Reproducibility of the Kinematics in Rotational High-Velocity, Low-Amplitude Thrust of the Upper Cervical Spine: A Cadaveric Study

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Abstract

Objective: This study aimed to investigate the reproducibility of the kinematics in rotational high-velocity, low-amplitude (HVLA) thrust of the upper cervical spine.

Methods: Twenty fresh human cervical specimens were studied in a test-retest situation with 2 manual therapists. Kinematics of C1-C2 and C0-C1 were examined during segmental rotational HVLA manipulation through an ultrasound-based tracking system. The thrust moment was analyzed by 3-dimensional aspects: the range of motion of axial rotation, flexion-extension, lateral banding, and the cross-correlation between the axial rotation and the coupled lateral banding components.

Results: During rotational HVLA thrust on C1-C2, the main axial rotation demonstrates an intraexaminer relationship varying from almost perfect to fair (intraclass correlation coefficient =0.71; intraclass correlation coefficient = 0.35) and a substantial interexaminer correlation of 0.73.

Conclusions: This study showed substantial levels of reliability for the main axial rotation component of segmental manual rotational HVLA thrust on C1-C2. Intra- and interrater reliability for flexion-extension, lateral bending, and cross-correlation was low. (J Manipulative Physiol Ther 2015;38:51-58)

Key Indexing Terms: *Manipulation; Spinal; Cervical Vertebrae; Reproducibility of Results*

Manipulation and mobilization in the cervical spine are commonly used as an effective treatment modality for neck pain.[1,2] Spinal manipulation is defined as a high-velocity, low-amplitude (HVLA) thrust applied to a bony prominence of a vertebral motion segment, whereas a mobilization is considered as a lower-velocity movement that may be applied over a broader area.[2]

The choice of which manual technique to use depends on the technical training performed, skill of the practitioner, and the experience in the assessment of risk versus benefit.[3]

The effectiveness of cervical manual therapy has been systematically reviewed by the Cochrane Collaboration: manipulation improves pain, functional activities, and patient satisfaction similarly to mobilization in a short-term, but not long-term, pain relief.[4] In addition, HVLA manipulation has shown positive physiologic effects including biomechanical, reflex neurologic, local muscle tone, pain modulation, and an augmented feedback tool.[5] Spinal manipulation has become increasingly popular among different disciplines including chiropractic, physiotherapy, manual therapy, and nursing. However, despite the efficacy and its surge in popularity as a cost-effective intervention modality, there is little basic science research[6]: only a small number of authors have examined the cervical kinematics during the HVLA techniques.[2] In particular, most of the studies have focused on the cervical global range of motion during HVLA techniques,[7–9] whereas a few studies examined the segmental kinematics during HVLA specially in the upper cervical spine.[10] Furthermore, the global scenario of evidence is generally lacking, limited, or conflicting. Even the reproducibility analysis of 3-dimensional (3D) motion aspects seems to be understudied. Reproducibility is an integral part of validity (reliability), which pertains to the consistency and repeatability, focusing on the degree of

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agreement between measurements or observations conducted on replicate measures in different locations under the same operating conditions over a period of time or by different people.[11]

The correct and repeatable execution of HVLA technique is important. It is expected that some spinal manipulation may include minor side effects; however, rare, serious adverse events have been reported.[12,13] Thus, study of reliability of thrust is important.

The amount of rotational thrust has been distinguished as important in the cervical district of C1-C2 because of the vulnerability of the arterial system.[14] An extreme force, excessive amplitude in one or several directions, or a combination of these parameters, can expose the vertebral artery to excessive stresses.[9,15]The estimates of stroke associated with (but not necessarily caused by) by spinal manipulation are small, about one in a million[16]; but the severity and consequences of such accidents make this a consistent risk.[17,18]

In the field of manual therapy, the reproducibility of the cervical spine techniques is a debated subject, creating a need for more specific research.[19-21] In vitro segmental reproducibility of kinematics in the upper cervical spine has never been examined during high-velocity thrust (HVLA) techniques. However, up to the present, an in vitro approach is the only possible way to analyze segmental joint kinematics of HVLA thrust due to major methodological and ethical limitations. Therefore, the main goal of this study was to investigate the reproducibility of the kinematics of the 3D motion components during manually performed rotational HVLA thrust on C1-C2.

Methods

Specimens

Twenty fresh human spinal specimens (9 male and 11 female) with a mean age of 80 years with a range of 59 to 97 (11 years) were included. Specimens were gathered from the body-donation program of the Vrije Universiteit Brussels (Belgium), and the mean age of the specimens was 80 years with a range of 59 to 97. Each specimen consisted of the occiput, the cervical segments, and the first 2 thoracic vertebrae. The room temperature was set between 15° and 20° C, and humidity was greater than 60% to prevent the dehydration of the specimens during the study.

Instruments

An adapted Zebris CMS20 ultrasound-based motion tracking system (Zebris Medical GmbH, Isny im Allgäu, Germany) was used in this study. The 3D measuring coordinates of the ultrasonic markers can be recorded with an overall scanning rate of 200 measurements per second. The measuring method is based on the travel time measurement of ultrasonic pulses transmitted by miniature transmitters (markers) to the 3 microphones built into the measuring sensor. The fully digitized conditioning of the sonic signals received guarantees high measuring accuracy in the millimeter range.

The angles of movements are reproduced with an accuracy of less than 0.1° for the axial rotation (the main motion component) and 0.2° for the coupled components.[22]

Procedure

In all specimens, the skin, subcutaneous tissue, and muscles were removed, preserving the bony tissues, muscular insertions, and ligaments. This dissection is necessary to prevent limitation of movements and uncontrolled coupled motions that might occur because of the fixation of the ultrasound system on the segments. Moreover, the biomechanical changes within the muscles might modify the results. It has however been demonstrated that the biomechanical properties of the tendons and ligaments do not change because of conservation by freezing.[23,24] The transmitters and receiver of the ultrasound-based tracking system were mounted on the specially fabricated fixation tools. These tools were inserted as reference points on the cranium (1 on the external occipital protuberance, 2 on equal distance left and right from the first marker on the superior nuchal line, and 1 on the most caudal point of each mastoid process), the atlas (on the left and right transverse processes and on the anterior tubercle), and the axis (on the left and right transverse processes and on the central part of the anterior surface of the vertebral body). The optimal positioning of the device was controlled for every specimen before the start of the mobilizations. Fixation pins were drilled cross-linked through the vertebral body of T2. The specimen was mounted in a wooden frame by the fixation pins. In this way, the specimen was positioned as if the subject was in a supine position on an examination table (Fig 1).

The preliminary procedure about dissection and optimal positioning of the fixation tools assured free mobility of the cervical spine.

Subsequently, each specimen was first moved in the 3 main planes of motion. In all specimens, a C1-C2 segmental manipulative rotational HVLA thrust was performed because the atlantoaxial joint demonstrates the most axial rotation among the upper cervical spinal motion segments.[25] All HVLA manipulations were achieved 3 times consecutively by 2 examiners with several years of experience in manual therapy, in a test-retest situation. The order of manipulation between the examiners was randomly allocated. Examiners were blinded from the data analysis. Both examiners had more than 10 years of practice in manual therapy. Although they performed a trial with feedback of the tracking system on 1 specimen to test the HVLA technique and the experiment setup and to optimize similarity between executers, they had diverse levels of familiarization with the HVLA technique.