THE VALIDITY OF CLINICAL TESTS FOR
CRANIOVERTEBRAL INSTABILITY

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Thesis presented for the degree of
Doctor of Philosophy
The University of Newcastle
May 2013
STATEMENT OF ORIGINALITY

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LIST OF ABBREVIATIONS

3D three dimensional
AAD atlantoaxial dislocation
AAS atlantoaxial subluxation
ADI atlantodental interval
A-P anterior-posterior
BDI basion dental interval
C1 first cervical vertebra
C2 second cervical vertebra
C3 third cervical vertebra
C6 sixth cervical vertebra
C7 seventh cervical vertebra
CI confidence interval
CSA cross sectional area
CT computed tomography
CV cervical vertebra
CVI cranovertebral instability
DICOM Digital Imaging and Communications in Medicine
FOV field of view
ICC intraclass correlation coefficient
mm millimetres
MPA Musculoskeletal Physiotherapy Australia
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>MRI</td>
<td>magnetic resonance imaging</td>
</tr>
<tr>
<td>MVA</td>
<td>motor vehicle accident</td>
</tr>
<tr>
<td>NA</td>
<td>not available</td>
</tr>
<tr>
<td>O</td>
<td>occiput</td>
</tr>
<tr>
<td>PADI</td>
<td>posterior atlantodental interval</td>
</tr>
<tr>
<td>PAL</td>
<td>posterior axial line</td>
</tr>
<tr>
<td>PD</td>
<td>proton density</td>
</tr>
<tr>
<td>PG</td>
<td>post-graduate</td>
</tr>
<tr>
<td>PLL</td>
<td>posterior longitudinal ligament</td>
</tr>
<tr>
<td>PPIVM</td>
<td>passive physiological intervertebral movement</td>
</tr>
<tr>
<td>r</td>
<td>Pearson’s correlation coefficient</td>
</tr>
<tr>
<td>SD</td>
<td>standard deviation</td>
</tr>
<tr>
<td>SE</td>
<td>spin echo</td>
</tr>
<tr>
<td>SLE</td>
<td>systemic lupus erythematosus</td>
</tr>
<tr>
<td>T</td>
<td>Tesla</td>
</tr>
<tr>
<td>TE</td>
<td>echo time</td>
</tr>
<tr>
<td>TR</td>
<td>repetition time</td>
</tr>
<tr>
<td>TSE</td>
<td>turbo spin echo</td>
</tr>
<tr>
<td>WAD</td>
<td>whiplash associated disorder</td>
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ABSTRACT

The work contained in this thesis encompasses four studies to examine the validity of clinical testing for clinical instability of the craniovertebral region. Validity was explored through the utilisation and exploration of the constructs of convention, biological plausibility and empirical proof.

Consensual validity for clinical testing was explored through a survey of knowledge and attitudes to instability testing in a nationwide survey involving 1528 Australian physiotherapists. Details of respondents’ understanding of the concept of instability, potential clinical presentations of patients with segmental hypermobility of the upper cervical spine, knowledge of published clinical stress tests, attitudes toward performing these clinical tests and inclusion of craniovertebral testing procedures in clinical guidelines were all assessed. On the basis of the information returned, it appears that the level of knowledge and understanding of these disorders, their clinical presentation, assessment and their risk factors is low. Understanding of the clinical testing manoeuvres was also poor, with the majority of respondents never applying these tests clinically. Completion of post-graduate coursework in musculoskeletal physiotherapy clearly improved exposure to these concepts and tests in respondents, but did not significantly affect use of testing for screening prior to treatment of the upper cervical spine overall. Consensual validity for clinical testing of craniovertebral instability must be considered to be low based upon the absence of agreement of the existence, presentation and assessment of the disorder.
Biological plausibility of testing was explored through examination of the morphology of
the ligaments of the craniovertebral region. Observations made during the dissection of
11 cadaveric specimens were mostly in accordance with descriptions of the anatomy
upon which the clinical test procedures have been based. However, the tectorial
membrane was observed to be a more complex structure than has previously been
understood with its fibre arrangement suggesting a role as a potentially limiting structure
to axial rotation of the upper cervical segments. The existence of the previously reported
‘atlantal’ portion of the alar ligaments was also challenged. It was not observed in any
specimen examined and the presence of these bands of tissue in any individual should be
considered an anatomical variant. Overall, the gross morphology of the craniovertebral
ligaments observed being consistent with the basis of the clinical tests confers face
validity on the testing procedures.

The biological basis for testing was further explored using magnetic resonance imaging
of six specimens at high (4.6T) and clinical (3.0T) definition acquisitions. Observations
were confirmed by dissection and the accuracy of measurements and observations
assessed. Again, the gross morphology was consistent with the structural assumptions
underpinning the clinical tests, thus enhancing their face validity. Clinical acquisitions
were compared using three different sequences to assess the optimal acquisition sequence
to be used in subsequent patient studies. Proton density-weighted sequences were found
to be superior in identification, delineation and measurement of the ligaments of this
region.
Empirical proof that clinical tests are capable of influencing the ligaments of this region was addressed in the final study. The upper cervical spines of 16 healthy volunteers were imaged using MRI in both neutral and end-range clinical test positions. Ligaments were assessed using both direct measurement and indirect estimates of bony displacement. Statistically significant changes in ligament dimension were demonstrated for the ligaments in all tests examined. Direct evidence that the ligament may be influenced in a predictable manner through the imposition of clinical tests provides a strong case for the establishment of construct validity for each of these described clinical tests.

Through utilising the three axioms of convention, biological plausibility and empirical proof, a number of aspects of the validity of clinically testing the craniovertebral region for instability have been assessed. Whilst the consensual validity of testing appears poor, the case for face validity and construct validity for the ligament stress tests is strong suggesting that further research is warranted which may now potentially involve individuals with demonstrable instabilities of this region.
PUBLICATIONS AND PRESENTATIONS ARISING FROM THE WORK IN THIS THESIS

Parts of the work presented in this thesis have been published and/or presented in the following forums:

PUBLISHED PAPERS


PUBLISHED ABSTRACTS


**CONFERENCE PRESENTATIONS - ORAL**


Osmotherly PG, Mercer SR, Rivett DA. (2006). The tectorial membrane; a multilayered structure. *3rd Annual Scientific Meeting of the Australian and New Zealand Association of Clinical Anatomists*. La Trobe University, Melbourne, Australia

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Osmotherly PG. (2009). Craniocervical stability testing; current research and clinical application. *Mini conference of combined Head and Neck, Shoulder, Arm Research group*


**CONFERENCE PRESENTATIONS - POSTER**

ACKNOWLEDGMENTS

I would like to extend my sincere thanks and appreciation to my supervisor, Professor Darren Rivett for his guidance of the research and in the completion of this thesis.

I would also like to thank Associate Professor Susan Mercer, formerly of The University of Queensland, for her guidance and training in anatomical investigation, providing access to the anatomy facilities at The University of Queensland and her generosity during my frequent periods in Brisbane completing this work.

My appreciation to Dr Gary Cowin, Centre for Advanced Imaging, The University of Queensland for his work on producing the magnetic resonance images of cadaveric specimens described in Chapter 7.

I would also like to express my gratitude to Conjoint Associate Professor Lindsay Rowe, Division of Radiology, Hunter New England Imaging, for facilitating access to magnetic resonance imaging facilities at John Hunter Hospital and providing expert knowledge on the acquisition, interpretation and measurement of images reported in Chapter 10.

Thank you to Musculoskeletal Physiotherapy Australia for distributing to their membership the knowledge and attitudes survey reported in Chapter 3.