

Side Impact Causes Multiplanar Cervical Spine Injuries

**The Journal of Trauma, Injury, Infection and Critical Care
Volume 63(6), December 2007, pp 1296-1307**

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FROM ABSTRACT

Background:

Side impact may cause neck and upper extremity pain, paresthesias, and impaired neck motion.

The goals of the present study were to identify and quantify cervical spine soft tissue injury and the injury threshold acceleration for side impact.

Methods:

Six human cervical spine specimens (C0-T1) underwent 3.5, 5, 6.5, and 8 g impacts.

Pre- and post-impact flexibility tests were performed. Soft tissue injury was defined as a significant increase in the average intervertebral flexibility above the baseline 2 g impact. The injury threshold was the lowest T1 horizontal peak acceleration that caused the injury.

Results:

The injury threshold acceleration was 6.5 g, with injuries occurring at C4-C5 through C7-T1 in flexion, axial rotation, or left lateral bending.

After 8 g, three-plane injury was observed at C4-C5 and C6-C7, whereas two-plane injury occurred at C3-C4 in flexion and left lateral bending and at C5-C6 and C7-T1 in axial rotation and left lateral bending.

Conclusions:

Side impact caused multiplanar injuries at C3-C4 through C7-T1 and significantly greater injury at C6-C7, as compared with head-forward rear impact.

THESE AUTHORS ALSO NOTE:

The estimated annual incidence of automotive side impacts in the USA is 3.18 million.

“Between 10% and 18% of occupants involved in side impacts sustain soft tissue neck injury.”

Clinical symptoms following side impacts include neck and upper extremity pain, paresthesias, and impaired neck motion, similar to those caused by front and rear impacts.

"The ligamentous neck injuries that occur during side impact are difficult to detect clinically using present imaging modalities, and may remain overlooked in light of readily identifiable chest, rib, and abdominal injuries that have been associated with occupants of side impacts."

"Cervical spine ligamentous injuries, including annular fiber and capsular ligament ruptures have been identified in radiographic and postmortem studies of side impact victims."

"Ligamentous hemorrhage, and laceration in the intervertebral discs, ligamentum apices dentis, ligamentum flavum, anterior longitudinal, posterior longitudinal, and capsular ligaments have been documented, primarily at the middle and lower cervical spine, C4-C5 through C7-T1, following simulated side impacts of whole cervical spines and whole cadavers."

RESULTS

In this study, whole cervical spines were subjected to a left sided impact. "The principal mode of injury was left lateral bending, which produced coupled injuries in axial rotation, flexion, and extension." The injury threshold acceleration was 6.5 g.

DISCUSSION

Previous epidemiologic, autopsy, and biomechanical studies have documented soft tissue cervical spine injury caused by side impacts.

In this study, injury was defined at each spinal level as a significant increase in any 1 of the 18 flexibility parameters above its corresponding baseline value. Because cadavers were used, this study simulated the "response of an unwarned subject."

Consistent with other studies, "functional and structural injury to the capsular ligaments and intervertebral discs at C5-C6 through C7-T1, with no injury to the upper cervical spine ligaments" were documented.

"Head-turned rear impact also caused greater injury severity than head-forward rear impact, but the increased severity occurred at C0-C1 and C5-C6."

“Multiplanar injury was documented in the present side impact study at C3-C4 through C7-T1, whereas it occurred as a result of head-turned rear impacts at C5-C6 and C7-T1, and it did not occur as a result of head-forward rear or frontal impacts. These data indicate that the dynamic three dimensional intervertebral rotation during side impact, and also during head-turned rear impact, caused multiplanar spinal instability resulting in significantly greater injury severity than head-forward rear impact.” **[Key Point]**

“The present results support those of previous biomechanical and epidemiologic studies which indicate that whiplash-type trauma may injure the middle and lower cervical spine, with minimal injury risk to the upper cervical spine.”

“The cumulative results of the present and previous studies indicate that whiplash trauma causes the highest potential for injury at the middle and lower cervical spine.”

“A cohort study of 3,014 occupants involved in automobile collisions found that 31% sustained neck injuries in rear impacts, 19% in side impacts, and 15% in frontal impacts.”

A study of 16,596 occupants involved in automobile collisions documented the greatest risk of sustaining soft tissue neck injury caused by rear impact followed by frontal and side impacts.

In a study of occupants who sustained neck injury caused by whiplash it “documented 52% of injuries in rear impact occupants, as compared with 27% in frontal impact and 16% in side impact.”

“The soft tissue injuries sustained during rear impacts may occur at lower accelerations than side and frontal impacts.”

CONCLUSIONS

In this experimental study, the injuries caused by side impact were found at levels C3-C4 through C7-T1 intervertebral levels.

“Left lateral bending injuries caused by side impact may cause capsular ligament and lateral annular fiber injury and ruptures.”

“The cumulative results of the present and previous studies using similar experimental models and protocols, indicated that whiplash-type trauma caused injury to the middle and lower cervical spine, with minimal injury risk to the upper cervical spine.”

"Based upon comparison of the injury threshold acceleration of the present and previous studies, neck injury risk is highest in rear impact, followed by side and frontal impacts."

KEY POINTS FROM DAN MURPHY

- 1) The annual incidence of automotive side impacts in the USA is 3.18 million.
- 2) "Between 10% and 18% of occupants involved in side impacts sustain soft tissue neck injury."
- 3) Clinical symptoms following side impacts include neck and upper extremity pain, paresthesias, and impaired neck motion, similar to those caused by front and rear impacts.
- 4) "The ligamentous neck injuries that occur during side impact are difficult to detect clinically using present imaging modalities, and may remain overlooked in light of readily identifiable chest, rib, and abdominal injuries that have been associated with occupants of side impacts."
- 5) "Cervical spine ligamentous injuries, including annular fiber and capsular ligament ruptures have been identified in radiographic and postmortem studies of side impact victims."
- 6) "Ligamentous hemorrhage, and laceration in the intervertebral discs, ligamentum apices dentis, ligamentum flavum, anterior longitudinal, posterior longitudinal, and capsular ligaments have been documented, primarily at the middle and lower cervical spine, C4-C5 through C7-T1, following simulated side impacts of whole cervical spines and whole cadavers."
- 7) Epidemiologic, autopsy, and biomechanical studies have documented soft tissue cervical spine injury caused by side impacts.
- 8) Side impact collisions produce coupled injuries in lateral bending, axial rotation, flexion, and extension.
- 9) Consistent with other studies, "functional and structural injury to the capsular ligaments and intervertebral discs at C5-C6 through C7-T1, with no injury to the upper cervical spine ligaments" were documented.
- 10) "Head-turned rear impact also caused greater injury severity than head-forward rear impact, but the increased severity occurred at C0-C1 and C5-C6."
[IMPORTANT: Head turned rear impact increases injury and specifically increases injury to the upper cervical spine occiput-atlas].

- 11) "Multiplanar injury was documented in the present side impact study at C3-C4 through C7-T1, whereas it occurred as a result of head-turned rear impacts at C5-C6 and C7-T1, and it did not occur as a result of head-forward rear or frontal impacts. These data indicate that the dynamic three dimensional intervertebral rotation during side impact, and also during head-turned rear impact, caused multiplanar spinal instability resulting in significantly greater injury severity than head-forward rear impact." **[Key Point]**
- 12) "The cumulative results of the present and previous studies indicate that whiplash trauma causes the highest potential for injury at the middle and lower cervical spine."
- 13) "The soft tissue injuries sustained during rear impacts may occur at lower accelerations than side and frontal impacts." **[Important]**
- 14) "Left lateral bending injuries caused by side impact may cause capsular ligament and lateral annular fiber injury and ruptures."
- 15) "Based upon comparison of the injury threshold acceleration of the present and previous studies, neck injury risk is highest in rear impact, followed by side and frontal impacts."
- 16) "Side impact caused multiplanar injuries at C3-C4 through C7-T1 and significantly greater injury at C6-C7, as compared with head-forward rear impact."