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The Correlation Between Surgical and fMRI Findings After Trauma to the Upper Cervical Spine

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ABSTRACT. Objectives. Trauma to the cervical spine can give rise to injuries that can be difficult to diagnose. This is especially valid for injuries to ligaments and joint capsules in the cranio-cervical joint complex (CCJ). The aim of the study was to see the relation between findings at surgery in the CCJ area and what was described in reports from functional Magnetic Resonance Imaging (fMRI).

Material and Methods. The findings from nine patients exposed to neck trauma and showing chronic symptoms were compared. The fMRI and surgery were performed a median time of 11 years (3-14) after the accident.

Interventions. Not applicable.

Results. All nine patients showed pronounced instability C1-C2 at surgery as well as at fMRI. Paradoxical mobility as a sign of alar ligament injury was seen in nine cases at fMRI and in eight cases at surgery. At fMRI scar formation in the joint capsule of C1-C2 was reported in nine cases and in six cases at surgery.

Discussion and Summary. Earlier radiological examinations including X-ray, MRI and CT were normal in all patients. The fMRI

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gave very precise information on injuries and functional disturbances that can be seen in trauma to the CCJ. The method consequently constitutes a valuable contribution to diagnosing injuries in the CCJ area. doi:10.1300/J180v05n02_04 [Article copies available for a fee from The Haworth Document Delivery Service: 1-800-HAWORTH. E-mail address: <docdelivery@haworthpress.com> Website: <<http://www.HaworthPress.com>> © 2006 by The Haworth Press, Inc. All rights reserved.]

KEYWORDS. Diagnosis, functional MRI, neck trauma, upper cervical spine, whiplash

INTRODUCTION

Trauma to the head or neck can give rise to injuries in tissues that can be difficult to diagnose.¹ This is especially true for injuries to ligaments and joint capsules in the cranio-cervical joint complex (CCJ). This complex comprises the region from the skull base joint to the C2-C3 zygapophyseal joint.² The concept includes ligaments, facet joints and muscles.

Injuries to connective tissues can give rise to mechanical instability between the head and the cervical spine and also at C2-C3. The injury will also give rise to a "functional instability," as ligaments, joint capsules and neck muscles have receptors registering positions and movements.³ That the region has a very important proprioceptive function is evident as the deep neck muscles in the upper cervical spine have an extremely high density of muscle spindles.⁴

Consequently, instability of the CCJ should not be looked at as a purely mechanical problem but as a potentially serious disturbance of the proprioceptive input resulting from different positions of the head in relation to the body.

Movement of the head sends afferent signals to the central nervous system (CNS) that make it possible to maintain body posture and balance. Although these signals principally come from the organ of equilibrium in the ear, they are also transmitted from the eyes. These signals normally harmonize with signals from the CCJ.

Disturbances of the interplay between proprioception from the head and cervical spine can give rise to vertigo or dizziness.^{5,6}

Whiplash injuries affecting the upper cervical spine may cause upper cervical syndrome⁷ characterised, among other things, by balance disturbances, with dizziness, visual problems and by derangements in muscular coordination with fumbling and jaw pain.

It has been demonstrated that such disturbances have been normalized or reduced after stabilisation surgery of the CCJ.^{8,9}

Consequently there are reasons to conclude that injuries to the CCJ may cause a variety of symptoms owing to mechanical factors as well as disturbed proprioception. Accurate diagnosis of such lesions is therefore important.

In 1995 Volle described an imaging technique, functional Magnetic Resonance Imaging (fMRI), wherein structural injuries in the CCJ could be studied and instability demonstrated.¹⁰ The technique is time consuming as it requires that the patient's head be adjusted in a number of different positions. The examination is very time intensive, requiring approximately 4 hours to complete. The technique has been recently described in a neurosurgery text book.¹¹

The aim of the present study was to evaluate the degree of correlation between findings of CCJ instability seen in fMRI and those of a subsequent surgery to address the instability.

METHODS

The study sample included nine patients exposed to cervical spine trauma (road traffic crashes or falls) and had developed chronic symptoms. Seven patients were female and two were male. The patients had been referred for CCJ fMRI with symptoms possibly indicating injury to the CCJ, and, based on the results of the fMRI evaluation, referred by the same doctor for stabilising surgery of the CCJ area. The fMRI and surgery were performed after a median time of 11 years (3-14) after the accident.

The fMRI was performed on a 1.0 Tesla Magnetom (Siemens AG) with a flexible circular surface coil positioned over the target points. Thin slices, mostly between 2 and 3 mm only orientated to the CCJ capsules and surrounding ligamentous structures were performed using different pulse sequences and additional positron density weighted sequences.

The fMRI examination was performed by continuous flexion and extension and lateral bending of the upper part of the cervical spine to the right and left with the head in fixed positions. Then the head was continuously rotated to the right and left until maximal end position was reached.

The surgical technique involved dorsal cranio-cervical fixation by plates and trans articular screwing at C1-C2 described by Magerl.¹²

The surgery reports were studied with respect to the injuries reported by the surgeon, regarding instability in the upper segments of the neck, paradoxical mobility and visible injuries including scar tissue on joint capsules at C1-C2. The surgical findings were then compared with the changes described at the fMRI examination by one of the authors (BHJ).

Both the surgeon and the radiologist diagnosed instability following their clinical experiences. No method of measurement was mentioned in their reports.

RESULTS

All nine patients showed pronounced instability C1-C2 at surgery as well as at fMRI. Paradoxical mobility as a sign of alar ligament injury was shown in nine cases at fMRI and in eight cases at surgery. At fMRI scar formation in joint capsule of C1-C2 was reported in nine cases and in six cases at surgery. All findings are presented in Table 1.

DISCUSSION

The patients had been referred for fMRI and surgery as their quality of life was extremely poor, with severe pain and many symptoms such as vertigo, dizziness, balance disturbances, fumbling, functional disturbances of their eyes and severe sleep problems after a history of cervical spine trauma. They consequently represented the most severely injured patient population wherein structural injuries would be most likely.

The patients had been referred for fMRI and surgery by the same doctor. The surgeon's report was independent from the fMRI report.

TABLE 1. Numbers findings described at surgery, fMRI and earlier radiological examination

	Surgery	fMRI	Earlier X-ray, MRI, CT
Pronounced instability C0-C1	8	4	0
Pronounced instability C1-C2	9	9	0
Paradoxical mobility/alar ligament injury	8	9	0
Injury at joint capsule C1-C2	5	1	0
Scar formation, joint capsule C1-C2	6	9	0

Earlier radiological examinations as X-ray, MRI and CT were normal in all patients.

At surgery it was possible to observe the injuries in the dorsal aspect of the neck and spine and functional disturbances could be observed. Some of the injuries that were registered at fMRI could not be observed at surgery. The study consequently comprised only the injuries that could be seen at surgery as well as fMRI.

Judgement of instability between C0-C1 and C1-C2 is in all essentials founded on the doctors' clinical experience. Both doctors have many years of experience with the injury type. The surgeon also has extensive experience with clinical evaluation of cervical spine instability. The concordance of the two doctors' determinations of instability would tend to indicate that their observations are of clinical relevance.

Paradoxical mobility refers to altered mobility of the atlas vertebra against the axis.¹³ Normally the atlas and axis rotate in opposite directions when lateral bending of the upper part of the cervical spine, but in paradoxical mobility they move in the same direction. The phenomenon is an objective sign of altered stabilisation function of one or both alar ligaments.

Injuries to the joint capsule of C1-C2 have been described in cervical trauma.¹⁴ Surgical reports occasionally mention different degrees of injuries to the capsules. Sometimes it is noted that the capsule is completely torn and that the surgeon consequently could look directly in to the joint space. Injuries to the joint capsule are seldom reported with conventional MRI, indicating either that injury is more difficult to diagnose with standard MRI or that often it is simply not looked for.

CONCLUSION

The fMRI gives accurate information on injuries and functional disturbances that may be present following trauma to the CCJ. Further study with larger study populations and controls is needed to substantiate the present findings.

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