The Usefulness of the Cervical Range of Motion Device in the Ocular Motility Examination

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Objectives: To determine if the cervical range of motion (CROM) device, an instrument designed to assess the range of motion in the cervical spine, may be suited for accurately quantifying the magnitude of a patient's abnormal head posture, limitation of ductions, or range of single binocular vision at distance fixation.

Methods: The CROM device was used to measure abnormal head postures in 10 subjects and limitations of ductions in 12 patients by 2 masked observers. In addition, it was used to test the diplopia field in 17 patients at one third of a meter and 6 m. These findings were compared with a standard diplopia field performed on a Goldmann perimeter.

Results: For 10 subjects with abnormal head postures, the findings of the 2 observers had a mean±SD difference of $1.0°±0.7°$ ($P=.15$, paired t test). For the assessment of limitations of ductions, the findings of the 2 observers had a mean±SD difference of $1.1°±2.6°$ ($P=.17$, paired t test). For the 17 patients undergoing diplopia field testing, the results obtained on the Goldmann perimeter and with CROM device at the same test distance were essentially identical (mean±SD difference of $1.3°±0.95°$; $P=.88$, paired t test); however, there was a significant difference between the results at one third of a meter and 6 m (mean±SD difference of $6.0°±1.1°$ for esotropic patients [$P=.001$]; mean±SD difference of $6.0°±2.6°$ for exotropic patients [$P=.002$]).

Conclusion: The CROM device seems to be suitable for testing abnormal head postures, limitations of ductions, and the range of single binocular vision.

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PROPER EVALUATION of patients with strabismus involves quantifying various aspects of their ocular motility. The angle of misalignment can be most accurately quantified with the prism and cover test, or less accurately assessed with the Hirschberg or Krimsky tests.[1] Clinicians would benefit from the availability of a simple and reproducible method to quantify several other aspects of the ocular motility evaluation. These include grading limitations of ductions and quantifying abnormal head postures that can accompany strabismus. In addition, although the diplopia field testing as performed on the Goldmann perimeter provides a reproducible evaluation of the field of single binocular vision at one third of a meter in patients with diplopia,[2-5] there is no readily available practical test for evaluating the field of single binocular vision at distance fixation. This is important, because many ocular motility disorders are characteristically associated with different angles of misalignment at distance fixation than at near fixation. Consequently, diplopia field testing may not accurately reflect a patient's limitation for performing distance visual activities, such as driving a motor vehicle. Also, because the standard diplopia field test as performed on the Goldmann perimeter uses a light for fixation, it may not accurately detect purely torsional diplopia and may be influenced by uncontrolled amounts of accommodation, as has been previously suggested.[4,6]

The cervical range of motion (CROM) device is an instrument that was designed to aid in the evaluation of the range of motion of the cervical spine and has been shown to have a high degree of interrater reliability and reproducibility in that regard.[7,8] The instrument consists of a spectacle frame that is worn by the subject. There are 3 dial angle meters attached to the instrument. A sagittal plane meter and lateral flexion meter serve as gravity meters that can assess a chin elevation or depression and head tilt, respectively. A third meter is a magnetic

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SUBJECTS AND METHODS

All testing for this study was carried out with a specially designed version of the CROM device modified for ophthalmic purposes. The main modification consists of a narrowing of the nasal bridge of the device to permit an unobstructed view by the subject as the eye moves into adduction (the device can be worn over a patient's usual spectacles). Several other minor modifications facilitate using the device in a standard ophthalmic examination room. Although the instructions that accompany the CROM device specifically suggest that the patient be seated facing true magnetic north, this proved unnecessary. When the patient was seated facing any direction, the magnetic yoke overrode the earth's magnetic force to provide sufficient stabilization of the compass. As long as the compass was set to 0 with the yoke in place for each examination, it was not necessary to exactly duplicate the orientation of the yoke on subsequent examinations.

This report consists of 3 separate studies of the usefulness of the CROM device.

EVALUATION OF ABNORMAL HEAD POSTURES

Because a patient with an abnormal head posture caused by abnormal ocular motility may not always spontaneously assume the same head position on repeated testing,[9] normal volunteer subjects were used who simulated abnormal head postures in a reproducible manner. Each subject was seated in a standard examination room chair while wearing the CROM device. Two laser pointers were securely taped to the CROM device (1 on each temple), and the pointer switches were taped in the "on" mode. The subject's head was then positioned to assume an abnormal posture that included a head tilt, face turn, and chin elevation or depression. The 2 spots on the wall illuminated by the 2 laser pointers were then marked, and an examiner read the amount of face turn, head tilt, and chin elevation or depression from the CROM device. The subject then assumed a normal head posture and was subsequently repositioned in the initial abnormal head posture. By superimposing the spots of light from the laser pointers on the 2 marks on the wall, exact duplication of the initial abnormal head position could be insured. A second examiner, masked as to the findings of the first examiner, recorded the abnormal head position from the CROM device. I then tabulated the 2 sets of responses. This means of testing was carried out for 10 abnormal head positions. The abnormal head positions that were chosen for this evaluation ranged from 0° to approximately 40° for each parameters studied (eg, head tilt, face turn, chin elevation, chin depression).

EVALUATION OF LIMITATION OF DUCTIONS

Twelve patients from my practice who had duction deficits were studied: 4 had a limitation of adduction, 3 of abduction, 2 of depression, and 3 of elevation in the eye being tested. They were selected randomly to represent a range of limitations of ductions over the spectrum typically seen clinically (see "Results" section).

The subject was seated in a standard ophthalmic examination chair while fixating a 20/40 OU optotype at 6 m with the tested eye in the primary position. The fellow eye was occluded, and the head was rotated away from the field of the limited duction while the subject maintained fixation on the target optotype. When the subject could no longer maintain the image of regard on the fovea, they noted an abrupt blurring of the optotype. The magnitude of rotation into the field of gaze being tested was then read from the CROM device to the nearest degree by an examiner. The test was then repeated by a second examiner, who was masked as to the findings of the first examiner. I then compared the results of the 1 trial from each observer for each subject.

EVALUATION OF FIELD OF SINGLE BINOCULAR VISION

Seventeen patients from my practice who had diplopia in at least some fields of gaze and single binocular vision in others were tested in the following manner. First, each patient underwent diplopia field testing in the usual manner on the Goldmann perimeter.[2] Then an examiner, who was masked as to the findings of the aforementioned diplopia field test, used the CROM device to assess the diplopia field in the vertical midline meridian and on horizontal side gaze at one third of a meter, using a light as a fixation target. A fixation light was held at one third of a meter in front of the patient wearing the CROM device. The patient's head was then rotated to the right, left, midline up, and midline down while the subject maintained fixation on the light. The subject reported when diplopia was noted and the number of degrees of eccentric head position was recorded by the examiner from the CROM device. Second, to assess the difference in the diplopia field that would be obtained with an accommodative target, the test was repeated at one third of a meter in the same manner except that the fixation target was a Jaeger 3 optotype. Finally, the same manner of testing was repeated while the patient fixated at 20/40 OU Snellen optotype at 6 m.

Because of the additional convergence that is necessary to maintain bifoveality at near fixation, as opposed to distance fixation, one would expect that patients with an exotropia associated with a limitation of adduction (eg, medial rectus paresis, lateral rectus fibrosis) would have a greater deviation at one third of a meter than at 6 m. Conversely, patients with an esotropia associated with a limitation of abduction (eg, lateral rectus paresis, medial rectus contracture) would be expected to have a greater deviation at 6 m than at one third of a meter. Therefore, one would expect to see a greater difference in the size of the diplopia-free fields at one third of a meter vs 6 m if the diplopia is associated with an exotropia or esotropia rather than a hypertropia. In theory, this would be irrespective of whether the horizontal deviation occurred with a vertical version, as occurs with an A or V pattern, or on horizontal side gaze. Consequently, the data analysis for comparison of a diplopia field with a CROM device at 6 m to that obtained with a CROM device on an accommodative target at one third of a meter was stratified based on whether the diplopia was caused primarily by an esotropia, an exotropia, or a hypertropia. This seemed more meaningful than a stratification based on whether the diplopia occurred in upgaze, downgaze, or horizontal side gaze.

For all 3 aspects of this study, the different measurements found with different examiners were compared using the paired *t* test.
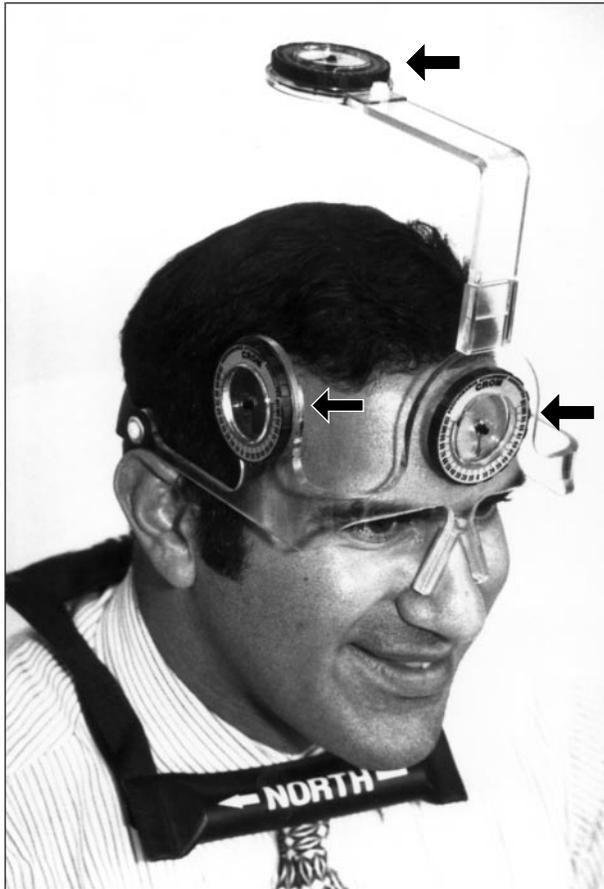
The cervical range of motion device as it is positioned on a patient. Small arrows indicate the gravity-driven meters for evaluating head tilt and neck flexion; the large arrow, the compass for detecting head turn.

compass that responds to a shoulder-mounted magnetic yoke and can measure a face turn (**Figure**). Each of the 3 meters can be read to an accuracy of approximately 1°. Theoretically, the CROM device might be ideal for use in the ocular motility examination for assessing abnormal head positions, limitations of ductions, and the range of single binocular vision at distance viewing. The purpose of this study is to assess that possibility.

RESULTS

ASSESSMENT OF ABNORMAL HEAD POSTURE

For the 10 abnormal head positions assumed, the amount of head tilt ranged from 0° to 40° (mean±SD, 15.3°±13.5°); face turns ranged from 0° to 39° (mean±SD, 16.5°±12.5°); and chin position ranged from 20° chin down to 38° chin up (mean±SD, 14.4°±10.7°). Comparison of the findings of the 2 examiners showed a high degree of reproducibility of findings with the CROM device. For the 30 parameters tested (10 each: head turn, tilt, and chin elevation or depression), the mean±SD difference (absolute value) in the findings of the 2 examiners was 1.0°±0.7° (range, 0°-2°) for all of the axis tested. This difference was not significant (P=.15).

EVALUATION OF LIMITATION OF DUCTION

For the 12 subjects involved in this aspect of the study, the mean±SD distance away from the primary position at which the tested duction was limited was 18.3°±11.3° (range, 5°-38°). These values were representatively split between limitations of adduction, abduction, elevation, or depression. There was a high degree of reproducibility between the results of the 2 examiners for this aspect of the study. The mean±SD difference (absolute value) between the assessment of the 2 examiners for each of the 12 ductions tested was 1.1°±2.6° (range, 0°-5°), which was not significant (P=.17).

EVALUATION OF RANGE OF SINGLE BINOCULAR VISION

There were 5 patients for whom the diplopia in the most restrictive meridian was primarily secondary to an exotropia, 5 in whom it was primarily secondary to an esotropia, and 6 in whom it was primarily associated with a hypertropia. In addition, there was 1 patient in whom the diplopia was primarily torsional. For each patient, the meridian evaluated for comparison was always chosen to be that in which the diplopia field was the most constricted (eg, the diplopia occurred closest to the straight ahead position). For 7 patients, this occurred in right gaze; 3, in left gaze; 3, in elevation; and 4, in depression (the latter included the patient with torsional diplopia).

The comparison of the standard diplopia field to that obtained with the CROM device at one third of a meter using a light for a fixation was to determine if similar results could be obtained with the 2 different testing modalities if the fixation target and distance were the same. For the 17 subjects tested, the mean±SD distance from the primary position at which diplopia occurred in the meridian being evaluated was 18.9°±9.0° (range, 5°-35°) on the Goldmann perimeter. The mean±SD difference (absolute value) between the value obtained on the Goldmann perimeter and that obtained on CROM device on a fixation light at one third of a meter was 1.3°±0.95° (range, 0°-3°), which indicates a high degree of similarity between the 2 tests. The differences obtained between the 2 tests were not significant (P=.88). In general, consistently greater ranges of diplopia-free field were obtained with the CROM device at one third of a meter using a light for fixation rather than an accommodative target; the differences were small (mean±SD, 1.4°±0.7°; range, 0°-3°) but significant (P=.04). However, greater differences were found when the CROM device was used with fixation at 6 m vs one third of a meter on accommodative targets at both distances. For patients in whom the diplopia was primarily associated with a hypertropia, the difference between the range of single binocular vision in the most constricted meridian when tested at one third of a meter and 6 m had a mean±SD of 1.2°±0.75°; this difference was not significant (P=.79). As predicted, however, there was a significant difference if the diplopia was associated with an exotropia or esotropia. For patients with diplopia associated with exotropia, the mean±SD difference in the range of single binocular vision at one third of a meter vs 6 m was

6.0°±1.1° (range, 5°-8°) and this difference was significant ($P=.001$). In some cases, the range of single binocular vision was smaller at one third of a meter than at 6 m and in others it was larger; there was no obvious pattern. For patients with diplopia primarily associated with an esotropia, the mean±SD difference between the range of single binocular vision at one third of a meter vs 6 m was 6.0°±2.6° (range, 3°-10°) and this difference was significant ($P=.002$). For these patients, the range of single binocular vision was smaller at one third of a meter than at 6 m in some cases and in others it was larger; there was no obvious pattern. For the 1 patient with torsional diplopia, the range of single binocular vision in the vertical meridian was 35° into downgaze when tested on the Goldmann perimeter with a light for fixation; horizontally the range was 25° at both right and left of center. When tested at one third of a meter with the CROM device on an accommodative target, the patient had no single binocular field; he was diplopic in all fields of gaze.

COMMENT

This study suggests that the CROM device is a useful instrument for the 3 aspects of the ocular motility examination for which it was evaluated. Typically, an abnormal head posture can be assessed either by estimation or by means of a goniometer.[9,10] Although in my opinion this latter device is more accurate than gross estimation, I have not found results obtained with it to be as reproducible as that with the CROM device.

Most clinicians assess duction deficiencies by gross estimation using a scale from −1 to −4. Even if there was a high degree of interobserver reproducibility with this system (which I believe is unlikely), it only subdivides limitations of rotations into 4 stratifications. Given the number of degrees a normal eye can rotate as it makes a maximum horizontal or vertical duction, each number in that grading system would correspond to approximately 15° to 20°. Clearly, it is far less accurate than the precision that can be obtained with the CROM device.

The data presented here suggest that there are substantial differences between the size of a patient's diplopia-free field at distance than at near fixation. Also, the use of an accommodative target instead of a light may substantially alter the size of the field. Currently, the standard diplopia-free field tested on the Goldmann perimeter is the test on which most disability evaluations are based.[11] Presumably, judgments as to the percentage of impairment of the ocular motor system have evolved over years of experience with the standard diplopia field test. I am not suggesting that the use of the CROM device to test the diplopia field at the distance should immediately replace this time-tested standard. However, I do hope that this study sheds light on the importance of the difference between diplopia field testing at distance and near, and points out the practical manner in which the distance diplopia field can be tested. Also, the use of an accommodative target should be incorporated into the standard testing protocol in some manner. The patient described in this report with torsional diplopia would be deemed to have a 30% loss of ocular motility based on the results obtained with the Goldmann perimeter.[11] Based on the results using an accommodative target, his loss of ocular motility would be listed as 100%. Previous investigators have also reported discrepancies between the range of single binocular vision obtained with a light and that obtained with an accommodative target.[4,6] I agree with them that testing with an accommodative target more accurately reflects a patient's real disability.[4,6]

The CROM device has the advantage of being an easy-to-use instrument that can be kept in an examination room. All of the testing described in the study can be carried out without having to move a patient to a special testing room and can be done in only a few minutes. The CROM device seems ideal for evaluating a recovering duction limitation over time and the evolution of the diplopia-free field in the 4 major meridians while a patient's clinical status is changing. Although it is also easy to use, the CROM device to test the range of diplopia-free field in the oblique fields by rotating the patient's head both horizontally and vertically at the same time, I typically find this is unnecessary for evaluating the evolution of the motility disorder in a particular patient. For definitive documentation of a patient's diplopia-free field, the Goldmann perimeter still provides a more complete picture, albeit one limited by the use of a light for fixation and the fact that it is a test of near range only. Testing with the CROM device does not permit as elegant grading of the field of single binocular vision as has been proposed for the standard method of testing.[3-5] Nevertheless, it does allow for a rapid and easy gross assessment of the range of single binocular vision and its evolution over time.

This study needs to be viewed in light of some obvious and important limitations. Although the study did address interobserver variability, it did not investigate reproducibility of measurements by the same examiner on different occasions. However, I believe that because there was such a high degree of agreement when the second measurements were carried out by a different examiner, it is unlikely that they would be less reproducible if the repeated measurements were carried out by the initial examiner. Also, although the CROM device seems useful for the older and cooperative patients, it is not suitable for use in small children. Finally, the use of the CROM device to detect a limitation of duction is dependent on visual acuity in the affected eye being of a sufficient level to read the appropriate optotype at 6 meters. It is not useful for eyes with profound visual acuity loss.

In conclusion, I believe the CROM device has a useful role in the ocular motility evaluation.

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ARCHIVES *Web Quiz Winner*

We stumped you last month! The correct answer to our April challenge was iris varix. For a complete discussion of this case, see the Clinicopathologic Report section in the May ARCHIVES (Shields JA, Shields CL, Pulido J, Eagle RC, Nothnagel AF. Iris varix simulating an iris melanoma. *Arch Ophthalmol*. 2000;118:707-710).

Clinical appearance of dark iris mass located nasally in the left eye.