

MORPHOMETRY OF OSTEODURAL BRIDGE AND THE MYODURAL BRIDGE OF THE RECTUS CAPITIS POSTERIOR MAJOR IN A BLACK KENYAN POPULATION

Wambua Brian, Julius Ogeng'o, Awori Kirsteen^a, Kevin Ongeti, Gikenye Gichambira^a, Olabu Beda

Department of Human Anatomy, University of Nairobi, PO Box 30197–00100, Nairobi, Kenya

Correspondence to Wambua Brian, Department of Human Anatomy, University of Nairobi, PO Box 30197–00100, Nairobi, Kenya. Tel: +254728325042

E-mail: michaelwambua327@gmail.com

ABSTRACT

The connective tissue between the rectus capitis posterior major and the cervical dura, popularly known as the myodural bridge has been postulated to contribute to dural tension monitoring. It prevents dural enfolding thus preventing stimulation of dural nociceptors which would result in cervicogenic headaches. Its length may be an indicator of its effectiveness; however, determination of its length radiographically is difficult. The osteodural bridge, the connective tissue between the axis and dura can be measured radiographically. The aim of the study was therefore to determine if there is a relationship between their lengths. Thirty formalin fixed cadavers were meticulously dissected at the department of Human Anatomy, University of Nairobi, to expose the suboccipital triangle. The lengths of the bridges were measured using a pair of digital vernier caliper. The data was recorded, coded and analyzed using Statistical Package for Social Sciences (SPSS) version 21.0. The means and standard deviations were determined. Histograms and probability plots were generated to determine the normality of the data. A Pearson's correlation coefficient was generated to determine a correlation between the length of the myodural bridge and osteodural bridge. Of the 30 cadavers dissected, all had the myodural bridge and Osteodural bridge present. The mean length of the myodural bridge was 4.02+/- 0.395 mm. Mean length of the osteodural bridge was 2.71 +/- 0.311 mm. There was a linear relationship of the equation $y=1.02x + 1.26$ ($R^2=0.640$). The length of the osteodural bridge may be used as a predictor of the myodural bridge's length.

Key words: Myodural, Rectus Capitis Posterior Major

INTRODUCTION

The myodural bridge (mdb) is connective tissue that links suboccipital musculature to cervical dura mater (Kahkeshani and Ward, 2012). It has been shown to connect obliquus capitis inferior, rectus capitis posterior minor and major to cervical dura mater (Mcpartland and Raymond, 1999; Pontell et al., 2013; Scali et al., 2013;

Zumpano, Sandra and Carl, 2006). Rectus capitis posterior major is the largest of the suboccipital muscles and its mdb has the largest cross-sectional area (Tagil, Levent and Cem, 2005).

The rectus capitis posterior major has a rich muscle spindle density coupled to proprioceptors

Submitted 7th October 2015, corrected 3rd March 2016. Published online 1st August 2016. To cite: Wambua B, Ogeng'o J, Awori K, Ongeti K, Gichambira G, Olabu B. Morphometry of the Osteodural Bridge and the Myodural Bridge of the Rectus Capitis Posterior Major in a Black Kenyan Population. *Anatomy Journal of Africa*. 2016, 5: 735 – 740.

in the mdb (Scali et al, 2013). It has been postulated that this neural component is vital in monitoring dural tension (Choudhary et al., 2014). The monitoring of the dural tension is crucial especially during hyperextension of the cervical spine (Alix and Deanna, 1999). During hyperextension of the cervical spine, the dura tends to enfold compromising the subarachnoid space (Grimshaw, 2001). The dura mater has been shown to be rich in nociceptors (Chou and David, 2002). The dural enfolding during cervical spine hyperextension stimulates the nociceptors thus causing nuchal pain (Hack and Richard, 2004). Mdb has been postulated to resist this enfolding by tensing the dura when the rectus capitis posterior major is activated during head extension (Hack and Richard, 2004). Therefore, functional integrity of the mdb may be related to the severity of cervicogenic headaches.

The reported lifetime prevalence of neck pain in the general population is 70% (Alix and Deanna, 1999). Consequently, 17% of patients who suffer from whiplash injuries will continue to experience cervicogenic pain after 6 months (Chou and David, 2002). Although cervicogenic headaches are a common occurrence, our understanding of its etiology is incomplete.

The osteodural bridge (odb) has not yet been associated with any clinical conditions. It has been stated to be linking the second cervical vertebrae to cervical dura mater (Scali et al., 2013). Its length can be measured radiographically. Length of the mdb is not easily defined radiographically (Humphrey et al., 2003). Therefore the study aimed at determining the relationship between the length of the MDB and ODB.

MATERIALS AND METHODS

Thirty formalin fixed cadavers were dissected at the department of Human Anatomy, University of Nairobi. Each head was placed on a wooden block, face down and aligned along the Frankfurt horizontal plane. Skin of the occipital region was incised midsagittally from the external occipital protuberance to the vertebra prominens. Horizontal incisions were then made from external occipital protuberance to mastoid process. A longitudinal incision was then made from the mastoid process along the anterior margin of trapezius muscles. The skin and superficial fascia was removed. The following muscles were then reflected: the trapezius, splenius capitis, splenius cervicis, and semispinalis capitis muscles to view the suboccipital region. The rectus capitis posterior major and minor were defined. The obliquus capitis inferior and superior muscles were then

defined. With the use of a scalpel, the rectus capitis posterior major was detached from its superior attachment and reflected inferolaterally. The loose areolar tissue was cleared with the blunt edge of the scalpel. The spine of the axis was cut midsagittally using an electrical oscillating power saw (DR-551-00, Surtex Instruments (UK)). The connective tissue linking the Rcpma cervical dura mater was defined as the mdb. Its length was measured using a pair of digital vernier caliper (Sealey Professional Tools™ with an accuracy of 0.1mm). The length was defined as its attachment points on the muscle and cervical dura mater. The Osteodural Bridge was measured from its point of attachment on the posterior arch of the axis to the insertion point on the posterior cervical dura mater using a pair of digital vernier caliper.

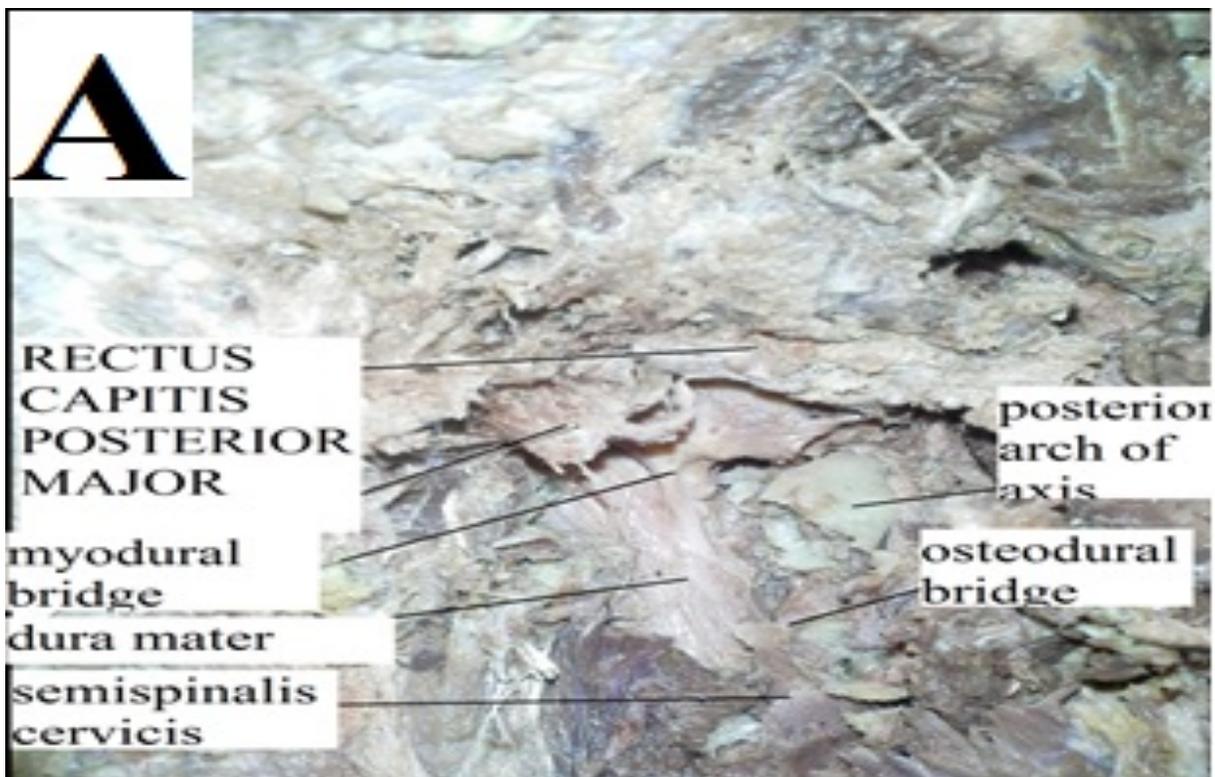
RESULTS

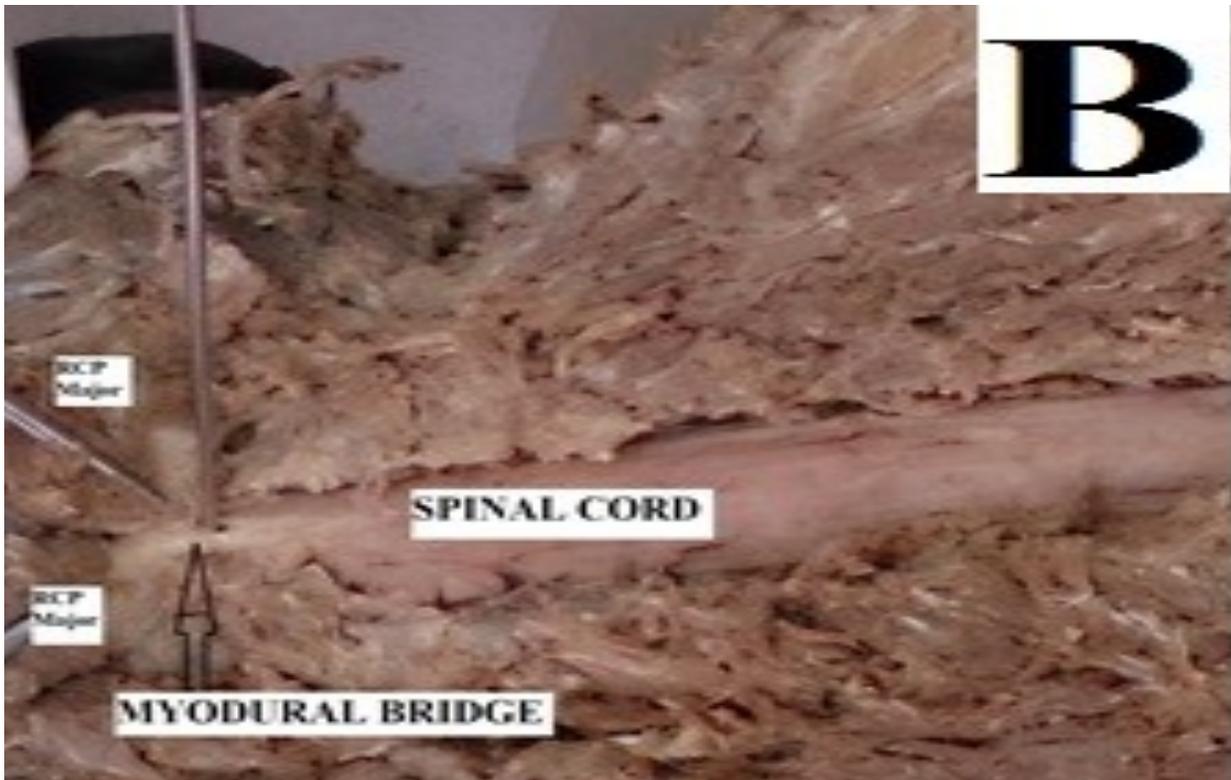
The line of best fit in the scatter plot showed a direct relationship between the lengths of the

osteodural and myodural bridges. The linear relationship was of the equation $y = 1.26 +$

1.02x. The R^2 was 0.640 implying that 64% of the outcome variable i.e. length of myodural bridge can be explained by the predictor variable i.e. length of osteodural bridge. The mean length of the myodural bridge is 4.02 mm with a standard deviation of ± 0.395 . The mean length of the osteodural bridge is 2.71 mm with a standard deviation of ± 0.311 . The distribution curve is normal. The semispinalis cervicis, a useful landmark in identifying the suboccipital triangle. In all dissected cadavers, rectus capitis posterior major was attached to cervical dura mater at the atlanto-axial interspace. Myodural bridge attached the deep surface of the Rcpma muscle to the transverse

fibers of the posterior atlanto-axial membrane, close to the margin of the spinous process of the axis. A ligamentous structure resembling a meningovertbral ligament was observed attaching the posterior cervical dura to the posterior arch of the axis. These fibrous strands blended together to form the osteodural bridge. The fibers of these bands, however, were not continuous with the fascial coverings of the muscles. The neural arches of the cervical vertebrae were disarticulated in this cadaver to expose the cervical segment of the spinal cord. The right and left rectus capitis posterior major were held apart by two pairs of forceps to elucidate the myodural bridge.





DISCUSSION

In our study, the mean length of the myodural bridge was found to be 4.02mm +/- 0.395 while that of the osteodural bridge was 2.71mm +/- 0.311. Previous literature is however silent on the morphometry of these ligamentous bands. In our study, the myodural and osteodural bridges were distinct from surrounding cervical fascia, a finding that contradicts Dean and Mitchell (2002) who observed that the rectus capitis posterior major had no direct link to the dura. A study by Humphreys et al (2003) found a connective tissue, linking the Rcpma and ligamentum nuchae. The length of the attachment site on the Rcpma ranged from approximately 5 mm to over 10 mm.

The myodural and osteodural bridges were found to be present in all the cadavers dissected confirming the findings of Scali et al (2013). The mean length of attachment of mdb ranged from 3.23 – 4.81 mm. The study by Humphrey et al (2003) found the length of the ligamentum nuchae- dura connection to range from 3-10

mm. The wide range can be explained by the fact that the ligamentum nuchae has an extensive origin from the external occipital protuberance and the fasciae of the nuchal muscles such as trapezius. The sample size used by Humphrey and colleagues was 30 cadavers. The cadavers were embalmed just as in our study.

There was evidence of a ligamentous structure resembling that described before as the meningovertebral ligament by Hack et al (1995). Its fibers were found to course within the midsagittal plane where they then attached the posterior cervical dura to the posterior arch of the axis. These fibrous strands blended together to form the osteodural bridge. In our study its length ranged from 2.09- 3.33 m with a mode of 2.60 mm.

The study by Humphrey et al (2003) observed a ligamentum nuchae-rectus capitis posterior major connective tissue link. This connective tissue blended over the posterior arch of the axis. It gives origin to the Osteodural Bridge (odb). The length of this link was found to range

from 5-10mm. The length of the odb can be determined via MRI with greater confidence than that of the mdb implying that knowledge of its length may aid in predicting the length of the mdb non-invasively (Scali et al., 2013).

Predicting the length of the mdb non-invasively may be of aid to clinicians investigating the relationship between the severities of cervicogenic headaches and degree of tension of the mdb. The degree of tension of the mdb may be influenced by its length.

Our results show that the linear relationship between the mdb and odb lengths of the equation $y = 1.26 + 1.02x$ may be used to determine the length of the mdb. A long mdb may prevent dural enfolding more efficiently than a short mdb. This may reduce stimulation of nociceptive pain fibers resulting in less cervicogenic headaches.

Cervicogenic headaches are a common medical problem. The reported lifetime prevalence of neck pain in the general population is 70% (Alix and Deanna, 1999). It is of particular concern that 17% of patients who suffer from whiplash injuries will continue to experience cervicogenic pain after 6 months (Chou and Lenrow, 2002). Although cervicogenic headaches are a common occurrence, our understanding of its etiology is incomplete.

The myodural bridge is active when the Rcpma extends the head and thickens the upper posterior cervical dura, (Taylor, Taylor and Twomey, 1996). It prevents the enfolding of the cervical dura mater during head extension (Kahkeshani and Ward, 2012). This protects the integrity of the subarachnoid space and prevents

compression of spinal nerve roots. Electromyographic studies have shown that the rectus capitis posterior minor is not activated during head extension whereas the Rcpma is activated (Hallgren et al., 2014).

The mdb has stretch receptors which get activated when the Rcpma is activated during head extension (Scali et al, 2013). The receptors detect the tension and stimulate a myotatic reflex. This reflexive pathway tenses the posterior cervical dura preventing it from buckling. Thus it prevents stimulation of nociceptors in the dura mater (Scali et al., 2013). The proprioceptive ability of the mdb is lost during whiplash injuries due to the destruction of the stretch receptors (Alix and Deanna, 1999). This compromises the ability of the mdb to detect dural tension and thus prevent its enfolding. According to Kahkeshani and Ward (2012), the presence of the mdb contributes to the efficacy of nuchal massages as a manipulative management of cervicogenic headaches.

Further studies should be carried out to characterize the osteodural bridge histologically. The tensile strength of the myodural bridge (mdb) should also be quantified to develop a better understanding of the forces the mdb generates to prevent anterior dural translation and enfolding. This could be augmented by using MRI to evaluate its integrity after whiplash injury as well as cadaveric studies after application of whiplash-type forces (flexion-extension forces). This could help scientists gain a deeper understanding of its functional significance.

REFERENCES

1. Alix M, Deanna K (1999) A proposed etiology of Cervicogenic headache: the neurophysiologic basis and anatomic relationship between the dura mater and the rectus posterior capitis minor muscle. *Journal of manipulative and physiological therapeutics*. 22 (8): 534-539.
2. Andary M, Richard H, Philip G, James R (1998) Neurogenic atrophy of suboccipital muscles after a cervical injury: A Case Study1. *American journal of physical medicine & rehabilitation*. 77 (6): 545-549.
3. Bilge O (2004) An anatomic and morphometric study of C2 nerve root ganglion and its corresponding foramen. *Spine*. 29 (5): 495-499.

4. Chou L, David L. Cervicogenic headache (2002) *Pain Physician*. 5 (2) : 215-225.
5. Choudhary A, Ramsay I, Thomas Z, Mark D (2014) Imaging of spinal injury in abusive head trauma: a retrospective study. *Pediatric radiology*: 1-11.
6. Cowin R, Peter B (2002) Hearing loss, otalgia and neck pain: a case report on long-term chiropractic care that helped to improve quality of life. *Chiropractic Journal Of Australia*. 32 (4): 119-130.
7. Dean A, Mitchell B (2002) Anatomic relation between the nuchal ligament (ligamentum nuchae) and the spinal dura mater in the craniocervical region. *Clinical Anatomy*. 15 (3):182-185.
8. Demetrious J (2007) Post-traumatic upper cervical subluxation visualized by MRI: a case report. *Chiropractic & osteopathy*. 15 (1): 1-7.
9. Grimshaw D (2001) Cervicogenic headache: manual and manipulative therapies. *Current pain and headache reports*. 5 (4): 369-375.
10. Hack G, Richard T, Walker L, Richard C, Philip E (1997) Letters In Response. *Spine*. 22 (8): 925-926.
11. Hack G, Richard C (2004) Chronic headache relief after section of suboccipital muscle dural connections: a case report. *Headache: The Journal of Head and Face Pain*. 44 (1):84-89.
12. Haldeman S, Simon D (2001) Cervicogenic headaches: a critical review. *The Spine Journal* 1 (1): 31-46.
13. Hallgren R, Steven J, Lawrence L, Jacob J, Angela S (2014) Electromyographic activity of rectus capitis posterior minor muscles associated with voluntary retraction of the head. *The Spine Journal*. 14 (1): 104-112.
14. Humphreys K, Shahar K, Bradley B, Gregory D (2003) Investigation of connective tissue attachments to the cervical spinal dura mater. *Clinical Anatomy*. 16 (2): 152-159.
15. Kahkeshani K, Peter W (2012) Connection between the spinal dura mater and suboccipital musculature: Evidence for the myodural bridge and a route for its dissection—A review. *Clinical Anatomy*. 25 (4): 415-422.
16. Mcpartland J, Raymond R (1999) Rectus capitis posterior minor: a small but important suboccipital muscle. *Journal of Bodywork and Movement Therapies*. 3 (1): 30-35.
17. Pontell M, Scali F, Dennis E, Patrick J, Ewarld M (2013) Histological examination of the human obliquus capitis inferior myodural bridge. *Annals of Anatomy-Anatomischer Anzeiger*. 195 (6): 522-526.
18. Pontell M, Scali F, Ewarld M, Dennis E (2013) The obliquus capitis inferior myodural bridge. *Clinical Anatomy*. 26 (4): 450-454.
19. Scali F, Matthew E, Dennis E, Ewarld M (2013) Histological analysis of the rectus capitis posterior major's Myodural bridge. *The Spine Journal*. 13 (5): 558-563.
20. Scali F, Matthew E, Aaron B, Theodore K, Ewarld M, Norman W (2013) Magnetic resonance imaging investigation of the atlanto-axial interspace. *Clinical Anatomy*. 26 (4): 444-449.
21. Tagil S, Levent Ö, Cem B (2005) Insight into understanding the anatomical and clinical aspects of supernumerary rectus capitis posterior muscles. *Clinical Anatomy*. 18 (5): 373-375.
22. Taylor J, Taylor M, Twomey L (1996) Posterior cervical dura is much thicker than the anterior cervical dura. *Spine*. 21: 2300–2301.
23. Zumpano M, Sandra H, Carl S (2006) Soft tissue connection between rectus capitis posterior minor and the posterior atlanto-occipital membrane: A cadaveric study. *Clinical Anatomy*. 19 (6): 522-527.