J. Yeh
A. Jackowski

Harvesting and preparation of cadaveric osseoligamentous lower cervical spine (C2-C7) for biomechanical testing

Received: 15 January 1997
Revised: 17 April 1997
Accepted: 29 April 1997

J. Yeh (✉) · A. Jackowski
The Birmingham Cervical Spine
Laboratory,
Academic Department of Neurosurgery,
The Queen Elizabeth Neuroscience Centre,
The University of Birmingham,
The Queen Elizabeth Hospital,
Edgbaston, Birmingham B15 2TH, UK
Tel. +44-121-6978231;
Fax +44-121-6272103;
e-mail: j.s.yeh@bham.ac.uk

Abstract Cadaveric osseoligamentous lower cervical spines (C2-C7) are often used in the investigation of spinal biomechanics *in vitro*. Surprisingly, however, the techniques of harvesting at postmortem and preparation of cadaveric osseoligamentous lower cervical spine for biomechanical testing have not been described in detail. We describe a simple and

effective method that can be readily integrated into the routine autopsy procedure. Points on the avoidance of disfiguring the cadaver and damaging the spinal osseoligamentous structures are highlighted.

Key words Autopsy · Cadaver · Cervical vertebrae · Human · Laboratory

Introduction

Cadaveric osseoligamentous lower cervical spine models are a valuable tool in the study of biomechanics of the cervical spine [1, 4, 6–8]. For accurate and reproducible test results, inter-specimen variations arising from preparation can be reduced by consistently following the same method of harvesting and anatomical dissection.

The aim of this paper is to describe a simple and effective method of postmortem harvesting and preparation of cadaveric lower osseoligamentous cervical spine for biomechanical testing, that avoids both damage to the osseoligamentous structures and disfigurement of the cadaver.

Method

Harvesting at postmortem

In harvesting the cervical spine at postmortem, ease of block dissection without damage to the spinal osseoligamentous structures and minimal disfigurement are the primary considerations.

At hospital autopsy, removal of the pre-vertebral viscera of the neck through the standard midline anterior thoracic incision extending to just above the manubrium angle often damages the anterior longitudinal ligament and intervertebral discs. This damage

can be avoided by simply angling the pathologist's knife parallel to the spine. Then, through the same autopsy incision, the anterior cervical spine is fully accessible under direct vision (Fig. 1).

Fig. 1 Anterior view of the cadaveric cervical spine. The cervical spine is fully accessible through the autopsy incision anteriorly (*l* longus muscles, *s* scalene muscles)

Fig.2 Removal of the muscles of the neck. **A** Removal of the longus coli muscles (*l*) using a scalpel. **B** Removal of the scalene muscles (*s*) using scissors (*c* facet capsule, *f* intervertebral foramen). **C** Removal of the erector spinae muscles (*e*) using rugines (*cl* cervical lamina, *ss* supraspinous ligament)

The caudal end of the cervical spine is freed first using a reciprocating saw. The necks of the thoracic ribs can be similarly divided if necessary. Starting distally, the surrounding muscles are incised laterally and posteriorly with a knife. A layer of muscles of sufficient thickness should be left surrounding the spine to protect its osseoligamentous structures.

The cranial end of the cervical spine is freed posteriorly by cutting the atlanto-occipital ligamentous complexes with a knife. Anteriolaterally, the atlanto-occipital joint is divided with a pair of heavy-duty angled bone-cutting forceps. Anteriorly, the atlanto-occipital ligamentous complexes and the apical ligaments of the dens are cut using a knife. The freed caudal end of the cervical spine can be lifted up to facilitate these manoeuvres. When direct visualization of craniocervical junction is not possible, landmark structures – the transverse processes of the atlas, the occipito-atlantal joints and posterior margins of the foramen magnum – can be felt and guide the placement of the knife and bone-cutting forceps. The atlanto-axial joints can be divided if complete preservation of C2 is not necessary.

Cosmetic reconstruction

Reconstruction of bulk and rigidity of the neck are the primary cosmetic objectives. The rigidity is restored by substituting an appropriate length of wooden rod in place of the harvested cervical spine. The wooden rod is sharpened at one end and inserted distally into the spinal canal, while the blunt end is inserted proximally through the foramen magnum into the skull. Sufficient post-mortem intracranial wadding should be used to allow the wooden rod to settle firmly in the skull, rigidly supporting the head. An alternative method of reconstruction, using wire, has also been described but we have found the use of a wooden rod to be equally satisfactory [2].

Significant neck-muscle bulk is removed with the harvested cervical spine, and is replaced by appropriate packing of wadding around the wooden rod. When the skin incision is then closed, the neck resumes a near natural appearance.

Anatomical dissection

The aim of the anatomical dissection is to preserve the osseoligamentous structures, and to remove or divide structures that may interfere with their testing. Larger non-osseoligamentous structures

can be easily removed, whereas for the smaller structures, the inter-segmental connections need only be divided.

On either side of the midline anteriorly, the longus coli muscles can be easily dissected with a knife along the musculoskeletal fascial plane (Fig. 2a). Laterally, the scalene muscles are removed using a pair of curved tissue scissors with a rounded tip, leaving intact the closely wrapped capsular ligaments around the facet joints (Fig. 2b). Posteriorly, the erector spinae muscle complex [5] is easily removed using rugines, but care should be taken not to damage the intertransverse, interspinous, and the deep portion of the nuchal ligaments (Fig. 2c).

The vertebral artery can be either removed completely or divided at each spinal level. The spinal nerves are freed from the intervertebral foramina with a small pair of pointed scissors. The spinal cord is then easily stripped out of the spinal canal by pulling on its dura. The dura can be encouraged to separate from the wall of the spinal canal by gentle teasing. Care should be taken not to damage the posterior longitudinal ligament.

Fig.3 **A** Anterior view of the dissected cervical spine specimen (C2-T3). **B** Lateral radiograph of the dissected specimen shown in **A**

If required, the atlas can be easily separated from the C2 by dislocating the atlanto-axial joints and dividing the transverse ligament of the atlas with a knife.

Discussion

It is advisable to include in the harvested cadaveric cervical spine some adjacent thoracic segments so as to protect the C7 segment and to provide a purchase for the vice of the biomechanical testing machine.

The deep portion of the ligamentum nuchae is akin to the supraspinous ligaments of other spinal regions, and should be carefully preserved [5, 9]. The superficial portion of the ligament extends from the deep portion and the base of the skull to attach to the deep cervical fascia beneath the skin. Although the superficial portion of the ligament may play a role in the biomechanics of the cervical

spine with a naturally intact occipito-cervical junctional region [3], it is unlikely to do so in a cadaveric lower cervical spine, which has no such region and is therefore not preserved [6, 8].

The anatomical dissection may be carried out immediately following harvesting or the specimen may be stored frozen at -20°C and then be thawed at 4°C overnight for dissection prior to biomechanical testing [1]. Following anatomical dissection, the specimen should be radiographed to ascertain that the correct spinal segments have been obtained, to ensure that no bony damage has occurred during the preparation, to grade the degree of spinal degeneration and to exclude occult pathologies (Fig. 3).

Acknowledgements We thank Drs. Allah Detta and Hussein El-Maghraby for helpful discussions, Mr. Lawson Davis for assistance with harvesting, and Mr. Bill Mitchell for photography.

References

1. Adams MA (1995) Mechanical testing of the spine. An appraisal of methodology, results, and conclusions. *Spine* 20: 2151–2156
2. Brigham CD (1992) Removal of the human cervical spine for research purposes during postmortem autopsy (letter). *Spine* 17: 252
3. Jirout J (1974) The dynamic dependence of the lower cervical vertebrae on the atlanto-occipital joints. *Neuroradiology* 7: 249–252
4. Kostuik JP, Smith TJ (1991) Pitfalls of biomechanical testing. *Spine* 16: 1233–1235
5. McMinn RMH (ed) (1994) *Last's anatomy: regional and applied*, 9th edn. Churchill Livingstone, Edinburgh, pp 543–548
6. Panjabi MM, White AA III, Johnson RM (1975) Cervical spine mechanics as a function of transection of components. *J Biomech* 8: 327–336
7. Smith TJ (1991) In vitro spinal biomechanics. Experimental methods and apparatus. *Spine* 16: 1204–1210
8. White AA III, Johnson RM, Panjabi MM, Southwick WO (1975) Biomechanical analysis of clinical stability in the cervical spine. *Clin Orthop* 109: 85–96
9. Williams PL, Bannister LH, Berry MM, Collins P, Dyson M, Dussek JE, Ferguson MWJ (eds) (1995) *Gray's anatomy. Anatomical basis of medicine and surgery*, 38th edn. Churchill Livingstone, New York, pp 510–522, 807–813