Kinematic Study of Spinal Manipulation – A Pilot Study  
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Introduction  
Spinal manipulation has long been used for the management of spinal disorder. It is a manual technique that the therapist applied an accurately determined and specifically directed manual force to the patient’s spine in order to produce some therapeutic effect. Although a lot of studies showed that spinal manipulation was useful for the management of neck and back pain (Bronfort, 1999), its exact mechanism and biomechanical effects are not clear. Hessell et al. (1990) pointed out that there were several distinct features in the manipulation procedure. It was found that a manipulation usually began with a preload force. A thrust would then be applied immediately until a peak or maximum force was reached. The time from the sudden increase in force to the peak force was defined as ‘thrust duration’. The duration for the force to decline to zero following the peak force was labeled as ‘resolution phase’. The force profile has been documented by using pressure pad (Herzog et al. 1993; Gál et al. 1995; Kawchuk & Herzog 1993). However, their studies did not provide any kinematic information for spinal manipulation. In this study, the kinematics of right rotational manipulation performed on human C5/6 was quantified using a 3-Dimensional Motion Analysis System (Vicon 370, Oxford Metrics Ltd., UK). Inter-rater and intra-rater reliability tests were performed to study the reliability of the kinematic pattern of spinal manipulation.  

Method  
Five normal healthy subjects (four females and one male, average age 22.8 years) were recruited. All of them did not suffer from neck pain or associated neck symptoms for the past six months. Each subject was asked to sign an informed consent prior to the experiment. At the beginning of the experiment, a Vertebro-basilar Insufficiency (VBI) screening test was performed to ensure that there was no contraindication for manipulation. Ethical approval for the study was obtained.  
In order to monitor the relative spatial position and orientation between the subject’s head and trunk, a Motion Analysis System (Vicon 370, Oxford Metrics Ltd, UK) was used. Retro-reflective markers of 25mm diameter were affixed to the subject’s head and trunk. Four 120 Hz infra-red cameras were used to capture the position of the reflective markers. Each subject was asked to lie on a plinth, relax and maintain the head in neutral position without any axial rotation, side bending and flexion. Two sets of markers were affixed to the subjects for defining the positions of the head and trunk during the experiment. For the head, the markers were attached to the left tergus, right tergus and just below the right inferior orbit. For the trunk, the markers were attached to the left/right anterior acromion processes and sternon-norch. Due to the relatively large range of head movement, it was not feasible to capture all the markers throughout the manipulation process. Two extra markers were affixed to the subject’s left/right frontal area. A static trial was firstly capture by the Motion Analysis System with all markers in place. Subsequently, the markers over the left and right tergus were removed. A right rotational manipulation technique was then applied to the subject’s C5/6 by an experienced physiotherapist. The markers were continuously monitored by the motion analysis system throughout the manipulation.
In order to study the inter-rater reliability, three chartered physiotherapists with more than 5 years post-qualification experience in spinal manipulation participated in the study. Each physiotherapist performed a manipulation on each subject. For the study of the intra-rater reliability, one of the physiotherapists performed the manipulation twice for each subject. To minimize the carry over effect, at least 48 hours were allowed between successive manipulation sessions.

Results and Discussion

The result showed consistent kinematic pattern similar to that described by Hessell et al. (1990). The manipulation process was started with a left axial rotation until a certain range was reached. After that, a small range of de-rotation towards the right side was performed. A high speed thrust towards the left side was performed shortly after the de-rotation. All the manipulations were accompanied by a click sound, which was recorded using an audio receiver.

Intra-class correlation coefficient, ICC(3,1), for pre-manipulation position was −0.643. ICC(3,1) for the range of de-rotation, the range of thrust, the time for thrust and the angular velocity of thrust were 0.806, 0.578, 0.504 and 0.578, respectively. ICC(3,1) for the neck flexion and side bending at pre-manipulation position were 0.286 and 0.424 respectively.

Inter-class correlation coefficient, ICC(2,1) for pre-manipulation position was 0.167. ICC(2,1) for the range of de-rotation, the range of thrust, the time for thrust and the angular velocity of thrust were 0.308, 0.584, -0.057 and 0.584 respectively. ICC(2,1) for the neck flexion and side bending at pre-manipulation position were 0.741 and 0.169 respectively.

The results showed that both the intra-rater and inter-rater reliability were low except the intra-rater reliability for the range of de-rotation.

Conclusion

Despite that there was consistent kinematic pattern in achieving a successful manipulation, spinal manipulation was shown to be a technique depending very much on individual therapist’s experience. The amount of rotation, side bending and flexion before manipulation thrust were not consistent among therapists and mainly determined by therapist’s hand feeling. However, as all the manipulations performed in this study were defined as “successful” according to the clinical definitions, we propose that there may have a threshold level beyond which a manipulation can be successfully performed. Further study is being conducted to identify this threshold level in order to explore further the relationship between the position of the neck at pre-manipulation position and the kinematics during manipulative thrust and to improve our understanding of the mechanism of spinal manipulation.

References
