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Authors' reply

Sirs: We would like to thank Professor Penning for his thoughtful comments on our article "Dynamic elongation of the vertebral artery during an in vitro whiplash simulation" [3]. Professor Penning states three points. First, he offers a suggestion for a future study: the vertebral artery (VA) elongation during physiological "chin-in/chin-out" maneuver should be investigated because it relates to the S-shaped neck curvature formed during the initial stage of whiplash. Second, he presents his hypothesis of head hypertranslation in whiplash trauma [5, 6]. Finally, based on his observation, Professor Penning concludes: the VA elongation takes place primarily in the craniovertebral region. We will respond to each point separately.

For the purpose of assessing potentially injurious dynamic elongation of the VA during whiplash, we were seeking the head motion as a baseline that would produce maximum physiological elongation of the VA. Lateral bending and axial rotation of the head in a contralateral direction to the VA has been shown to produce its maximal elongation [3].

We agree with Professor Penning that the "chin-in/chin-out" maneuver will not likely result in a significant stretch of the VA, because this translation movement takes place in a plane perpendicular to the VA. Our conclusions pertaining to the hyperelongation of the VA during whiplash related to its dynamic elongation which exceeded the maximum physiological elongation. Our conclusions pertaining to the hyperelongation of the VA during whiplash related to its dynamic elongation which exceeded the maximum physiological elongation.

Our work indeed supports the observations of Penning [5, 6] that the head translates posteriorly in the initial stage of whiplash trauma [1]. Lower cervical levels undergo extension while the upper levels undergo flexion and the neck forms an S-shaped curvature [2]. However, our results do not support Penning's hypothesis that the craniovertebral region is the principal site of cervical spine injury in whiplash. We found that the lower cervical levels more consistently exceeded their physiological limits in extension [2]. The injuries to the lower cervical joints were confirmed by the increased flexibility at these levels after trauma [4]. The joint flexibility at the upper cervical levels increased only after the highest sled acceleration traumas. We recognize that Professor Penning lacked the opportunity to review our work in its entirety, as many of our

papers were scheduled for publication after he had written his letter to the Editor [1, 2, 4].

In conclusion, it may well be that the VA elongation takes place primarily in the craniovertebral region, but as we measured only the VA elongation as a whole in the present study, this statement cannot be verified based on our results. Future studies will be directed towards identifying the site of the greatest strain in the VA.

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