any statistically significant difference ($p = 0.583$) (table 1).

Table 1. AADI in lateral neutral position view

AADI – neutral position			
	Normal	Abnormal value	Total
Patient group (last follow-up)	59	3	62
Control group	28	0	28

The analysis of the number and proportion of patients in the last follow-up and in the control group, where AADI parameter in lateral flexion view was normal, did not show either any statistically significant difference ($p = 0.315$) (table 2).

Table 2. AADI values in lateral flexion view

AADI – flexion			
	Normal	Abnormal value	Total
Patient group (last follow-up)	67	5	72
Control group	31	0	31

The analysis of the number and proportion of patients in the last follow-up and in the control group, where AADI parameter in lateral extension view was normal, did not show any statistically significant difference ($p = 0.668$) (table 3).

Table 3. AADI values in lateral extension view

AADI – extension			
	Normal	Abnormal value	Total
Patient group (last follow-up)	70	1	71
Control group	31	0	31

The instability of C2–C3 segment according to Roy–Camille's criteria – anterior translation (A.T.)

The analysis of the number and proportion of patients in the last follow-up and in the control group, where Roy–Camille's A.T. value in lateral neutral view was normal, did not show any statistically significant difference ($p = 0.842$) (table 4).

Table 4. Anterior translation (A.T.) in lateral neutral view according to Roy–Camille

Roy–Camille's A.T.			
	Normal	Abnormal value	Total
Patient group (last follow-up)	60	1	61
Control group	27	1	28

The analysis of the number and proportion of patients in the last follow-up and in the control group, where Roy–Camille's A.T. value in lateral flexion view was normal, did not show any statistically significant difference ($p = 0.234$) (table 5).

Table 5. Anterior translation (A.T.) in lateral flexion view according to Roy–Camille

Roy–Camille's A.T.			
	Normal	Abnormal value	Total
Patient group (last follow-up)	69	3	72
Control group	27	4	31

The analysis of the number and proportion of patients in the last follow-up and in the control group, where Roy–Camille's A.T. value in lateral extension view was normal, did not show any statistically significant difference ($p = 0.650$) (table 6).

Table 6. Anterior translation (A.T.)
in lateral extension view according to Roy–Camille

Roy–Camille's A.T.			
	Normal	Abnormal value	Total
Patient group (last follow-up)	72	0	72
Control group	29	1	30

Instability of C2–C3 segment according to Roy–Camille – regional angulation (R.A.)

In all radiological views, the analysis of the number and proportion of patients in the last follow-up and in the control group, where Roy–Camille's R.A. value was normal, did not show any statistically significant difference.

Instability of C3–C7 segment according to Panjabi and White – anterior translation (A.T.)

The analysis of X-rays in lateral neutral views did not show any pathological results in either group.

The analysis of number and proportion of patients in the last follow-up and in the control group, where Panjabi and White's A.T. value in lateral flexion view for C4–C5 segment was normal, did not show any statistically significant difference (p = 0.867) (table 7).

Table 7. Anterior translation (A.T.) in C4–C5 segment
in lateral flexion view according to Panjabi and White

Panjabi and White's A.T.			
	Normal	Abnormal value	Total
Patient group (last follow-up)	69	2	71
Control group	31	0	31

Table 8. Anterior translation (A.T.) in C5–C6 segment
in lateral flexion view according to Panjabi and White

Panjabi and White's A.T.			
	Normal	Abnormal value	Total
Patient group (last follow-up)	69	2	71
Control group	31	0	31

The analysis of the number and proportion of patients in the last follow-up and in the control group, where Panjabi and White's A.T. value in lateral flexion view for C5–C6 segment was normal, did not show any statistically significant difference (p = 0.867) (table 8).

The analysis of C3–C7 segment radiograms in lateral extension views did not show any pathological results in either group.

Instability of C3–C7 segment according to Panjabi and White – regional angulation (R.A.)

In all radiological views, the analysis of the number and proportion of patients in the last follow-up and in the control group, where Panjabi and White's R.A. value was normal, did not show any statistically significant difference.

Articular process coverage

The analysis of C3–C7 segment radiograms in lateral neutral views did not show any pathological results in either group.

The analysis of the radiograms in lateral flexion view showed one case with pathological coverage at the level of C3–C4, three cases of pathology in both groups in C4–C5 segment and one case of instability at the level of C6–C7 in patient group. The results were not statistically significant in either of groups (p = 0.853).

4. Discussion

The instability of motor units is, by definition, a biomechanical term. The clinical concept of instability is based on evaluative and biomechanical criteria. However, we still lack specific and sensitive clinical presentation that would be a reliable evidence of cervical spine instability. There is a huge divergence between biomechanical results and studies (mostly in vivo) and the results of clinical evaluation. That is why the concept of instability should be considered in two ways: as the mechanical instability and the functional one. The first type is the phenomenon that can be measured mathematically and physically. On the other hand, the functional instability is the disorder of statics and kinetics of cervical spine subject to physiological pressure which subsequently elicits clinical symptoms. By analogy with peripheral joints, one should assume the possibility of mechanical instability with and without clinical manifestations. Most authors who work on cervical spine instability adopt WHITE and PANJABI's criteria [20], [21]. COX and KNOPP in their studies consider anterior translation (A.T.) to be pathological if it exceeds 2 mm [20], [21]. Most cases of abnormal anterior translation were observed in radiograms in lateral flexion view. In clinical practice, the radiographs are the only studies which enable functional assessment of cervical spine motor units. If both location and interaction of vertebrae are known an indirect evaluation of ligament condition is possible. In the case of suspected instability, the authors of the NEXUS study recommend imaging with MRI [22]–[24]. However, this study still provides us with static image only. We think that the functional MRI would be promising [25].

5. Conclusion

The authors demonstrate that there is no influence of whiplash injury on mechanical stability of cervical spine measured on radiograms in static-functional lateral views.

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