

Head-turned rear impact causing dynamic cervical intervertebral foramen narrowing: implications for ganglion and nerve root injury

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FROM ABSTRACT:

Object.

A rotated head posture at the time of vehicular rear impact has been correlated with a higher incidence and greater severity of chronic radicular symptoms than accidents occurring with the occupant facing forward.

No studies have been conducted to quantify the dynamic changes in foramen dimensions during head-turned rear-impact collisions.

The objectives of this study were to quantify the changes in foraminal width, height, and area during head-turned rear-impact collisions and to determine if dynamic narrowing causes potential cervical nerve root or ganglion impingement.

Methods.

The authors subjected a whole cervical spine model with muscle force replication and a surrogate head to simulated head-turned rear impacts of 3.5, 5, 6.5, and 8 G following a noninjurious 2-G baseline acceleration.

Continuous dynamic foraminal width, height, and area narrowing were recorded, and peaks were determined during each impact.

Analysis of the results indicated that the greatest potential for cervical ganglion compression injury existed at C5–6 and C6–7.

Conclusions.

Extrapolation of present results indicated potential ganglion compression in patients with a nonstenotic foramen at C5–6 and C6–7.

In patients with a stenotic foramen the injury risk greatly increases and spreads to include the C3–4 through C6–7 as well as C4–5 through C6–7 nerve roots.

THESE AUTHORS ALSO NOTE:

“Chronic radicular symptoms such as neck, shoulder, upper-back, and arm paresthesias have been documented in whiplash-injured patients.”

These symptoms have been associated with dorsal root ganglion and nerve root compression within the cervical intervertebral foramen.

Biomechanical studies document increased cervical foraminal narrowing during simultaneous neck extension, axial rotation, and lateral bending, compared with neck extension alone.

"The foraminal space narrowing documented during three-dimensional neck motion provides a basis for clinical diagnoses of cervical radiculopathy in whiplash-injured patients to whom the Spurling test is administered."

"The chronic radicular symptoms reported by whiplash-injured patients may be explained by the occurrence of cervical ganglion or nerve root injury during whiplash."

"A rotated head posture at the time of rear impact has been shown to be associated with a higher incidence and greater severity of chronic radicular symptoms compared with rear impacts occurring when an occupant is facing forward."

Some studies have indicated that a rotated head posture was the only factor associated with chronic whiplash symptoms and associated radiculopathy was most frequently noted in individuals whose heads were rotated at the time of rear impact, and that "after 1 year the symptoms significantly worsened." **[Important]**

"A rotated head posture at the time of rear impact caused significantly greater neck pain and increased the risk of chronic symptoms."

Cervical ganglion and nerve root injury is exacerbated if the head is rotated at the time of rear impact.

"Although foraminal narrowing and potential cervical ganglia and nerve root injury have been shown to be associated with head-forward rear impact, no studies have been conducted to quantify the dynamic change in foraminal dimensions during head-turned rear impact."

This study used 6 human cadavers. Prior to impact, the head was rotated about 28 degrees and laterally flexed (ipsilaterally) about 18 degrees.

"The greatest width narrowing of 1.8 mm was observed in the left C5-6 foramen at 8 G and in the left C4-5 foramen at 5 G."

DISCUSSION:

"Clinical and epidemiological studies have documented increased chronic radicular symptoms, including muscle weakness and neck, shoulder, upper-back, and arm paresthesias, in individuals whose heads were rotated at the time of a rear-impact collision compared with individuals who are facing forward."

“Cervical nerve root and ganglion compression within the intervertebral foramen can cause these radicular symptoms.”

This study documents intervertebral foramen width, height and area narrowing during simulated head-turned rear impact in a whole-cervical spine model with muscle force replication and a surrogate head.

“The cervical nerve root and ganglion complex are anatomically localized within the medial zone of the intervertebral foramen and, thus, are at risk for compression injury.”

“Foraminal width narrowing due to head-turned rear impact can potentially compress the cervical ganglia and nerve roots causing injury and leading to chronic radicular symptoms, especially in individuals with stenotic spines.” **[Key Point]**

The mean age of the specimens in this study was 80.2 years, and therefore most likely stiffer than those of the younger population most likely to suffer whiplash trauma. Thus, “the peak dynamic foraminal narrowing data acquired in the present study are conservative, relative to those that might be obtained in a younger population.” **[Important]**

In a stenotic foramen, the injury risk greatly increases and extends to include the C3–4 through C6–7 foramina and nerve roots.

The dynamic foraminal height narrowing may also cause C6–7 ganglion compression in the nonstenotic foramen.

“Analysis of the present data suggests that a head-turned rear impact may cause cervical ganglion or nerve root injury that leads to chronic radicular symptoms.”

“The results of the present study support previous clinical and epidemiological findings, which have indicated that a rotated head posture at the time of rear impact leads to a higher incidence and greater severity of radicular symptoms compared with an impact occurring when the individual is facing forward.”

“Increased ganglion impingement has been shown to cause an elevated neural response due to the high susceptibility of the dorsal root ganglion to mechanical compression, thus exacerbating the resultant radiculopathy.”

The potential “increased severity of C3–4 through C6–7 injury resulting from head-turned compared with head-forward rear impact may result in more severe acute symptoms of radicular irritation, including increased dermatomal pain, paresthesias, numbness, and weakness.”

This “increase in nerve injury and symptom severity may also lead to a worse clinical prognosis, including increased chronic radicular symptoms.”

“Chronic radicular symptoms reported by whiplash-injured patients may be exacerbated by increased residual cervical instability following head-turned compared with head-forward rear impact.”

“The acute cervical ganglion injury sustained during head-turned rear impact may increase the neural sensitivity to repeated and less severe compression, producing a protracted state of tactile allodynia (that is, pain sensation without mechanical stimulus).”

The increased ganglion impingement observed in the present study, in conjunction with the residual joint instability documented in a previous head-turned rear-impact study explains the “increased severity and duration of radicular symptoms associated clinically with rotated head posture, compared with head-forward rear-impact collision.”

CONCLUSIONS

Head-turned rear impact causes ganglion compression in nonstenotic C5–6 and C6–7 foramina, and the injury risk greatly increases and extends to the C3–7 foramina and nerve roots, in cases involving a stenotic foramen.

“Compression injury at these spinal levels may cause pain and paresthesias in the periclavicular region, anterior and posterior neck, deltoid and trapezius muscles, and dorsal arm, forearm, and hand.”

“The greater potential severity of ganglion injury observed as a result of head-turned compared with head-forward rear impact is supported by clinical and epidemiological observations.”

“Chronic radicular symptoms reported by whiplash-injured patients may be caused by dynamic cervical ganglion or nerve root compressive injury or repeated and less severe compression due to cervical instability.”

KEY POINTS FROM DAN MURPHY

- 1) A rotated head posture at the time of vehicular rear impact is correlated with a higher incidence and greater severity of chronic radicular symptoms than accidents occurring with the occupant facing forward.
- 2) The greatest potential for cervical ganglion compression injury is at C5–6 and C6–7.
- 3) In patients with a stenotic foramen the injury risk greatly increases and spreads to include the C3–4 through C6–7 ganglions and nerve roots.

- 4) "Chronic radicular symptoms such as neck, shoulder, upper-back, and arm paresthesias have been documented in whiplash-injured patients." These symptoms have been associated with dorsal root ganglion and nerve root compression within the cervical intervertebral foramen.
- 5) The Spurling test, which couples cervical extension, rotation, lateral flexion and compression is valid in the clinical diagnoses of cervical radiculopathy.
- 6) "A rotated head posture at the time of rear impact caused significantly greater neck pain and increased the risk of chronic symptoms."
- 7) Cervical ganglion and nerve root injury is exacerbated if the head is rotated at the time of rear impact.
- 8) "Clinical and epidemiological studies have documented increased chronic radicular symptoms, including muscle weakness and neck, shoulder, upper-back, and arm paresthesias, in individuals whose heads were rotated at the time of a rear-impact collision compared with individuals who are facing forward."
- 9) "Foraminal width narrowing due to head-turned rear impact can potentially compress the cervical ganglia and nerve roots causing injury and leading to chronic radicular symptoms, especially in individuals with stenotic spines." **[Key Point]**
- 10) "Analysis of the present data suggests that a head-turned rear impact may cause cervical ganglion or nerve root injury that leads to chronic radicular symptoms."
- 11) Increase in nerve injury and symptom severity leads to a worse clinical prognosis, including increased chronic radicular symptoms.
- 12) The increased ganglion impingement observed in the present study, in conjunction with the residual joint instability documented in a previous head-turned rear-impact study explains the "increased severity and duration of radicular symptoms associated clinically with rotated head posture, compared with head-forward rear-impact collision."
- 13) "Compression injury at these spinal levels may cause pain and paresthesias in the periclavicular region, anterior and posterior neck, deltoid and trapezius muscles, and dorsal arm, forearm, and hand."