

# THE EFFECTS OF BITE LINE DEVIATION ON LATERAL CERVICAL RADIOGRAPHS WHEN UPPER CERVICAL JOINT DYSFUNCTION EXISTS: A PILOT STUDY

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## ABSTRACT

**Purpose:** To demonstrate the impact of inconsistent bite line positioning during pre and post lateral cervical radiographic examinations and to suggest certain additional imaging studies if the bite line cannot be consistently maintained.

**Methods:** Radiographic measurements of relative flexion and extension in the atlantal-occipital (AO) and atlantal-axial (AA) joints were taken from neutral lateral cervical and cervical flexion and extension radiographs of 20 subjects.

**Results:** The average relative AO flexion was  $-0.9^\circ$  and  $12.0^\circ$  of extension, while the average relative AA flexion and extension values were  $8.5^\circ$  and  $2.8^\circ$ , respectively. In addition, 12 (60%) of the 20 subjects exhibited paradoxical motion at the AO joint during cervical flexion. Of these 12 subjects, 10 also displayed excessive relative AO extension (beyond  $7.5^\circ$ ).

**Conclusions:** If a bite line deviation exists in pre and post lateral cervical radiographic examinations, dynamic cervical flexion and extension radiographs should be taken to calculate the maximum tolerances in the upper cervical spinal joints. If these tolerances are exceeded, the measurement of the cervical lordosis from the back of the second cervical vertebra and seventh cervical vertebra may be altered, thus incorporating the possibility of a 20.3% measurement error on the post lateral cervical radiograph. (*J Manipulative Physiol Ther* 2003;26:e17)

**Key Indexing Terms:** *Radiography; Cervical Spine; Joint Motion*

## INTRODUCTION

In recent literature, it has been shown that the cervical curve is directly influenced by the position of the bite line. The bite line is a line parallel to the chewing surface of the dentition. In some cases, a flattened object, such as a tongue depressor, is inserted into the patient's mouth to more clearly demonstrate the bite line during radiographic imaging. In 1 study, it was concluded that the degree of the cervical curvature, measured from the posterior vertebral bodies of the second and seventh cervical vertebrae with Ruth Jackson stress lines, can be changed up to  $6.9^\circ$ , with up to a  $13.9^\circ$  change in the bite line.<sup>1</sup> The same authors have previously published a mathematical model of

a normal cervical spine.<sup>2,3</sup> This model demonstrates the average cervical curve to be  $34^\circ$ . Therefore, according to these 2 studies, a bite line deflection of  $13.9^\circ$  or less may change the cervical curve measurement by 20.3%. Furthermore, the aforementioned authors have previously stated that, "the atlanto-occipital joint acts as the pivot for the flexion/extension motion of the cranium. The occiput-to-C2 articulations average about 23 degrees of flexion/extension." From this they concluded, "slight head nodding occurs in the upper cervical spine, and does not affect curve measurements from C2-C7."<sup>4</sup> Due to the seemingly contradictory results of these studies, it became necessary to reevaluate their conclusions collectively.

Even though the last study mentioned above was thorough and well documented, it is inevitably based on an assumption. This article assumes that any individual, prior to the onset of chiropractic care, will have normally functioning atlantal-occipital (AO) and atlantal-axial (AA) joints. When these joints are working correctly (ie, normal or full ranges of motion),<sup>5,6</sup> the conclusions of these studies may indeed be accurate. However, there may be evidence to suggest that an unknown portion of the population may display a functional deficit at 1 or both of these upper

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cervical joints.<sup>7-9</sup> Due to the possibility of these functional deficits, we propose a method of evaluating the upper cervical joints radiographically by analyzing lateral cervical flexion and extension radiographs. This method may determine if these joints are, in fact, working normally in each patient. We propose that upper cervical joint dysfunction may compromise the reliability of pre and post lateral cervical radiographs if consistent patient positioning is not maintained on pre and post lateral cervical radiographs.

According to the literature, there exists an average of approximately 14.0° of flexion and extension in the AO joint and approximately 12.5° of flexion and extension in the AA joint.<sup>5,6</sup> This breaks down into 7.0° in either direction at the AO joint and 6.3° in either direction at the AA joint. Therefore, these ranges of motion are the maximum amounts that can occur at these joints before the measurement of the cervical lordosis from C2-C7 is affected. However, these are the values for a normally functioning upper cervical spine. When the AO and/or AA joints are restricted, these normal ranges are decreased, which may lead to compensatory flexion and extension in the middle to lower cervical joints so that the proper amount of global flexion and extension can still be achieved.

## METHODS

Twenty sets of cervical radiographs, provided by various chiropractors in private practice, were analyzed for atlantal-occipital and atlantal-axial joint function. These films included a neutral lateral cervical and cervical flexion and extension views. The radiographs were taken according to the specific patient positioning methods outlined by Jackson et al.<sup>10</sup> The subjects represented in the sample radiographs were between the ages of 18 and 40. The histories of the subjects are not reported because the purpose of this study is to investigate the existence and effects of upper cervical joint dysfunction, not the cause of the dysfunction.

The AO and AA joints were evaluated on the neutral lateral radiograph to determine their positions in relation to each other via a vertical gravity line. A skull base line, an atlas plane line, and a C2 disk plane line were all constructed on each of the 20 sets of radiographs to evaluate relative atlantal-occipital and atlantal-axial flexion/extension. The skull base line was constructed by connecting 2 points just posterior and just anterior to the occipital condyle-cranial base junction. The atlas plane line was created using a point in the center of the anterior tubercle of atlas and a point halfway between the posterior tubercle and lateral mass on the posterior arch of atlas. Marking both the anterior-inferior and the posterior-inferior corners of the C2 vertebral body provided the reference points for the C2 disk plane line. The line is constructed parallel to the C2 disk. The position of the atlantal-occipital joint was evaluated by measuring the angle created by the intersection of the skull base line and the atlas plane line on each radiograph. The

atlantal-axial joint was evaluated by measuring the angle formed by the intersection of the atlas plane line and the C2 disk plane line. These lines and measurements were performed on all 60 radiographs. The relative amounts of flexion and extension at both joints were calculated by taking the end value of the dynamic view (flexion or extension) and subtracting the value of that joint in the neutral position (neutral lateral cervical). For example, when an occiput, initially positioned in 5° of extension on the atlas in the neutral lateral cervical radiograph, repositions to 2° of extension in the flexion radiograph, the net result is a relative flexion of 3° in the AO joint complex.

## RESULTS

Utilizing the methods mentioned above and measuring all the angles on each film, only 2 of the sample subjects demonstrated a normal active range of motion at the AO joint. Most of these radiographs also revealed a deficit at the AA joint. The average relative amounts of flexion were -0.9° (the assigned negative value indicates paradoxical motion that will be defined later in this article) in the AO joint and 8.5° of flexion in the AA joint. As previously mentioned, these values should be 6.5° and 5.0°, respectively. Therefore, on average, a 7.4° functional deficit existed at the AO joint and 2.2° of excessive motion occurred at the AA joint. In extension, the average relative amounts in the AO and AA joints were found to be 12.0° and 2.8°, respectively. These values are normally expected to be 7.0° (AO) and 6.3° (AA). Therefore, our findings suggest an average of 5.0° of excessive AO joint extension and an average AA joint extension deficit of 3.5°.

Paradoxical motion, which can be defined as a motion that occurs opposite of the expected motion, is an indicator of kinematic instability, according to White and Panjabi.<sup>11</sup> In our subjects, AO and AA joint extension occurred during full cervical flexion in a significant portion of the sample size. In fact, 12 (60%) of the 20 patients exhibited paradoxical motion at the AO joint during cervical flexion, compared to 1 (5%) of 20 patients exhibiting paradoxical motion in the AO joint during cervical extension. Paradoxical motion occurred with much less frequency at the AA joint. Flexion and extension at this joint displayed roughly the same amount of paradoxical motion (10% in flexion and 15% in extension).

Another factor of kinematic instability, according to White and Panjabi<sup>11</sup>, is the presence of excessive motion in a given joint complex. Our sample subjects demonstrated excessive AO joint extension in 15 (75%) of 20 cases, as compared to only 3 (15%) of 20 cases in AA joint extension. The opposite was true in AO and AA joint flexion, with excessive motion occurring in 2 (10%) of 20 cases and 13 (65%) of 20 cases, respectively. Thus, our sample group displayed evidence of kinematic instability of the upper cervical spine in both quantity and quality of motion. It is

also interesting to note that 10 (83%) of the 12 subjects who displayed paradoxical motion at the AO joint during cervical flexion also demonstrated excessive AO joint extension during cervical extension. Further studies need to be conducted to investigate any possible links or relationships between these 2 indicators of kinematic instability.

## DISCUSSION

Due to the small, nonrandom sample size of this study, any conclusions made from the given results are premature. However, the occurrence of upper cervical spine dysfunction in this study is consistent with the previous findings of past research.<sup>12-15</sup>

Given that reproducing patient positioning on preimaging and postimaging studies can be quite difficult, many line analysis systems may contain a large degree of mensuration error. However, in the present study, the patient positioning methods utilized have previously been shown to produce a mensuration error of about 3% to 6%.<sup>10</sup>

Many chiropractic radiologists agree that the bite line must be consistently maintained in the same position on preradiographs and postradiographs to more accurately quantify cervical lordosis restoration. Any chiropractic technique focused on obtaining consistent, quantifiable results must take the necessary precautions to avoid exaggerated or embellished measurements. In addition to reproducible patient positioning, the interreliability and intrareliability of marking the radiographs are of key importance, as outlined by Jackson et al<sup>10-12</sup> and Rochester.<sup>13</sup>

Radiographic analysis of upper cervical spine dysfunction may also have other implications. Previous studies have correlated upper cervical dysfunction with headaches of cervicogenic origin.<sup>16-30</sup> Several authors have also documented the related anatomy,<sup>17-23</sup> symptomatology,<sup>24-26</sup> neurophysiology,<sup>17,27-30</sup> and proposed mechanisms<sup>18,27</sup> involved in cervicogenic headache, as well as treatment options in various disciplines.<sup>31-36</sup> Conservative manual therapy trials have shown promise in treating cervicogenic headache through the manipulation of the upper cervical spine.<sup>34-36</sup> Additional studies should attempt to correlate the presence of both upper cervical spine dysfunction and cervicogenic headache symptoms.

If it is previously known that maintaining the same bite line position from preimaging to postimaging studies will not be achieved, cervical flexion and extension views may be taken to properly calculate the ranges of motion in the AO and AA joints. This may then be used as a tolerance for the greatest amount of bite line deviation that can exist for each patient from preevaluation to postevaluation. If the bite line deviation exceeds the calculated tolerance of the upper cervical joints, any quantitative evaluation of the cervical curvature may be rendered inaccurate, and the radiographic postevaluation may need to be reperformed. This provides an inherent check and balance system to ensure quantitative

accuracy for a reliable comparison of pretreatment and posttreatment radiographs. From this, the chiropractic physician may more accurately chart a patient's progress throughout a given treatment protocol.

For accurate evidence-based outcome measures to be achieved, universal standards should exist so that all chiropractic care can be consistently evaluated regardless of the chiropractic techniques employed. Currently, the vast number of chiropractic technique systems makes it difficult to objectively compare the outcome measures of each chiropractic method. Due to the questionable reliability and validity of certain chiropractic diagnostic procedures, such as palpation and inclinometry,<sup>37-42</sup> radiographic biomechanical evaluation standards should be employed. In this regard, the authors agree with the previous conclusions by Harrison et al<sup>43</sup> that, "the use of radiography for identification of any abnormal lateral cervical configuration is absolutely mandatory." However, their conclusion, based on the evidence presented in this study, could be expanded to include the position and function of the upper cervical spine.

## CONCLUSION

The process of evaluating the relative flexion and extension of the upper cervical spine from its neutral position may determine the maximum allowable tolerances of the upper cervical joints for each patient. These tolerances serve as the limits for which the upper cervical joints (and therefore the bite line) can vary before the curvature of the cervical spine is altered. These tolerances may decrease the amount of error inherent in measuring cervical curve measurements on pre and post lateral cervical radiographs. Omission of this process in radiographic analysis of lateral cervical radiographs may result in a measurement error of up to 20.3% in an unknown portion of the population. These tolerances, as well as upper cervical spine dysfunction, cannot be evaluated by visualization or surface curve measurements.<sup>44,45</sup> These findings may provide an indication for conducting biomechanical radiographic evaluations in instances of cervicogenic headache and other symptoms.<sup>18,25-27</sup> Future research should include a reproduction of this study on a larger sample before these findings are applied to the population.

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