DETAILED EXAMINATION OF THE LOWER CERVICAL SPINE FACET JOINTS IN A ROAD TRAFFIC CRASH FATALITY – A CASE STUDY

Lars Uhrenholt¹², Edith Nielsen³, Annie Vesterby Charles¹, Markil Gregersen¹, Flemming Melsen⁴

¹ Department of Forensic Medicine, University of Aarhus, Denmark
² Nordic Institute of Chiropractic and Clinical Biomechanics, Odense, Denmark
³ Department of Neuroradiology, Aarhus Sygehus, University Hospital of Aarhus, Denmark
⁴ Institute of Pathology, Aarhus Sygehus, University Hospital of Aarhus, Denmark

ABSTRACT

The lower cervical spine facet joints of a road traffic crash fatality were examined using diagnostic imaging and histological techniques. No injuries to the cervical spine facet joints could be identified with diagnostic imaging including conventional radiology, CT and MRI. Examination of stained histological sections visualised the morphology and integrity of the facet joints in detail. Occult injuries to and in close proximity to the cervical spine facet joints were identified only on histological examination.

This case study emphasises the need for development of more sensitive diagnostic methods in clinical settings where symptomatology may be present despite negative diagnostic imaging.

Keywords: cervical spine, whiplash, facet joint, diagnostic imaging, histology

THE CERVICAL SPINE has a central role in many clinical pain syndromes. Recently a number of studies have identified the upper and lower cervical spine facet joints as potential culprits in relation to the clinical conditions of whiplash associated disorders (WAD) following road traffic crashes (Barnsley 1994, Barnsley 1995, Lord 1996).

At the same time traumatological studies using both post-mortem human subjects (PMHS) and volunteers have identified pathophysiological “s-shape” kinematics during rear-impact collisions at low speed collisions with risk of injury of particularly the facet joints (Grauer 1997, Kaneoka 1999).

The anatomy of synovial joints (typically the knee or hip joint) have been described in great detail including the typical structure and organisation of the articular cartilage, calcified cartilage and underlying bone. However, detailed histological description of the cervical spine facet joints with regard to morphology and pathoanatomy is limited (Bland 1990, Hirsch 1967, Fletcher 1990).

Histological examination of the cervical spine facet joints is often difficult and time-consuming. Through the 1990’es an increasing number of studies appeared where cryomicrotomy methods had been utilised in the investigation of the cervical spine (Jonsson 1991, Jonsson 1994, Rauschning 1989, Yoganandan 2001, Yoganandan 2003). However, only few studies have been published where large un-decalcified unfrozen osseous specimens have been produced for histological examination (Giles 1983, Hahn 1991).

We present a case of a road traffic fatality whose lower cervical spine facet joints were examined by both neuroradiological techniques as well as by microscopy of un-decalcified unfrozen histological sections.

MECHANISM OF TRAUMA

On a clear day a previously healthy male in his thirties was driving approximately 100 km/hour on a freeway when his van suddenly turned over on the side, collided with the road barrier on the right side of the road and continued to skid until it stopped, placed on its side. At the scene the unbelted driver was found dead inside the vehicle.
AUTOPSY FINDINGS
The medico legal autopsy performed at our institute revealed extensive bruising, abrasion and laceration of the face on the right side, bleeding from both ears and diagonal fractures of the basis of the cranium on both sides extending to the cranial vault on the right side (Figure 1). There were minute bleeding in the meninges of the cerebellum and the brainstem, and there were minor lesions in the temporal lobe on the right side and cerebral oedema. Furthermore, several superficial lesions were identified over the body. There were no penetrating injuries to the cervical spine. The immediate cause of death was brain injuries associated with the skull base fractures. The blood alcohol concentration was 0,71{degre}$/00. There was no record of narcotics in the blood or urine.

![Figure 1 - Head and upper neck injuries at autopsy](image)

DIAGNOSTIC IMAGING FINDINGS
The lower four cervical spine vertebral segments including the facet joints on both sides were removed en bloc during the autopsy and a neuroradiological examination was performed using standardised clinical procedures including conventional radiography, spiral CT (thickness 1,3 mm, increment 0,6 mm, FOV approx. 100 mm and matrix 512x512) and MRI (Sagittal T1, T2, STIR, axial T1 and T2 and coronal T2, thickness 3 mm, spacing 0 and FOV 16x16). There was no evidence of fracture, dislocation or haemarthrosis of the facet joints. Retrospective evaluation after histological examination reached the same conclusions.

HISTOLOGICAL PROCEDURE
Histological examination of the lower cervical spine facet joints on both sides was performed with a specialised technique (Uhrenholt 2005). This approach consisted of fixation of the specimen in 70% ethanol gradually increased to 99%, followed by immersion in methyl methacrylate. Following hardening of the embedding material serial parasagittal sectioning into 3-mm slices was performed followed by re-embedding of slices containing facet joint structures. A 10 µm thick section was made from each re-embedded slice and stained with Masson Goldner-Trichrome followed by microscopical examination by an experienced pathologist.

HISTOLOGICAL FINDINGS
Macroscopical examination of the 3-mm sections showed extensive soft tissue bleeding at the anterior aspect of the articular pillars, adjacent to the facet joints structures, on both sides from C5 to C7. There were signs of haemarthrosis and bleeding in the underlying bone in several facet joints in the mid-cervical region on both sides (Figure 2a).

Microscopical analysis of the 10 µm stained sections revealed discrete injuries to the lower cervical spine facet joints bilaterally, primarily on the left side, including haemarthrosis, avulsion of capsular attachments, muscular haemorrhages, contusions of the synovial folds and discrete fractures extending from the deep cartilage through the subchondral plate to the underlying cancellous bone with associated bleeding (Figure 2b).
DISCUSSION

This is a study of a road traffic crash fatality whose lower cervical spine facet joints were examined in detail with emphasis on diagnostic imaging and histological findings. The neuroradiological examination did not identify injuries to the facet joint structures on either the initial nor respective examination despite knowledge of histologically identified lesions.

The microscopical examination revealed numerous discrete injuries to lower cervical spine facet joints that included injuries to the joint capsule, muscular attachments, synovial folds and the deep hyaline cartilage fissures extending through the underlying cancellous bone as fractures.

The cervical spine facet joints contain a number of nociceptive structures such as the intra-articular synovial fold, joint capsule and adjacent musculature. Due to these morphological characteristics in combination with traumatological exposures, including the “s-shape” during rear-impact collisions, these structures may be injured and cause symptoms following road traffic crashes.

Although this study is a post-mortem investigation it must be kept in mind that injuries identified at post-mortem may in fact be a reasonable indication of what injuries could have been sustained had the patient been subjected to forces short of lethal forces (Barnsley 1994, Uhrenholt 2002). Therefore, the findings in this study are highly relevant for clinical practice where road traffic crash victims often consult physicians, such as orthopaedic specialists and chiropractors, who are specialised in the diagnosis and treatment of musculoskeletal disorders, where diagnostic imaging may be negative.

Uhrenholt et al. (2002) systematically reviewed post-mortem studies that had examined the cervical spine following road traffic crashes with specialised autopsy techniques under controlled settings. Three studies fulfilling the criteria for in-depth analysis revealed that a high number of injuries could be identified only if the post-mortem technique used was of high quality, and that diagnostic imaging (conventional radiography) missed more than 93% of discrete lesions to the cervical spine intervertebral discs and facet joints (Schonstrom 1993, Taylor 1993, Taylor 1996, Uhrenholt 2002).

Other studies have identified similar discrete lesions to the cervical spine of road traffic crash fatalities and in accordance with our findings concluded that conventional radiological examination of the cervical spine misses the majority of discrete or occult lesions, with computed tomography and MR-imaging also not being able to identify all lesions (Stabler 2001, Uhrenholt 2002).

CONCLUSIONS

We have presented a case of a road traffic crash fatality whose lower cervical spine facet joints were examined with diagnostic imaging and specialised histological methods.

It is clear from this study that discrete injuries to the cervical spine facet joints are very likely to be missed on standard diagnostic imaging procedures including conventional radiology, CT and MRI. In contrast, histological analysis allows precise description of the integrity of the facet joints.

Hence, only microscopical examination identified discrete lesions in and around the articulating structures of the cervical spine facet joints in this case of a road traffic crash fatality.
ACKNOWLEDGEMENTS

This paper is made possible by generous financial support from the European Chiropractors’ Union Research Fund, Geneva, grant no. A.03-5, and support from the Fund to Promotion of Chiropractic Research and Postgraduate Education, Copenhagen.

REFERENCES