Evaluation of dynamic formation of cervical spine column
based on functional radiological studies
in patients after cervical spine injury

JACEK MARTYNKIEWICZ, SZYMON FELIKS DRAGAN, KATARZYNA PŁOCIENIAK,
ARTHUR KRAWCZYK, MIROSŁAW KULEJ, SZYMON ŁUKASZ DRAGAN*

Department and Clinic of Orthopaedic and Traumatologic Surgery, Wroclaw Medical University.

The purpose of this study was to evaluate cervical spine function, based on our own functional method of roentgenometric analysis in patients who suffered from cervical spine sprain injury. Study involved 72 patients who suffered from cervical spine whiplash injury. Conventional plain radiographs in all patients included three lateral views: maximum flexion, neutral (resting) and maximum extension. All views allowed roentgenometric evaluation of ligament instability of the lower cervical spine C5–C7 according to the White and Panjabi criteria. Furthermore, based on literature analysis and their own clinical observations, the authors proposed new classification of dynamic formation of cervical spine column. The dynamic formation of cervical column is evaluated based on pathomechanical chain of being between normal and unstable. Authors’ own evaluation system in flexion views can be useful in diagnosis and treatment of this type of injury.

Key words: cervical spine, injury, pathomechanism

1. Introduction

Every year almost 60 thousand people are involved in traffic accidents, out of which almost 10% are fatal [1]. The outcomes and sequel of those injuries are treated mainly by orthopaedic surgeons. A modern safety means used in motor vehicles (e.g., multipoint seat belts, airbags) improved the protection of head and chest. However, cervical spine is one of those very important body regions that are still not protected. The use of seat belts caused the inertial forces affecting cervical spine in the indirect mechanism to be much greater [2]. This subsequently led to a higher incidence of acceleration–deceleration cervical spine injury (the so-called whiplash injury). In most cases there is no damage to bone tissue of cervical spine. There is no proof either of the higher incidence of ligament instability after such injuries [3]–[6]. Strictly defined criteria for diagnosing instability allow us to distinguish a group of results that are “controversial”, i.e., image studies are not normal, but still do not meet the criteria of instability [7], [8].

This article evaluates cervical spine function, based on our own functional method of roentgenometric analysis in patients who suffered from cervical spine sprain injury.

2. Materials and methods

The study involved 72 patients who suffered from cervical spine whiplash injury (figure 1) and were treated in the Department of Orthopaedic and Traumatology in Wroclaw between 2003 and 2006. In this study, 34 men (47.2%) and 38 women (52.8%) aged between 24 and 66 (mean of 36 ± 10.1) participated. To
verify the results the authors examined also the control group whose representatives have never suffered from any cervical spine injury and met all exclusion criteria. 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). Patients with diagnosed cervical spine fracture were excluded from the study. The first follow-up was held 6 months after injury at a minimum. The mean follow-up in the group under examination was 29.25 months.

Conventional plain radiographs in all the patients included three lateral views: maximum flexion, neutral (resting) and maximum extension [9], [10]. All views allowed the roentgenometric evaluation of:

- Ligament instability of the lower cervical spine C5–C7 according to the White and Panjabi criteria – anterior translation (A.T.) of more than 3.5 mm, regional angulation (R.A.) of more than 11° [7], [11].

Furthermore, based on literature analysis and our own clinical observations, the authors proposed [12]–[16]:

- New classification of dynamic formation of cervical spine column (called further in the text the JM classification):
  
  For lateral flexion view (figures 2–5):
  
  Fig. 2. Type 1. Arched anterior curve (our own material)
  
  Fig. 3. Type 2. Simple anterior curve (our own material)
  
  Fig. 4. Type 3. Anterior “stepping” curve: (our own material)  
  3.1 – does not meet the Panjabi and White criteria  
  3.2 – meets the Panjabi and White criteria
  
  Fig. 5. Type 4. Angular curve (our own material)  
  4.1 – does not meet the Panjabi and White criteria  
  4.2 – meets the Panjabi and White criteria

For lateral extension view (figures 6–9):

Fig. 1. Number of patients in both groups with sex distribution

Fig. 6. Type 1. Arched posterior curve (our own material)
Evaluation of dynamic formation of cervical spine column based on functional radiological studies

3. Results

Lateral resting view did not show any pathological values of anterior shift to meet the White and Panjab instability criteria. Lateral functional view in flexion showed pathological values of anterior shift at C4–C5 level in two cases in patient group, and did not show any substantial difference as compared with the control group ($p = 0.867$). Two cases of pathological values of A.T. parameter were found as well at the level of C5–C6 and again the comparison with control group was statistically insignificant ($p = 0.867$).

Based on lateral functional views in flexion in the patient group, most cases, i.e., 20 (27.7%) patients and 22 (30.5%) patients were classified into type 2 of JM classification (simple curve) and type 3 (stepping curve), respectively. In the control group, most individuals, i.e., 15 cases (48.5%), presented type 1 (arched curve) (table 2). The statistical analysis of the incidence of JM parameter in lateral functional view in flexion revealed that the distribution of this parameter in the patient and control groups was statistically insignificant ($p = 0.156$).

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

Table 2. JM classification for both groups in lateral flexion view

<table>
<thead>
<tr>
<th>JM</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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</thead>
<tbody>
<tr>
<td>Patient group at last follow-up</td>
<td>19</td>
<td>20</td>
<td>22</td>
<td>11</td>
</tr>
<tr>
<td>Control group</td>
<td>15</td>
<td>7</td>
<td>7</td>
<td>2</td>
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</tbody>
</table>

In lateral functional views in extension, the number of the patients was similar, most individuals from both groups were identified as type 1: 52 cases in patient group (72.2%) and 29 cases in control group (94.5%). Statistical analysis of the incidence of JM parameter for functional extension view showed that the distribution of this parameter in the patient and control groups was statistically insignificant ($p = 0.156$) (table 3).
Both groups were evaluated based on the symptoms of NDI. In the patient group, the symptoms were classified mainly into mild and moderate ones, as they applied to about 77% of patients. Heavy and severe symptoms were declared by 7% of patients. In the control group, almost 88% of individuals had no complaints or they suffered from mild symptoms only (table 4).

The study showed higher values of NDI parameter in post-injury group and the difference was statistically significant \((p < 0.001)\) (figure 10).

The Goodman–Kruskal gamma correlation index between JM parameter in functional view in flexion and NDI for the control group was \(-0.014\). Statistical analysis did not prove any significant correlation between those two parameters \((p = 0.938)\). The Goodman–Kruskal gamma correlation index between JM parameter in functional extension view and NDI for control group was \(-0.294\). Statistical analysis did not show any significant correlation between those two parameters \((p = 0.548)\).

4. Discussion

A sprain injury of cervical spine subsequently leads to disturbances in dynamic formation of cervical column in flexion. Individuals suffering from such an injury more often present its symptoms and complaints. The authors proposed their own classification (JM) which was based on clinical observations. There is no correlation between JM classification and NDI value for lateral extension view; however, statistical analysis has proved to be a correct research path, and JM classification for extension view needs further research. Dynamic formation of cervical spine column is the total of force directions of individual motor units during the movement in sagittal plane. Only type 4 refers to one motor unit. Straight axis of the spine, i.e. type 2 of JM classification, is referred to as a “string
sign” in clinical terminology and is the first type of pathologic dynamic formation of the spine column. Literature defines this type as an “apprehension” sign (muscle tension) in patients during the acute phase [19]. A prolonged muscle tension testifies to an increased coherence of motor units; however, it does not identify the cause of this process. The muscle tension disorders appear very unlikely to be responsible for JM of types 3 and 4; it is more probable that they are caused by ligament and capsular disorders. Panjabi’s study shows that whiplash mechanism causes injury within the anterior column of spine (anterior longitudinal ligament, disc), i.e., the injury to the structures that are stretched and squeezed (disc), being responsible for ligamentous restrictions of cervical spine extension [20]–[22]. Currently, there is no objective diagnostic method for verifying patient’s complaints and symptoms. The use of MRI did not yield the expected results [23], [24]. According to WILMING and PATIJAN [25] normal results of MRI studies in patients who suffer from cervical spine sprain injury are caused by still poor efficiency of this method. There are still no objective prognostic factors. So far, the most important prognostic factors include symptoms emerging just after the injury and general severity of injury according to QTF (Quebec Task Force) [26]–[28].

5. Conclusion

Whiplash injury causes dynamic disorders in individual motor units which subsequently affect cervical spine formation in sagittal plane. The dynamic formation of cervical column is evaluated based on pathomechanical chain of being between normal and unstable. Authors’ own evaluation system in flexion views can be useful in diagnosis and treatment of this type of injury.

References