The influence of lower cervical joint pain on range of motion and interpretation of the flexion–rotation test

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Objective: The purpose of this study was to investigate the impact of lower cervical facet joint pain (CFP) on the flexion–rotation test (FRT).

Methods: A single blind, comparative group design was used to investigate whether lower CFP influences FRT mobility and examiner interpretation. Twenty-four subjects were evaluated, 12 with cervicogenic headache (age 26–63 years) and 12 with lower CFP (age 44–62 years), confirmed by therapeutic cervical facet joint intervention. A single blinded examiner conducted the FRT, reporting the test state (positive or negative) before measuring range of motion using a goniometer. Subjects with lower CFP were evaluated by the FRT prior to therapeutic intervention and were excluded from analysis if they did not gain complete symptomatic relief following the procedure. Only subjects with immediate complete relief were included.

Results: The average range of unilateral rotation to the limited side during the FRT was 26 and 37.5° for the cervicogenic headache and lower CFP groups respectively. The difference between groups was significant ($P < 0.01$). Sensitivity and specificity for cervicogenic headache diagnosis was 75 and 92% respectively. A receiver operating curve revealed that an experienced examiner using the FRT was able to make the correct diagnosis 90% of the time ($P < 0.01$), with a positive cut-off value of 32°.

Discussion: These findings provide further evidence for the clinical utility of the FRT in cervical examination and cervicogenic headache diagnosis.

Keywords: Cervicogenic headache, Diagnostic accuracy, Flexion–Rotation test, Sensitivity, Specificity

The flexion–rotation test (FRT) is a commonly used assessment of upper cervical movement and is typically used in differential diagnosis of cervicogenic headache and as a treatment outcome measure.¹ The test is typically performed in supine with the cervical and upper thoracic spine maximally flexed. Passive rotation to the left and right is compared for range, pain provocation and resistance.¹ Anatomical morphology suggests movement during the FRT is likely to be constrained to the C1/2 motion segment as a result of flexing the cervical spine to its end range.² End range flexion theoretically blocks/attenuates movement at segments below C2 by ligamentous tensioning. There is some evidence to support this conjecture, as magnetic resonance imaging has recently been used to measure cervical spine segmental movement *in vivo* during the FRT, where it

was shown that the majority of movement occurs at the C1/2 level.³

Normal range of movement for the FRT is reported as 44–45° to each side,^{4,5} while a cut-off value of 32–33° determines a positive test.^{6,7} Previously the FRT has been investigated in a number of different patient groups including those with cervicogenic headache,^{4,6,7} sub-clinical neck pain,⁵ and migraine with and without aura.^{7,8} Migraine pain had little impact on FRT range of motion.⁹ In contrast an association between sub-clinical neck pain and range of motion during the FRT has been reported.^{5,9} However, the cervical segmental source of the neck pain was not identified, so whether the association identified was related to upper or lower cervical disorders could not be examined.

Presently, the best method for determining from which spinal motion segment pain originates is by diagnostic block.¹⁰ Under ideal circumstances, to control for false-positive responses which occur with a single block,¹¹ diagnostic blocks should be

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performed using placebo controls or comparative local anaesthetic blocks.¹⁰ However, comparative local anaesthetic blocks are not usually performed in general clinical practice. In this setting, if complete symptomatic relief is obtained from blocking, for example, the C4/5 facet joint, this is considered to indicate that segment as the source of the patient's neck pain. If the anatomical theory regarding the relative isolation of the FRT to the C1/2 segment is correct, then pain arising from or dysfunction of motion segments other than C1/2 should have little influence on range of motion recorded during the FRT. If the FRT were to be influenced by the presence of lower cervical facet pain then the validity, sensitivity and specificity of the FRT would be diminished.

The purpose of this study was to investigate the impact of lower cervical facet pain (CFP) (confirmed by therapeutic cervical facet joint intervention) on range of motion recorded during the FRT, and examiner interpretation of the FRT. The hypotheses were that FRT mobility is reduced in subjects with cervicogenic headache when compared to those with lower CFP. Second, an examiner using the FRT is sensitive and specific in identifying subjects with C1/2 dominant cervicogenic headache from subjects with lower CFP.

Methods

A single blind, between group design was used to investigate whether lower cervical joint pain, confirmed by zygoapophyseal joint block, influences FRT mobility and examiner interpretation of the test. The Curtin University Human Research Ethics Committee granted approval for this study. Subjects gave written informed consent prior to the study commencement and were able to withdraw from the study at any time.

Subjects

A sample of convenience of subjects was recruited through advertisements placed in local newspapers and through the University website. Inclusion criteria for this group were based on criteria developed by Sjaastad *et al.*¹² and further developed by Antonaci *et al.*,¹³ with the exception of diagnostic anaesthetic blocks. These criteria include intermittent, side dominant headache of moderate intensity without side shift, headache preceded by neck pain, headache precipitated or aggravated by neck movement or posture and associated neck, shoulder or arm symptoms, thereby fulfilling 5 of 7 criteria outlined by Antonaci *et al.*¹³ as indicative of 'probable' CGH. Additionally headache frequency was at least once per week and episodic headache occurred for more than the previous three months. Exclusion criteria were headache not of cervical origin according to International Headache Society guidelines,¹⁴ and inability to tolerate the FRT.

Subjects with lower CFP scheduled for therapeutic cervical facet joint intervention consisting of cervical facet intraarticular injections, cervical medial branch block or cervical radiofrequency neurotomy were recruited from private physiotherapy clinics in the Perth metropolitan area. Inclusion criteria for this group included episodic or continuous neck pain for more than three months and complete, even if temporary, pain relief from therapeutic cervical facet joint intervention at cervical segments other than at C1/2. Exclusion criteria for this group were cervicogenic headache, arm symptoms, and inability to tolerate the FRT procedure. Subjects thus selected were believed to have neck pain arising from lower cervical motion segments. Table 1 details for each subject the cervical level of therapeutic cervical facet joint intervention.

Sample size estimate was based on data collected from a previous report⁷ and pilot data. *A priori* power analysis determined that a total sample size of 24 subjects (12 in each group) was required to obtain a statistical power of 0.80 with alpha set at 0.05. This was based on a single measurement of the FRT, together with a known mean value of 27° (SD=11) for the FRT in subjects with cervicogenic headache, with a mean value of 41° (SD=5.1) for the lower CFP group. Accordingly 12 subjects with cervicogenic headache (seven female), and 12 subjects with lower CFP (four female) were recruited.

Procedures

Prior to measurement all subjects with cervicogenic headache completed a headache questionnaire to obtain an index of headache severity (0–100, with 100 being maximum severity).¹⁵ This index is based on a composite score of headache intensity, duration and frequency with equal weighting given to each element. Test–retest measures of 20 subjects with cervicogenic headache over 24-hours showed high levels of reliability with ICC_(2,1) of 0.92.¹⁵ Additional information was sought from the subjects with lower CFP, including overall severity of neck pain prior to anaesthetic block, recorded on a visual analogue scale (VAS) consisting of a 10 cm line anchored at one end

Table 1 Cervical level of therapeutic cervical facet joint intervention for each subject (n=12)

Subject	Cervical level blocked
1	C4/5 and C5/6
2	C5/6 and C6/7
3	C3/4
4	C2/3
5	C2/3 and C3/4
6	C5/6 and C6/7
7	C5/6
8	C5/6 and C6/7
9	C4/5 and C5/6
10	C6/7
11	C5/6
12	C4/5 and C5/6

Figure 1 The cervical flexion-rotation test.

with the words ‘no pain’ and at the other end with ‘worst pain imaginable’, and duration of symptoms.

One specialist musculoskeletal physiotherapist assessed all 24 subjects while blind to the subject’s group allocation. Experienced clinicians using the FRT have excellent inter-rater reliability [ICC 0.93 (CI, 0.87–0.96)].⁶

The FRT is shown in Fig. 1. The subject lay relaxed in supine with the cervical and upper thoracic spine passively flexed to end range, or if pain prevented this, to a comfortable limit determined by the patient. The head was then passively rotated left and right. Range was determined either by the subject reporting the onset of pain, or firm resistance encountered by the therapist, whichever came first. At this point the examiner made a visual estimate of the rotation range and was required to state whether the FRT was positive or negative, and which side was positive. A test was defined as positive where the estimated range was reduced by more than 10° from the anticipated normal range of 44°. ^{4,7} The examiner then repeated the procedure and measured FRT mobility using a cervical range of motion device (CROM). The CROM is a floating compass (Plastimo Airguide Inc. (Compasses), Buffalo Grove, IL, USA) attached to the apex of the head by Velcro straps. ^{4,7}

All subjects were tested once only. Those with cervicogenic headache were tested on a headache free day to negate the influence of headache at the time of testing. ¹⁶ Any subject complaining of headache on the day of testing was required to return on a symptom free day. Subjects with lower CFP were tested days prior to the therapeutic cervical facet joint intervention procedure. Only subjects who subsequently had complete relief of neck symptoms (even if short term) following the therapeutic cervical facet joint intervention procedure were retained in subsequent data analysis. In all, 19 subjects were tested for inclusion in the lower CFP group. Seven were rejected because they did not get complete relief from the therapeutic cervical facet joint intervention. The order in which subjects were presented to the examiner was randomly allocated, so that the

examiner was always blind to subject group allocation.

Statistical analysis

Statistical analysis was carried out using SPSS V17.0. (SPSS Inc., Chicago, IL, USA). An independent *t*-test was used to compare FRT mobility to the most restricted side between the two groups. To calculate the sensitivity and specificity, the subjects with cervicogenic headache were compared to the subjects with lower CFP. The dichotomous variable was determined according to the therapist’s identification of the presence or absence of a positive FRT (10° estimated limitation of range). The frequencies used for these calculations are given in Table 2. The relationship between sensitivity and specificity is illustrated in a receiver operating curve that was created using data from the FRT. The receiver operating curve plots the false positive rate on the X axis and 1–the false negative rate on the Y axis. It shows the trade-off between the two rates. If the area under the receiver operating curve is close to 1, this represents a very good test. If the area is close to 0.5, this represents a very poor test, no better than chance at identifying the disease state. The point on the curve nearest the upper left-hand corner represents the value with the best diagnostic accuracy, and this point is selected as the cut-off defining a positive test.

Results

Headache symptoms and other characteristics are shown in Table 2. All underlying assumptions for an independent *t*-test were met. Range of rotation towards the most restricted side was significantly lower in the cervicogenic headache group than the group with lower CFP (Table 2). The difference between groups was significant ($P < 0.01$), with a mean difference of 11.5° (95% CI 16.8, 6.2).

Table 3 outlines the sensitivity, specificity, positive predictive value, and negative predictive value as well as likelihood ratios for cervicogenic headache diagnosis based on interpretation of the FRT. A receiver operating curve (Fig. 2) revealed that presented with a randomly chosen pair of patients, using the FRT, the clinician is able to make the correct diagnosis 90% of the time ($P < 0.01$). Additionally, coordinates on the receiver operating curve indicated that the test value, which provided the highest sensitivity and the lowest 1–specificity, is 32°. In other words, 32° represents the cut-off score for a positive test.

Discussion

To our knowledge, this is the first reported study to compare FRT range of motion determined by an experienced examiner in subjects with cervicogenic headache and lower CFP. On average, range was 11.5° less in subjects with cervicogenic headache than those with lower CFP. Our data for range of motion measured during the FRT are similar to previous

Table 2 Characteristics of the subjects in each group (n=24)

Variable	Group	
	Cervicogenic headache (n=12)	Lower cervical facet pain (n=12)
Gender		
Male	5	8
Female	7	4
Age (years)		
Mean (SD)	42.2 (12.2)	52.1 (5.5)
Range	26–63	44–62
History of pain (years)		
Mean (SD)	4.5 (3.2)	5.9 (2.3)
Range	0.5–12.0	2.0–11.0
VAS for symptoms/10		
Mean (SD)	5.3 (2.0)	6.3 (1.6)
Range	2.7–10.0	2.7–8.7
Index of headache severity (/100)		NA
Mean (SD)	51.2 (14.5)	
Range	33.7–83	
Dominant side of headache		
Left	6	NA
Right	6	
Bilateral	0	
Positive FRT		
Yes	9	1
No	3	11
FRT – range to restricted side (degrees)		
Mean (SD)	26.0 (7.4)	37.5 (5.0)
Range	18–38	24–45
FRT – range to the right (degrees)		
Mean (SD)	31.0 (8.9)	38.9 (5.4)
Range	19–49	24–46

Note: VAS, visual analogue scale anchored at 0 and 10; FRT, flexion–rotation test.

studies using the CROM device in subjects with cervicogenic headache.^{6,8} Mobility towards the most restricted side was 26 degrees in the current study and 22 and 26 degrees in previous reports.^{6,8} Small variation in range may relate to differences in severity of headache symptoms, among the different studies. Previously, variability in headache intensity, duration and frequency have been shown to influence range of motion recorded during the FRT.⁸

Mean range recorded in the subjects with lower CFP was 38°, which is less than the previously reported normal range of 44–45° to each side for the FRT,^{4,5} but within the normal limits of an ‘eyeballed’ 10° estimated limitation of range. Reduced range may reflect the presence of sub-clinical upper cervical joint dysfunction or may simply be due to the presence of pain itself. The presence of pain (headache) has recently been shown to reduce the measured range recorded during the FRT by an average of 6°.⁸

Table 3 The sensitivity, specificity, positive and negative predictive values as well as likelihood ratios of the cervical flexion–rotation test

Test	Value
Sensitivity	0.75
Specificity	0.92
Positive predictive value	0.90
Negative predictive value	0.79
Positive likelihood ratio	9.38
Negative likelihood ratio	0.27

Previously, consistent with the current study, we have established a goniometer determined cut-off score of 32–33° for a positive FRT,^{6,7} that is well below the mean range recorded for subjects with lower CFP in this study. This indicates that dysfunctional cervical motion segments below C2 do not influence the range sufficiently to change the interpretation of the FRT. This provides further evidence for the validity of the FRT as a test of upper cervical motion. Further evidence of the relative isolation of the FRT to the C1/2 motion segment has recently been demonstrated in a study using magnetic resonance imaging to measure segmental mobility during the FRT.³ In that study, segmental rotation at all cervical segments was measured during axial rotation with the neck in neutral and with the neck in flexion (FRT). Seventy-four percent of the total rotation occurred at the C1/2 motion segment with the neck in a flexed position. The remaining movement arose from all other cervical levels. In addition, when compared to axial rotation in neutral, rotation during the FRT was reduced by more than 73% at all segments apart from at the C1/2 segment, which only reduced by 12%. This might explain our finding that range recorded during the FRT was not greatly influenced by the presence of lower CFP.

The receiver operating curve (Fig. 2) shows the relationship between sensitivity and specificity. The area under the curve represents the ability of the test to discriminate between the diseased and non-diseased

Diagonal segments are produced by ties.

Figure 2 Diagnostic accuracy of the cervical flexion-rotation test. The area under the curve is 0.90 ($P=0.001$, CI 0, 1.0).

state. The receiver operating curve can be interpreted as follows: an area of 0.9, indicates that a randomly selected individual from the cervicogenic headache group has a lower range recorded during the FRT than that for a randomly chosen individual from the lower CFP group 90% of the time.¹⁷ Furthermore, the closer the receiver operating curve value area under the curve is to 1 the better the test, the closer to 0.5 the worse the test. A receiver operating curve value of 0.9, as found in our study, falls within the range 0.75–0.92, which is rated as good.¹⁷ In addition, the positive likelihood ratio was 9.4 indicating high certainty about a positive diagnosis in a positive test, whereas the negative likelihood ratio of 0.27 indicates with high certainty about a negative diagnosis in a negative test. Overall diagnostic accuracy in this study is consistent with a previous report, which found an overall diagnostic accuracy of 91% for the FRT.⁷

A number of other studies have examined the sensitivity and specificity of the FRT in cervicogenic headache diagnosis, although in highly selected homogenous samples.^{6,7} In the present study, sensitivity (75%) and specificity (92%) were consistent with previous reports of high levels of sensitivity and specificity for the FRT when used by experienced examiners.^{6,7} In contrast to those previous studies, this is the first study to identify sensitivity and specificity of the FRT with a comparative group consisting of neck pain patients. The relatively high levels of diagnostic accuracy with which the FRT could discriminate between groups in this study, provides support for the validity of the FRT.

There are potential limitations of this study that may affect the interpretation and generalization of these results. Firstly, subjects were recruited in a manner of convenience that may have introduced some sampling bias. Under ideal circumstances subjects should be recruited from consecutive patients attending a single clinic, but for logistical reasons this was not possible. Secondly, all subjects were tested by the same examiner, which may limit the generalizability of the findings; however, previous research indicates that naive examiners with minimal training can identify a positive FRT with high reliability,⁶ hence examiner experience is not a major factor in the FRT application or interpretation. Third, a single therapeutic cervical facet joint intervention procedure was used to determine the symptomatic segment. We recognize that single blocks have a significant rate of false positive findings.¹¹

Conclusion

Range of motion towards the most restricted side during the FRT is significantly reduced in subjects with cervicogenic headache when compared to subjects with lower CFP. The cut-off value for a positive test is range of motion less than 32°. These results provide evidence that the FRT can discriminate between the presence or absence of cervicogenic headache in subjects with neck pain and the presence of neck pain does not diminish test sensitivity or specificity. These findings provide further evidence supporting the clinical utility of the FRT.

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