AN APPARATUS TO EVALUATE THE EFFECTIVENESS OF CERVICAL ORTHOSES IN RESTRICTING NECK MOTION

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INTRODUCTION

Cervical orthoses (COs) and cervical thoracic orthoses (CTOs) are commonly prescribed to restrict neck motion post trauma and/or surgery and a better understanding of their effectiveness in motion restriction is essential. Nowadays, there is a wide range of COs and CTOs with various materials, structures and designs which significantly impact their mechanical properties and effectiveness. The effectiveness of motion restriction is one of the most import characteristics and various methods have been attempted. In most of the studies, subjects are asked to bend the neck with maximum voluntary contraction in each of the three anatomical planes in order to compare effectiveness of neck motion restriction. However, the outcome is not always satisfactory due to the wide range of strength levels of participants. Ideally, a controlled loading level delivered to the head neck system is needed. Lunsford et al. placed a known dead weight at different locations with respect to the head in order to control the loading level. It was the first attempt to objectively evaluate the effectiveness of neck restriction in vivo. However, the approach has limitation. Though the dead weight is constant, the moment arm (i.e. the distance between the anchored point and the rotation axis of the neck) varies from person to person and the resultant torque applied to the head-neck system does not remain constant. This discrepancy makes it difficult to compare the effectiveness across subjects. In addition, the dead weight will produce both a moment and a translational force which further complicates the evaluation. The objective of this study is therefore to develop an apparatus which is capable of delivering a controlled torque to the head and neck system in the three anatomical planes and quantifying the relative head/neck motion with respect to the trunk.

METHOD

The apparatus has key components including a custom helmet, a T-handle attached to a single-axis torque sensor. The custom helmet is modified from a Half Helmet. The cushion foam was cut into five pieces and each piece was attached to a Fluted Knob Thumb Screw. A snug and tight fit can be achieved via adjusting the thumb screws appropriately. A four prong rotation adapter was placed on the top of the helmet to serve as an anchor point. A T-shaped handle made of aluminum tube was attached to a single-axis torque sensor and a socket adaptor with universal joint was used to connect to the rotation adapter on the top of the helmet. The universal joint allows the controlled loading to be applied in all three anatomical planes (i.e. sagittal, frontal and transverse) with ease. A single-axis torque sensor (Transducer technique Inc. USA) was used to provide feedback regarding both the level and rate of loading. A custom LabVIEW GUI (National instrument Inc. Austin, TX) was used to show the loading pattern on the monitor in real-time. A three-dimensional electromagnetic motion analysis system (mid-range 3D Guidance, trakSTAR, Ascension Technology Corp. USA) was used to quantify the relative motion between the head and trunk.

RESULTS

During the pilot test, the subject was seated in the chair and a five-point harness system was used to restrict the body motion. Subject was instructed to relax during the test and the experimenter used the T-shaped handle to apply a force couple to the head-neck system with real-time feedback on the computer monitor. Mechanically, the force couple is equivalent to a moment/torque which produces pure rotation instead of translation. Pilot results confirm that that apparatus works as expected and the experimenter has no difficulty in controlling the level of torque after practice.

DISCUSSION AND CONCLUSION

The system shows good angular resolution of .1 degrees. In addition, the system provides the tester flexibility when applying loading in all possible directions. The apparatus allows us to apply controlled force couple to the head-neck system which makes the evaluation more consistent across test conditions and subjects. The apparatus is also easy to operate. In summary, we have successfully developed an apparatus for quantitative and objective evaluation of effectiveness of COs and CTOs and the consistency of loading is demonstrated in the pilot test. The apparatus will be further validated regarding the intra-rater and inter-rater reliability.

CLINICAL APPLICATIONS

The developed apparatus will be a useful tool to provide both quantitative and objective evaluation of effectiveness of COs and CTOs in restricting neck motion. The outcomes will be helpful for practitioners to make optimum clinical decision.

REFERENCES

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