Length variations of the vertebral artery in vivo. 
Comparative study between physiological rotation and pre-manipulative position of the cervical spine.

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SUMMARY
The purpose of this in vivo study is to compare the segmental and total length variations of the vertebral artery (VA) between maximum physiological rotation and pre-manipulative position of the cervical spine. A complete CT scanner of the cervical spine was realized on three groups of ten subjects each. Images acquisition for the first and the second group were carried out in neutral position and in right, respectively left rotation positions. For the third group, the images were acquired in neutral position and in pre-manipulative position of the cervical spine at C4/C5 right level using multiple component technique. The length variations were calculated according to the inter-foraminal distances. A major finding during manipulative technique used in our study, demonstrate that length variations of the vertebral are significantly less than the variations during physiological rotations to left and right side.

INTRODUCTION
Cervical manipulation using high velocity low amplitude (HVLA) is regularly considered as risk factor for vertebral artery (VA) lesions. It is generally assumed that such lesions are the result of mechanical lengthening of the AV [1]. The localization of these complications is generally on level C1-C2 because of the great mobility of this segment together with the particular path and the tissue properties of the AV. The description of the path of AV is multiple according to the anatomical variations [2]. AV is generally divided into four parts (V1 to V4) but the studies do not agree on the exact description of these parts. Moreover, literature has documented that full cervical rotation and traction are the most provocative positions for vertebral artery compromise [3]. Given that the older style of high-velocity manipulative techniques utilizes end physiological range, often with a traction component, the potential for vertebral artery damage at least from a technical perspective is evident. Such considerations have led to an evolution of these techniques with a drastic reduction in the range of motion. Such newer techniques are referenced as multiple component techniques. The purpose of this retrospective study is to determine if the length variation of VA in the pre-manipulative position of the cervical spine is different from the position in maximal rotation of the head.

METHODS
A complete CT scanner (Sensation 16 Siemens®, spiral acquisition, slice thickness 0.75 mm with pitch 0.6, CARE Dose software Siemens®) of the cervical spine (C0 to C7) was realized on three groups of ten subjects. The procedures used were in accordance with the ethical standards of the hospital’s ethical committee on human experimentation and has been approved by the hospital’s institutional review board. Written consent was obtained from all volunteers. Images acquisition for the first and the second group were carried out in neutral position and in right or left rotation positions. For the third group, the images were acquired in neutral position and in pre-manipulative position at C4/C5 right level using multiple component technique [Fig 1]. Three dimensional bone reconstructions were done for each subject in the two positions. Anatomical landmarks were placed at each transverse foramen from C1 to C6 at the right and left side [Fig 2]. The distance between these landmarks in neutral position, left - right rotations as well as in pre-manipulation position was calculated. Reliability and precision of anatomic landmarks were performed ten times by three different observers. Intraclass correlation coefficients (ICC) were chosen to quantify both the consistency and the absolute agreement of anatomic landmarks placement.

Figure 1: Pre-manipulative position at C4/C5 level using multiple component technique.
RESULTS AND DISCUSSION
ICC between observers 1-2 was 0.94, between observers 1-3 was 0.96 and between observers 2-3 was 0.94, and intra-observer ICC was 0.98. The VA elongation (ΔL %) were defined as the percentage change in length over the original segment length obtained with the head and neck in neutral position. Positive value indicates elongation of the segments from the neutral length, whereas negative value indicates shortening.

Figure 2: 3D cervical spine reconstruction and landmarks

The segmental length changes from C1 to C6 of the right and left VA in the pre-manipulative position at C4/C5 right level, was significantly less than the variation length during left and right head rotation (p<0.01) (Fig 3). In the same way, the results confirm the large mobility C1/C2 inducing a maximum lengthening on the opposite side during rotations but on the same side during the pre-manipulative position. However, the pre-manipulative position decrease considerably the lengthening of the VA on C1/C2 compared to physiological rotations (Fig 4).

Furthermore, during head rotation, the VA segments elongate on the opposite side of rotation and shorten on same side. We hypothesized that the elongations and shortenings occurring simultaneously on VA segments were caused by coupled motions [4] During pre-manipulative position using multiple component technique at C4/C5 right level, the head was turned to the left and lateral bended to the right which involved a shortening of 1% of the right artery and lengthening of 6% of the left artery. These variations length follow the same tendency as those during the right rotation, this could be explained by the lateral flexion component used during the technique of manipulation.

Our results support the finding of the in vitro study of Wuests et al [3]. These authors used sonomicrometry crystal superimposed on the VA during rotation and manipulation; they concluded that cervical spinal manipulation does not appear to put any tensile stress beyond normal on VA segments C1-C6 compared to physiological head rotation. Other in vitro study confirms that the breaking strain of VA is around 20% [2]. This value is much more important than the maximum measured in our study.

Figure 3: the variation length (ΔL %) of VA from C1 to C6.

Figure 4: the variation length (ΔL %) of VA between C1 and C2.

CONCLUSIONS
Our findings give new and important insight into the behavior of vertebral artery strain during manipulation using this kind of multiple component technique, and support that the vertebral artery strains experienced during pre-manipulative position is substantially less than the strain during normal neck rotation.

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REFERENCES