314 Journal of Manipulative and Physiological Therapeutics
Volume 17 • Number 5 • June, 1994
0161-4754/94/1705-0314 $03.00/0 © 1994 JMPT

Absence of Symmetry in Superior Articular Facets on the First Cervical Vertebra in Humans: Implications for Diagnosis and Treatment

MARC S. GOTTLIEB, D.C.*

ABSTRACT

Objective: Little attention has been given to the craniovertebral articulations. Specifically, gross observations of variations of the superior articular facets on the atlas have not been described with respect to static and motion palpation findings. This study describes the anatomical variations of these facets and the clinical implications associated with asymmetrical structure.

Design: The superior articular facets of thirty human first cervical vertebrae were chosen for this study because the atlas constitutes the middle of the upper cervical complex and the atlanto-occipital joint contributes greatly to head movements.

Setting: The basic science research department of Logan College of Chiropractic, St. Louis, Missouri.

Specimen Population: All available previously dissected anatomy laboratory and library specimens (30) were used in this study. All of the specimens were dry with intact facet surfaces and no regard was given to age, gender, or race.

Interventions: The atlases were studied out of situ and all soft tissue was removed so that the bony articular surfaces could be clearly viewed and photographed.

Main Outcome Measures: Palpation and unaided visual examination were performed on 30 atlases. The shape, size, angle, texture, border, and number of superior articular facets on each atlas were recorded to determine symmetry.

Results: The classically described kidney-shaped facet was in fact an infrequent finding. Upon comparison of right and left sides, none (0%) of the facets were mirror images of symmetry, while 19 of the atlases (63%) had grossly asymmetrical facets, and 11 of 30 atlases (37%) had facets which were only slightly asymmetrical in regard to shape, border, depth and angle. Furthermore, 7 of the 19 grossly asymmetrical atlases (37%) had three or four separate superior articular facets. Three atlases had two facets on the left and one on the right, while two atlases had two facets on the right with a single facet on the left, and two atlases had four superior facets (two on each side).

Conclusion: The validity of vertebral joint assessment based on the assumption of facet symmetry is challenged, impugning certain chiropractic theories and/or techniques which rely on symmetry as being "normal." To achieve symmetrical function, the anatomical structure must be symmetrical. Since true structural symmetry does not exist, true symmetry of segmental movement may not be possible. (J Manipulative Physiol Ther 1994; 17:314–320).

Key Indexing Terms: Atlas Vertebra, Chiropractic, Asymmetry, Morphometrical Variation.

INTRODUCTION

Little attention has been given to the craniovertebral articulations. Specifically, gross observations of variations of the superior articular facets on the atlas have not been described with respect to static and motion palpation findings. This study describes these facets and the associated clinical implications.

The first cervical vertebra or atlas is very important due to its inherent range of motion, which is greater than any other vertebra in the spine. The upper cervical complex, including occiput, atlas and axis, is often regarded as a separate and distinct entity. Although the three bones are attached to each other by articulations and/or ligaments, the bones are very different in shape and have biomechanical properties which are equally different from the rest of the spine. The occiput artic-

* Private practice of chiropractic.
Submit reprint requests to: Logan College of Chiropractic, Basic Science Research Department, P.O. Box 1065, Chesterfield, MO 63006-1065.

Paper submitted June 1, 1993; in revised form July 23, 1993.

ulates with the atlas via a ginglymus or hinge joint consisting of two occipital condyles which are received by two atlantal lateral mass depressions or superior articular facets. The anterior arch of the atlas articulates with the odontoid process of the axis, and the inferior facets of the atlas articulate with the superior facets of the axis. There is no bony articulation between the axis and the occiput, but alar and apical ligaments from the odontoid process do attach to the inside of the foramen magnum. The atlas is in the middle of the upper cervical complex and thus was chosen for observation in this study.

Most chiropractic theories and techniques consider the atlas to be a source or contributing factor to many maladies, including cervicogenic headaches, dysequilibrium, and otalgia when the biomechanics of the atlanto-occipital and/or atlanto-axial joints are disturbed. Fitz-Ritson reported a high correspondence of upper cervical joint fixations in patients suffering from cervicogenic vertigo. After 18 chiropractic treatments, 101 of the 112 patients (90.2%) were symptom free. Of the remaining 11 patients, six (5.4%) had decreased vertigo and five (4.5%) had no change (1). "Guyton notes that by far the most important proprioceptive information needed for the maintenance of equilibrium is that derived from the *joint receptors of the neck*" (2). Neurophysiological studies of cervical joint manipulation at levels C3 and C4 show reflex effects on arm and thigh electromyographic tracings (3). This evidence may support the far-reaching effects of neuroreceptor stimulation. These studies offer support for maintaining joint function, at the very least for postural control, although other functions could be hypothesized.

The most frequent assessment procedures of the upper cervical spine involve gross range of motion, static palpation and motion palpation. Joint assessment has historically relied upon symmetry for comparison and interpretation of joint function. Examiners judge the population with set ranges of motion as a guideline and have an expectation that each person should fall within the population average and individually have similar motion bilaterally (i.e., 60+ degrees of rotation to the right and left sides). Many confuse the term normal with the their expectations of what is optimal, while in fact the term "normal" refers to that which is statistically average. If symmetry is not a normal finding, then range of motion and palpation assessments may mislead the examiner and thus cause the implementation of incorrect treatment plans. This may compound the problem that gross range of motion gives no information about intersegmental movement, and with some motion palpation assessments there is an inherent lack of interexaminer reliability (4).

The purpose of this study is to explore the possibility that symmetry is less common than asymmetry and, if that is so, to discuss the effects of asymmetry on the biomechanics and methods used to evaluate these joints.

Stated ranges of intersegmental cervical motion vary greatly among authorities. Ironically, this variation confounds assessment of joints because a statistical average or "normal" has not been agreed upon. Since ranges of motion do vary, this also supports the possibility that joints are not symmetrical among individuals. About one-half of all cervical flexion and extension occurs at the occipito-atlantal joints (5). The condyles of the occiput roll backward and slide slightly posteriorly on the atlas, while the atlas rolls anteriorly and superiorly on the occiput to produce 10 degrees of flexion (5). The converse action produces 15 degrees of extension. About 7 degrees of lateral bending is accomplished when the occipital condyles translate laterally toward the convexity and the atlas slips toward the concavity (5). There is also some evidence to suggest that lateral flexion is combined with rotation of the head to the opposite side (6). Gillet suggests that because the atlas is caught between trying to follow the motion of the occiput and the axis, a slight amount of rotational end play of the occiput on the atlas occurs even though the design of the joint is not conducive to rotation (5). Rotation of the occiput on the atlas is disputed; some authorities deny its occurrence, while Schafer and Faye estimate 3 degrees. Once again this may reflect anatomical differences among individuals rather than the reference source being right or wrong. Passive testing between the mastoid process of the occiput and the transverse process of the atlas reveals that a small amount of passive rotation is possible (6). Pure movements are difficult to isolate because the axis couples with atlas motion.

To achieve symmetrical function, the anatomical structure must be symmetrical. Since true structural symmetry does not exist, true symmetry of segmental movement is not possible (7). Most anatomy texts and plastic skeletal models support the intuitive notion that bones and joint surfaces are symmetrical under the guise of "normal" anatomy. Ideal shapes and sizes are displayed as normal and little or no mention is made of individual variation. The superior articular facets of the atlas are often described as smooth, slightly concave, oval or kidney-shaped surfaces on top of the lateral masses of the atlas (see Figure 1). This description is actually found in very few cases (8). Most of the facet outlines are irregular, yielding various shapes. Shapes

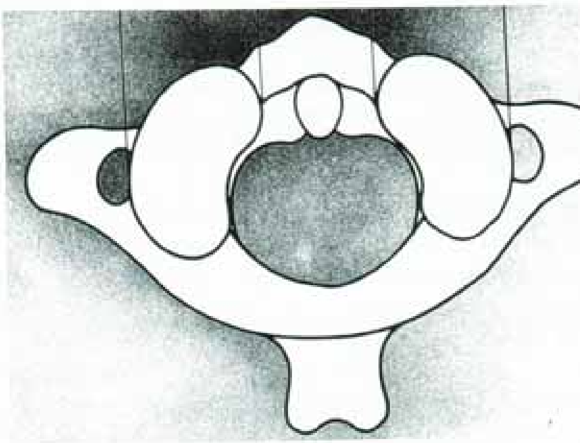

Figure 1. The classically described symmetrical, smooth, slightly concave, oval or kidney-shaped surfaces on top of the lateral masses of the atlas. Although the described condition is actually found in very few cases, practitioner learn from illustrations and plastic models such as this one, which perpetuates the misconception of symmetry being normal. (Adapted from Herbst RW. Gonstead Chiropractic Science & Art: The Chiropractic Methodology of Clarence S. Gonstead, D.C., Sci Chi Publications, Figure 232, page 125.

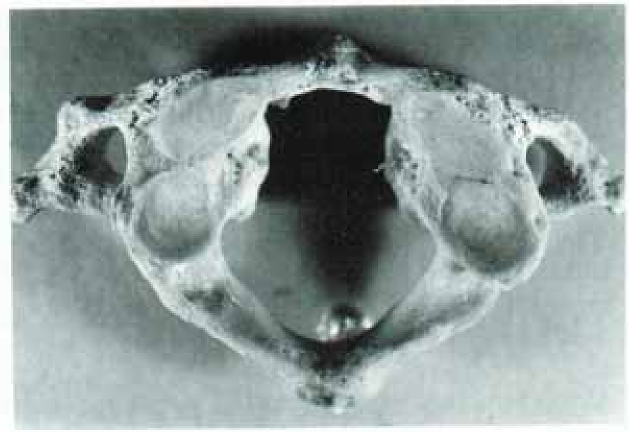

Figure 2. The tendency of the superior articular facet of the atlas to divide into two separate facets on the right side due to medial and lateral notches causing a central constriction which is accompanied by a groove. Note that the left side is totally divided into two separate facets due to the wider groove at the central constriction.

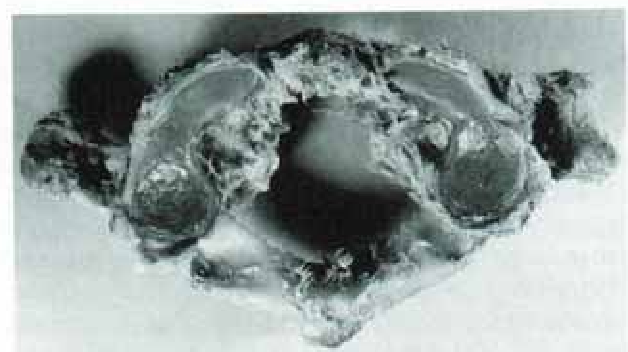

Figure 3. The circular areas found in the anterior and posterior parts of the facet probably represent areas of greater pressure during movement of the atlanto-occipital joint and the rough areas in the middle constriction may indicate that parts of the facet are nonarticular.

differ between atlases as well as from side to side on the same specimen. The outlines of the facets often have constrictions in the middle and, when present on both sides, cause the shape to appear as a figure eight or dumbbell (8). Singh studied 200 atlases and described some superior facets with no middle constriction, a few with medial constriction only, a few with a lateral constriction only, and a majority with constrictions on both sides. A tendency for separation of one superior articular facet to divide into two at the middle constriction was seen in 171 of the 200 atlases studied and 22 of the 400 facets were completely divided (see Figure 2). The facet surface was rough, and Singh noted smoother circular areas within the outline of the facet. The circular areas found in the anterior and posterior parts of the facet probably represent areas of greater pressure during movement of the atlanto-occipital joint. The rough areas may indicate that parts of the facet are nonarticular (see Figure 3). Mysorekar and Nandedkar (9) noted that human beings tend to incline their heads to one side more than the other and that may influence the amount of articular surface area on each side of the atlas as well as on the occipital condyles. Tulsi (10) corroborates the findings of complete division of some articular facets and adds that the depth of intact facets can vary from being flat, 3 mm or less, to 5 mm or greater (see Figure 4). The depth of the superior articular facets of the atlas influences the amount of flexion and extension possible between the occipital condyles and the atlas. Asymmetry of the craniovertebral bony and ligamentous structures is almost the rule rather than the exception (7).

The studies mentioned above dealt only with the atlas. Since the two bones have a reciprocal relationship, a brief overview of the occiput is warranted. The occipital bone develops from six ossification centers (11). The articular surface of the occipital condyles has a sole-like configuration and is subdivided by a deep cleft in the newborn and infant (12). This cleft corresponds to the synchondrosis intraoccipitalis anterior before maceration (12). In the cases illustrated, in which the synchondrosis did not macerate, a cleft remains separating each condyle into two parts, leaving an appearance remarkably similar to the separated atlas facets

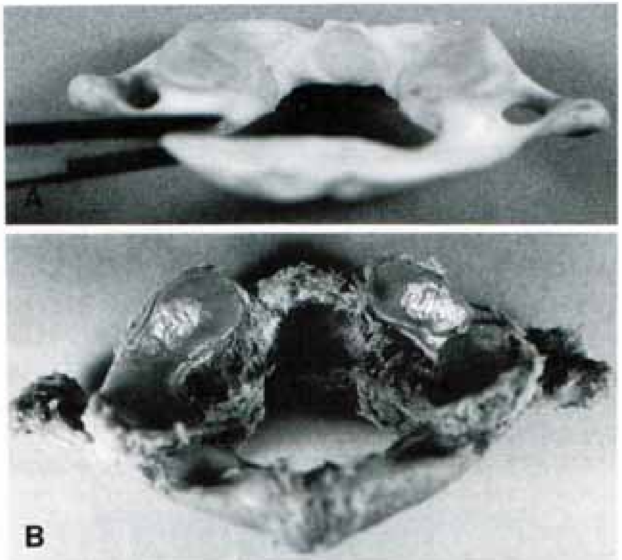

Figure 4. The depth of the superior articular facets of the atlas vary from being flat, 3 mm or less (A), to 5 mm or greater (B), which influences the amount of flexion and extension possible between the occipital condyles and the atlas.

Figure 5. (A) Twelve yr old. The synchondrosis is totally ossified. In the right occipital condyle, a deep furrow runs transversally through the subchondral bone. (B) Adult. Bilobed occipital condyle on the right. In comparison to the smooth surface of the bone in the furrow seen in Figure 5A, the surface of the cartilage-free zone in the middle of this condyle is rough. (With permission. Tillman B, Lorenz R. The stress at the human atlanto-occipital joint. Anatomy and Embryology. Springer Verlag Publishing 1978;153: Figure 4e, 4f, pp. 172–3).

mentioned above (see Figure 5). Febbo et al. performed computer-assisted analyses of radiographs and found asymmetry between all of the occipital condyles examined, thus suggesting that the condyles may be much more variable than is commonly assumed (13, 14). The variability of the curvature, and the orientation of the occipital condyles, poses the problem of how movement at the atlanto-occipital articulation is performed (15). There must be asymmetry in the movement between the occiput and the atlas because the morphological differences cannot be neutralized (15). True symmetry occurs infrequently in the musculoskeletal system (16), so in order to determine what is aberrant or abnormal, a decision must be made about what constitutes the typical or normal situation.

The validity of vertebral joint assessment based on the assumption of facet symmetry is challenged, which impugns certain chiropractic theories and/or techniques which explicitly teach or rely on symmetry as being the "normal" condition.

METHODS

The superior articulating facets of human first cervical vertebrae were chosen for study. The superior articular facets of excised atlases were inspected for facet symmetry. The bilateral comparison involved contrasting facet shape (the border which defined the facet surface, including any notches), number (if facets were divided by grooves or notches), depth (shallow, deep or planar contour), angle (the degree of eversion in the transverse plane), surface texture (smooth or rough, and presence of grooves or wear patterns), and location on lateral masses (within the same plane or not). Factors such as race, age and gender of the specimens were not included as records were not available. All available previously dissected anatomy laboratory and library specimens (30) were used in this study. No models or casted reproductions were used. Unaided visual observation was utilized because gross anatomical asymmetries are more likely to account for palpable static and motion abnormalities than minute measurements. All observations were made and reported by a single examiner. A determination was made with respect to symmetry by comparing the details mentioned above. Each atlas was assigned a category of symmetrical, slightly asymmetrical or grossly asymmetrical. The atlases were randomly assigned arbitrary numbers to prevent memorization of the results. The examiner then repeated the observations and analyzed the extent of agreement between the two separate observations. The intraexaminer concordance was 100% on each of the assigned categories.

The objectives of the analysis were to note the existence of symmetry or asymmetry, and to discuss the implications of the findings with regard to vertebral joint assessment and interpretation.

RESULTS

The classically described kidney-shaped facet was in fact an infrequent finding. Upon comparison of right and left sides, none (0%) of the facets were mirror images of symmetry, but 11 of the 30 atlases (37%) had facets which were only slightly asymmetrical in regard to shape, border, depth and angle. Nineteen of the atlases (63%) had grossly asymmetrical facets. Furthermore, seven of those nineteen atlases (37%) had three or four separate asymmetrical facets. Furthermore, seven of those 19 atlases (37%) had three or four separate superior articular facets. Three atlases had two facets on the left and one on the right, while two atlases had two facets on the right with a single facet on the left, and two atlases had four superior facets, two on each side (see Figure 6). Textbooks often describe the facets as continuous, smooth surfaces facing medially and superiorly. A common misconception of the condyloid joint is that the articulation is much like a machine-made ball and socket joint. Conspicuous areas of wear on the articular surface were apparent in various locations within the facet. The apparent areas of wear within the facet were smoother patches and often rounded, while other areas of the facet, especially near the middle constriction, were rough as though not in contact with the occiput (see Figure 7). This suggests that the facets and condyles are not well matched cup and ball articulations. Some joint surfaces were flat and more planar, while others were concave and curved (see Figure 4). The middle constriction of the facet was accompanied by a groove in many specimens. The width of this groove varied and, in some cases, was wide enough to cause two separate facets unilaterally as mentioned above.

Figure 6. The left superior articular facet remains single, while the right facet is divided into two separate facets.

Figure 7. The smooth round patches are apparent areas of wear within the facet, while other areas of the facet, especially near the middle constriction, are rough and stippled as though not in contact with the occiput.

DISCUSSION

The superior articular facets of the atlas provide the sole bony support between the head and the spine. The craniovertebral junction is a clinically important part of the body which is often functionally assessed by static and motion palpation. A study in which the tips of the transverse processes of atlases were palpated to detect the presence of any bony or positional anomalies found no relationship between the static findings of asymmetrical prominence or nonprominence and joint movement tests (17). Hence, a bone that feels "out of place" (a high spot, prominence or lack thereof) may just be asymmetrically shaped and have no bearing on joint motion. The data collected suggest that clinical interpretation of static palpation findings may be difficult because facets frequently do not line up in the same plane (i.e., facet plane angle, contour and placement on lateral mass). This anatomical finding might give the examiner/palpator a subjective feel of displacement to either the occiput or atlas on a live patient. For instance, a facet that is anatomically more posterior on one side of the atlas could statically palpate as an anterior atlas or a posterior occiput on that side. Since the facets of the atlas and the occipital condyles are not matched surfaces, the position of the head must also be considered. A prominence of one surface may fit into a depression of the opposing surface in a neutral position. As the condyles roll on the facets with flexion or extension of the head, two prominences may meet giving the examiner using static palpation the impression that the occiput is inferior on the contralateral side or superior on the ipsilateral side. The converse may be true as two depressions approximate.

This study supports the contention that subluxations are not necessarily bones out of place, and that some of the so-called minor misalignments are "built-in" anatomically and are thus not correctable with manipulation. Unless examined correctly, extrapolating motion palpation findings of the atlanto-occipital joint may be equally unreliable. The primary motion of the joint is nodding, accomplished by roll of the condyles while some glide is also present. Many examiners motion palpate the joint bilaterally with nodding motions and then attempt to isolate each side by laterally tilting the head to the individual side and pushing the skull through the range of motion with a "scooping" action. A flatter planar joint surface may motion palpate freely, while a more concave surface could give the examiner a subjective feel of restriction. Given the degree of variations detected and with no two joint surfaces being identical, comparing right and left craniovertebral joints may have limited clinical application unless the characteristic qualities listed below are considered. The degree and direction of movement may indeed be different on each side due to the varying shape of the joints. This may also be apparent in that the ranges of motion reported as normal vary considerably between authorities as mentioned above. Therefore, instead of comparing direction and amount of motion from one side to the other, each side of the joint should be considered separately to determine the presence or absence of joint fixation. Palpating for presence or absence of joint fixation thus examines quality of movement rather than quantity. Assessing joints in this manner may eliminate some variables and may improve interexaminer reliability. Aberrancies of the coupling mechanism in the cervical spine are pathological and can be associated with neurological deficits (18). There is a direct correlation between the level of clinical radiculopathy and the level of pathomechanics in the cervical spine (18). These pathomechanics can be reduced by manipulation with corresponding improvement of the subjective and objective clinical picture of cervical radiculopathy (18).

Manual examination of intersegmental motion can identify symptomatic cervical synovial joints. The pathognomic features of symptomatic joints that have been verified by a clinical trial are altered quality of movement, abnormal end feel and pain reproduction upon testing passive, accessory movements of the target joint (19, 20). The current "gold standard" for the diagnosis of cervicogenic headache is injection techniques. Needles may be used to provoke or anesthetize a pain causing structure (19). Similarly, palpation can be used to provoke pain and manipulation used to alleviate the pain. The ability of a manipulative therapist to diagnose symptomatic cervical zygapophysial joint syndromes accurately was evaluated in a series of 20 patients. In 11 patients the presence, or absence, of a symptomatic joint was established by means of radiologically controlled diagnostic nerve blocks. These patients were assessed by the manipulative therapist, without knowledge of the medical diagnosis. Another nine patients were first seen by the manipulative therapist whose diagnosis was then evaluated by means of diagnostic blocks. The manipulative therapist identified correctly all 15 patients with proven symptomatic zygapophysial joints, and specified correctly the segmental level of the symptomatic joint. None of the five patients with asymptomatic joints was misdiagnosed as having symptomatic zygapophysial joints. Thus, using the criteria of abnormal end feel, abnormal quality of resistance to motion, and reproduction of pain, the manipulative therapist in this study had both a sensitivity and specificity of 100% (20). However, interexaminer reliability must be tested before broader generalizations can be made about the accuracy of manual diagnosis.

Still arguable are the controversies of adjusting into or away from the fixated joint, and the need for statically listing a vertebra which may or not be accurate due to undetected structural variation. Adjusting and manipulating practitioners have long disagreed about assessment and treatment of malfunctioning joints, and despite that fact treatment outcomes are promising. Perhaps the simple cavitation of a joint promotes the necessary proprioceptive neural responses and the motion allows the joint to better nourish and maintain itself. Potentially, the subjective static listings and precalculated lines of drive for adjusting joints have little effect on outcome when the only common ground between most high velocity, low amplitude manipulations is cavitation of the joint.

CONCLUSION

When deciding which manipulative procedure should be instituted, the significance of the palpation findings should be carefully weighed in light of the many variables that influence the examiner's subjective interpretation of these findings. Practitioners must continue the pursuit of understanding and improving the art of palpation.

ACKNOWLEDGMENTS

I gratefully acknowledge the help of my father, Dr. Gilbert Gottlieb, for his many additions and editorial assistance; Dr. Robin McCauley for her encouragement and review of the manuscript; Dr. David Seaman for his review and assistance with references; and Dr. Rodger Tepe and Dr. Gary Sanders for their help with the proposal and original abstract.

The financial contributions of the Chiropractic Assistants' Association of North Carolina (CAANC) are greatly appreciated, as is the partial support of Logan College of Chiropractic. My parents, Gilbert and Nora Gottlieb, have given most generously to this and other research projects. Without their support, much of my current research would not have been possible. To this avail, I dedicate this work to my parents with much gratitude.

REFERENCES

1. Fitz-Ritson D. Assessment of cervicogenic vertigo. J Manipulative Physiol Ther 1991; 14:193–8.
2. Guyton AC. Textbook of medical physiology, 8th ed. Philadelphia: W. B. Saunders, 1991.
3. Dvorak J, Dvorak V. Manual medicine diagnostics, 2nd ed. New York: Thieme, 1990.
4. Nansel DD, Peneff AL, Jansen RD, Cooperstein R. Interexaminer concordance in detecting joint-play asymmetries in the cervical spines of otherwise asymptomatic subjects. J Manipulative Physiol Ther 1989; 12:428–33.
5. Schafer RC, Faye LJ. Motion palpation and chiropractic technic, 2nd ed. Huntington Beach, CA: Motion Palpation Institute, 1990.
6. Edwards BC. Examination of the high cervical spine (occiput-C2) using combined movements. In: Grieve GP, Ed. Modern manual therapy of the vertebral column. New York: Churchill-Livingstone, 1986.
7. Grieve GP. Applied anatomy-regional. Common vertebral joint problems. New York: Churchill-Livingstone, 1988.
8. Singh S. Variations of the superior articular facets of atlas vertebrae. J Anat 1965; 99:565–71.
9. Mysorekar VR, Nandedkar AN. Surface area of the atlanto-occipital articulations. Acta Anat (Basel) 1986; 126:223–5.
10. Tulsi RS. Some specific anatomical features of the atlas and axis: dens, epitransverse process and articular facets. Aust N Z J Surg 1978; 48:570–4.
11. Olivier G. Biometry of the human occipital bone. J Anat 1975; 120:507–18.
12. Tillmann B, Lorenz R. The stress at the human atlanto-occipital joint. Anat Embryol (Berl) 1978; 153:269–77.
13. Febbo TA, Morrison R, Valente R. Asymmetry of the occipital condyles: a computer-assisted analysis. J Manipulative Physiol Ther 1992; 15:565–69.
14. Febbo TA, Morrison R, Bartlett P. A preliminary study of occipital condyle asymmetry in dried specimens. Chiropractic Technique 1990; 2:49–52.
15. Guidotti A. Morphometrical considerations on occipital condyles. Anthropol Anz 1984; 42:117–19.
16. Howe JW. Some considerations in spinal X-ray interpretations. J Clin Chiro 1971; 1:75–96.
17. Jull GA. Clinical observations of upper cervical mobility. In: Grieve GP, ed. Modern manual therapy of the vertebral column. New York: Churchill-Livingstone, 1986:318–9.
18. Carrick FR. Cervical radiculopathy: the diagnosis and treatment of pathomechanics in the cervical spine. J Manipulative Physiol Ther 1983; 6:129–37.
19. Bogduk N. The anatomical basis for cervicogenic headache. J Manipulative Physiol Ther 1992; 15:67–70.
20. Jull G, Bogduk N, Marsland A. The accuracy of manual diagnosis for cervical zygapophysial joint pain syndromes. Med J Aust 1988; 148:33–6.

Volume 17 Number 5
June 1994
ISSN 0161-4754

JMPT

JOURNAL OF MANIPULATIVE AND PHYSIOLOGICAL THERAPEUTICS

Williams & Wilkins

Dedicated to the Advancement of Chiropractic
Health Care Principles and Practice