Kinematic analysis of the lower cervical spine in the protracted and retracted neck flexion positions

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Abstract. [Purpose] The aim of this study was to analyze lower cervical spine kinematics in protracted and retracted neck flexion positions in healthy people. [Subjects and Methods] The craniovertebral angle (CVA) and intervertebral body angles of the lower cervical spine of 10 healthy individuals were analyzed using fluoroscopy in a neutral sitting with the head in the neutral (N), protracted (Pro), and retracted (Ret) positions and with the neck in full flexion with the head in the neutral (N-fx), protracted (Pro-fx), and retracted (Ret-fx) positions. [Results] There were significant differences in the CVA and intervertebral body angle at the C3–4 level, and the Ret position showed the highest values followed by the N and Pro positions. Regarding the intervertebral body angle at the C4–5 level, the Pro position showed a higher value than the N and Ret positions. At the C6–7 level, the Pro position showed the lowest value compared with the N and Ret positions. In the CVA, the Ret-fx position showed a higher value than the N-fx and Ret-fx positions. [Conclusion] The results suggest that in the neutral sitting position, protraction is an ineffective posture due to overstress of the C6–7 segment, which is placed in a hyperflexed position at this level. Instead, retraction is the recommend posture for the patient with C6–7 degeneration, which makes for a more flexed position in the upper cervical spine and a less flexed position in the lower cervical spine.

Key words: Head posture, Intervertebral body angle, Lower cervical spine

INTRODUCTION

Recently, incidences of disease of the cervical spine have increased, and the age groups affected by it are getting younger due to increased sitting activities with neck protraction, which is referred to as video display terminal (VDT) syndrome4. Clinically, the retracted neck position is recommended for improving the neck pain that occurs due to VDT syndrome2. A retracted neck position means a posture in which the posterior draws the head without rotational neck movements, and the head becomes reward gliding3. When this occurs, the suboccipital muscles, which are exposed to compressive forces by the VDT posture, could be stretched and relaxed2.

Although the retracted neck position is recommended for treatment of cervical spine diseases, performance of a quantitative study is inadequate during retraction and protraction in the neck neutral and flexion postures. There are some reports concerning cervical spine kinematics3, but these are focused on neck motion, not the cervical vertebra motion, or only cover the simple head position4 5. Movements of the cervical spine can be determined through the contribution of each cervical vertebrae, and after quantitatively defining each cervical spine motion, the total cervical movement at a specific neck position can be calculated9. Acquisition of quantitative data from a normal person in pathological or recommended positions is the first step to understanding cervical spine diseases6. Recently, there have been a few studies about the neck flexion and extension motions7-9; however, these studies are insufficiently related to the cervical vertebra kinematics in the neck flexion position with different head postures.

Therefore, the aim of this study was to measure cervical range of motion (ROM) and intervertebral movement through the use of fluoroscopy in cervical protracted and retracted neck flexion positions in healthy people.

SUBJECTS AND METHODS

Ten subjects participated in this experiment. The inclusion criteria were age between 20–25 years; no subjective complaint of pain in the upper back, head, cheeks and upper limbs; no history of medical management for any spinal problem during the last year; and full ability to sit and stand without difficulty.

The exclusion criteria were a previous medical history of cervical spine injury (e.g., instability, fractures, dislocation, facet pathology, or disc herniation), current medical treatment for spinal pain, and systemic disease involving the spine (e.g., rheumatoid arthritis).

The subjects understood the principal objective of this
study and provided written informed consent before participating in the study. This protocol was approved by the Institutional Review Board of Yeungnam University Hospital and was conducted in accordance with the ethical standards of the Declaration of Helsinki.

One trained physical therapist gave instructions to the subjects on the exact movements to perform. The subjects practiced each position three times in preparation for the subsequent radiographic studies. For measuring the craniovertebral angle (CVA), which is representative of the cervical ROM, adhesive markers were fixed on the tragus of the ear and the spinous processes of the seventh cervical vertebra before other procedures.

Subjects placed their heads in three postures, that is, neutral (N), protracted (Pro), and retracted (Ret) positions, while in a relaxed sitting posture. After that, the subjects placed their heads in the maximum flexion position with the N, Pro, and Ret head posture. These positions were named neutral flexion (N-fx), protracted flexion (Pro-fx), and retracted flexion (Ret-fx) respectively. N-fx was the neutral head position without rotational neck movements followed by maximal head flexion. Pro-fx was the maximal forward gliding position of the head without rotational neck movements followed by maximal head flexion. Ret-fx was the head rearward gliding position without rotational neck movements followed by maximal head flexion. The CVA is measured using a goniometer, and it is the angle between a line from the tragus of the ear and the horizontal line of the seventh cervical spine. Lumbar support was used to prevent compensation of the lumbar and thoracic spine.

For measuring the intervertebral body angle, video images were obtained with a fluoroscopy unit (ARCADIS Orbic, Siemens, Malvern, PA, USA) in the sagittal plane. These images were analyzed using the LabVIEW software (National Instruments, Austin, TX, USA). For kinematic analysis, the intervertebral body angles were analyzed based on our previous study. The intervertebral body angle is the angle between the midplane of the adjacent vertebral spine as described by Frobin et al. The angle is counted as positive if the wedge opens ventrally.

Differences in the CVA results and intervertebral body angle results among the N, Pro and Ret and N-fx, Pro-fx and Ret-fx positions were analyzed using one-way ANOVA with the LSD test as the post hoc test. SPSS 21.0 for Windows was used for the statistical analyses. Statistical significance was accepted for values of p<0.05.

### RESULTS

Ten subjects were enrolled in the study, all of whom were males. They had a mean age of 22.60±0.84 years, a mean weight of 67.50±7.91 kg, and a mean height of 171.20±3.67 cm.

There were significant differences in the CVA and intervertebral body angle results at the C3–4 level (p<0.05). The CVA showed the highest values followed by the N and Pro positions (p<0.05). Regarding the intervertebral body angle at the C4–5 level, the Pro position showed a higher value than the N and Ret positions (p<0.05). At the C6–7 level, the Pro position showed the lowest value compared with the N and Ret positions (p<0.05). However, there were no significant differences in the intervertebral body angles at the C5–6 level (p>0.05) (Table 1).

In the case of the CVA, the Ret-fx position showed a higher value than the N-fx and Ret-fx positions (p<0.05). However, there were no significant differences in the intervertebral body angle (p>0.05) (Table 2).

### DISCUSSION

We studied the cervical ROM and intervertebral body angle of the lower cervical spine with the head in the neutral, protracted, and retracted flexion positions in order to analyze biomechanical changes in pathological and recommended head postures.

In our study, the CVA and intervertebral body angle results at C3–4 showed the highest values in the Ret position, followed by the N and Pro positions. The CVA represented the cervical ROM and a larger ROM represented a wider scope of visual field. Villanueva et al. reported that the viewing angle appeared to be decided mainly by the inclination of the neck and the eye. When watching a monitor in the Pro position, a person makes an effort to secure their field of vision due to a lower ROM, and this causes the neck extensor muscle to lift the head. Repeated use of a poor posture causes muscle overloading and fatigue. This could...
also be a risk factor for myofascial pain syndrome, cervical radiculopathy, rotator cuff syndrome, tenosynovitis, carpal tunnel syndrome\(^2\), and dry eye syndrome\(^3\).

With regards to the intervertebral body angle, head posterior gliding in the retracted position caused a relatively upper segment, like the C3–4 level segment, to draw back into a flexion position, which formed a natural curved shape. Ordway et al.\(^4\) reported that the upper spine is in the maximum flexion position and the lower spine is in the extension position during cervical retraction and vice versa during cervical protraction, which supports our studies.

Regarding the intervertebral body angle at the C6–7 level, the Pro position showed the lowest value in comparison with the N and Ret positions. Moreover, we found the intervertebral body angle at the C6–7 level showed a sharp decline in comparison with other cervical segments in the Pro position. This means that the Pro position puts the C6–7 level in a more hyperflexion position than other cervical spine segments. Generally, degenerative changes frequently occur in lower segments\(^5\). Our previous study\(^6\) showed that a protracted position during head extension also creates a higher ROM of the intervertebral body angle at the C5–6 and C6–7 levels. Considering these results, we assumed the Pro position is one of the strong reasons for degenerative changes in the C6–7 segments. On the other hand, the Ret position showed a less flexed position at the C6–7 level and can be recommended to the patients with C6–7 degeneration.

In the fully flexed head posture, the CVA was larger compared with those in the other postures; however, in the Ret fx position, there were no significant differences among the three head positions with respect to the intervertebral body angle. A greater CVA value means a less flexed posture. We noticed that to achieve a closer distance from chin to chest, a protracted head posture is required. However, this posture seemed not to be affected by the intervertebral body angle. Our biomechanical data showed that when the head is placed in full flexion, a retracted posture is not recommended over other postures for achieving a greater ROM. A previous study explained that active neck flexion muscles were negatively correlated with the mean cervicothoracic angle\(^5\). We did not study muscle activity patterns, so it is difficult to definitively state that the protracted head full flexion posture is a bad posture. This needs further study.

The limitations of this study were its small sample size and the lack of analysis of the muscle activity pattern and upper cervical motion due to the limited field of view available.

In conclusion, the results suggest that during the neutral sitting position, protraction is an ineffective posture because it overstresses the C6–7 segment, which creates a hyperflexed position at this level, and that retraction is the recommended posture for patients with C6–7 degeneration, which causes a more flexed position in the upper cervical spine and a less flexed position in the lower cervical spine. However, during full flexion of the head, to achieve a closer distance from chin to chest, a protracted head posture is required. It is difficult to definitively state whether protraction is a good or bad posture during full neck flexion. We believe these results are fundamental to establishment of a good therapeutic diagnosis and to exercise strategies for patients with cervical spine impairment.

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