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ORIGINAL STUDY

The short term effects of a single corticosteroid injection on the range of motion of the shoulder in patients with isolated acromioclavicular joint arthropathy

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This study is aimed at evaluating the short-term effects of a single corticosteroid injection of the acromioclavicular joint on the range of motion of the shoulder joint using a three dimensional electromagnetic tracking system (FASTRAK) in patients with isolated unilateral acromioclavicular joint (ACJ) arthropathy. Eighteen patients (16 male, 2 female ; mean age : 47.53 years), with isolated unilateral ACJ arthropathy were included in the study. Injection of the symptomatic ACJ with local anaesthetic and corticosteroid was performed under image intensifier guidance. Bilateral shoulder FASTRAK assessment before and two weeks after injection of the symptomatic ACJ was performed, measuring flexion/extension, anatomical abduction, scapular abduction and horizontal cross body adduction. Pain was measured using a visual analogue scale.

There was a significant difference in the range of movement between the symptomatic and asymptomatic shoulder before the injection ($p < 0.01$). Range of extension and pain score of the symptomatic shoulder improved significantly ($p < 0.05$ and $p < 0.001$, respectively) after the injection. In patients with radiographical evidence of degenerative ACJ disease, there was also significant improvement in the range of horizontal flexion ($p < 0.05$).

Injection of the ACJ with local anaesthetic and corticosteroid was found to produce short-term pain relief and partial improvement in the range of movement. FASTRAK is useful in the measurement and documentation of range of motion, and can be used to assess the treatment outcome in patients with isolated ACJ arthropathy.

Key words : acromioclavicular joint ; corticosteroid injection ; shoulder movement.

INTRODUCTION

Pathology affecting any of the glenohumoral, acromioclavicular, scapulothoracic and subacromial articulations is likely to affect the range of movement of the shoulder joint complex *(8)*. If more than one of these four articulations is symptomatic, it is often difficult to ascertain the primary cause for the pain and the restricted range of motion of the shoulder.

The function of a joint may be determined by the assessment of activities of daily living, but measurement of joint movement depends on suitable equipment and techniques. Recent developments in goniometer design have allowed reliable clinical

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Table I. — Range of movement of the glenohumeral joint before and after the injection of ACJ

Range of Movement in degrees : Mean (Standard Deviation) (n=18)			Flexion	Extension	Anatomical Abduction	Scapular Abduction	Horizontal Abd/adduction
Gleno-humeral motion	Symptomatic	Pre-injection	125.5° (30.1)	37.1° (10.2)	129.2° (35.8)	127.4° (31.6)	126.2° (43.2)
		Post-injection	137.8° (18.1)	45.0° (9.8)	142.9° (29.2)	138.7° (23.9)	144° (30.6)
	Asymptomatic	First measurement	143.8° (15.7)	48.9° (12.8)	160.1° (25.3)	148.9° (16.4)	150.6° (28.5)
		Second measurement at 2 weeks	148.8° (12.6)	48.2° (13.5)	161.7° (26)	149.4° (17.8)	157.6° (20.1)

measurement of motion at one and two axes articulations (e.g. knee or wrist) *(9)*. Goniometric measurements for scapular and glenohumeral movements have high interobserver variability *(9)*.

Over the past decade, three-dimensional tracking devices have been evaluated for their accuracy, consistency, validity, reproducibility and intra- and inter-observer reliability *(1-3, 6, 10, 20)* on normal shoulder joints *(5, 6, 10, 12)* and the cervical *(6)* and lumbar *(10, 13, 19)* spine. These three-dimensional tracking devices are either optoelectronic or magnetic. FASTRAK has been used to assess shoulder *(6)* and scapular *(7)* movement, spinal movements in normal subjects and patients with lower back pain *(2)*. Other electromagnetic systems have been used for three-dimensional assessment of shoulder and scapular movement in normal subjects and in patients with frozen shoulder *(20)*. Measurements using sensors attached to the skin has been compared with those using sensors fixed directly to the bones. Sensors attached to the skin provide a reliable representation of motion of the underlying bone *(11)*.

The acromioclavicular joint (ACJ) permits motion in three planes : anteroposterior gliding of the acromion during protraction and retraction of the scapula, tilting of the acromion during abduction and adduction of the arm, and rotation of the acromion. We evaluated the short term effects of a single corticosteroid injection of the acromioclavicular joint on the range of motion of the shoulder joint using a three dimensional tracking system (FASTRAK) in patients with isolated unilateral acromioclavicular joint (ACJ) arthropathy.

PATIENTS AND METHODS

Eighteen patients (16 male, 2 female), with a mean age of 46.3 years (range : 31 to 69) were studied. All patients had been diagnosed with isolated, unilateral ACJ arthropathy [osteoarthritis (n = *13*), weightlifters clavicle (osteolysis of the distal clavicle *(17)* (n = 4), acromioclavicular disruption (n = 1)] by the senior author (CWJ). Patients with any clinical or radiographical suspicion of more than a single pathology around the affected shoulder, patients with bilateral involvement or any evidence of pathology below the ACJ level (i.e. combined subacromial and acromial pathologies) were excluded from the study.

After informed consent was obtained, demographic data were collected. The pain level was assessed using a visual analogue scale.

FASTRAK measurements were performed before and after injection of the ACJ with a mixture of 20 mg Triamcinolone Hexacetonide (Wyeth Laboratories, Berkshire, UK, Bristol-Myers Squibb SpA., Contrada Fontana del Ceraso, Italy) and 1 ml of 0.5% Bupivacaine (Astra Pharmaceuticals Ltd, Kings Langley, England). FASTRAK has been developed by Polhemus (Colchester, VT, USA) in the early 1990's to monitor aircraft pilots and to be used in the animation industry. FASTRAK is a 3-dimensional tracking device based on emission of a

low frequency magnetic field by a transmitter. Within this magnetic field, the position and orientation of up to four sensors and their spatial relationship can be recorded simultaneously. It provides dynamic, real-time six degrees of freedom measurement. It computes the position (X, Y, Z Cartesian coordinates) and orientation (azimuth, elevation and roll) of the sensor through space relative to the source transmitter *(6)*. Each sensor measures data in three different planes : a primary plane of movement and two secondary planes. The recording is performed digitally on a computer. The data can be represented as a real time graph or numerically as range of movement.

The first FASTRAK assessment was done before injecting the ACJ. Double-sided adhesive discs were used to fix all sensors to the skin. The first sensor was placed on the manubrio-sternal joint. The second sensor was placed on the acromion, identified as the mid-point between the most prominent lateral part of the acromion process and the lateral end of the clavicle. The third sensor was placed on the ipsilateral lateral epicondyle. The wires connecting the sensors to the transmitter were secured with Micropore surgical tape (3M Healthcare Ltd. Loughborough, Leicestershire, UK) to avoid pull on the sensors.

Movements in each plane were performed consecutively without stopping so as to obtain three measurements of each movement : one in the primary plane and two in the secondary planes. The Fastrak was centred at 0° before movements in a new plane began. Four active motions of the shoulder were assessed. The patients sat on a high stool in front and within 60 cm of the electromagnetic wave transmitter with the elbow fully extended beside the trunk and the thumb pointing anteriorly (neutral position). The patient was asked to elevate the arm as forward as possible (forward flexion) and then to swing it backwards as far as possible passing through the neutral position (extension). The second movement was abduction in the frontal plane (90° to the sagittal plane), starting from the neutral position and back to neutral. The third movement assessed was abduction in the scapular plane (at 45° to the frontal plane). Finally, cross body adduction of the arm with the shoulder in plane of 90° forward flexion was performed *(15)*. This maneuvre began with maximal abduction in this plane followed by adduction across the chest. Each manoeuvre was recorded after a trial run and confirmation that the patient satisfactorily understood the instructions.

Intervention

The symptomatic ACJ was injected under image intensifier control with aseptic technique using a mixture of 20 mg Triamcinolone Hexacetonide and 1 ml of 0.5% Bupivacaine. The subcutaneous tissue was injected with 2 ml of 1% Lignocaine prior to the joint injection.

All patients were reviewed two weeks after the injection. Each patient was asked whether the pain had improved, remained unchanged, or worsened. Also, patients were asked about the duration between injection and noticing pain relief, how long did the pain relief last, and how much pain they had at the time of the FASTRAK measurement on visual analogue scale. Thereafter, the second FASTRAK assessment was performed in the same fashion as described. After the second FASTRAK measurement, patients were followed clinically after 6 months.

Statistics

Motion of the affected side was compared with the unaffected side. Data were entered in a commercially available database and descriptive statistical analysis was performed. Student’s t test was used to analyse the difference between two the groups. The difference between the motion and pain score before and after the injection was compared. We also analysed the data after excluding the patients who had no radiographical evidence of degenerative joint disease of the ACJ.

RESULTS

Of the 18 patients studied (M : F - 16 : 2) 15 were right-handed, and 3 were left-handed. The right shoulder was symptomatic in 10 patients. The

pre-injection average pain score on the visual analogue scale was 7 (range : 2 to 10). This improved to 3.6 (range : 0 to 8) two weeks after the injection. The average duration of onset of pain relief after the injection was 5.4 days (range : 0 to 21). The average duration of pain relief was 14.3 weeks (range : 8 to 24). All patients felt subjectively better at 2 weeks review after the injection.

FASTRAK Measurements

The range of motion of the shoulder in different planes is shown in Table I.

Flexion and Extension : The mean forward flexion and extension on the symptomatic side was 125.5° (SD : 30.1) and 37.1° (SD : 10.3), respectively. On the asymptomatic side, the values for flexion and extension were 143.8° (SD : 15.7) and 48.9° (SD : 12.9). Two weeks after the injection, the mean values were 137.8° (SD : 18.1) and 4° (SD : 9.8) for flexion and extension on the symptomatic side. On the asymptomatic side, flexion and extension at the two weeks interval was 148.8° (SD : 12.6) and 48.2° (SD : 13.5) respectively.

Abduction in the frontal plane : The mean value of abduction in the frontal plane prior to injection was 129.2° (SD : 35.8) for the symptomatic shoulder and 160.1° (SD : 25.3) for the asymptomatic shoulder. This improved to 142.9° (SD : 29.2) on the symptomatic side after injection. On the asymptomatic side, the range of abduction was almost the same two weeks after the first assessment (mean : 161.7° ; SD : 26).

Scapular abduction : The mean value of abduction in the scapular plane prior to injection was 127.3° (SD : 31.6) and 148.9° (SD : 16.4) on the symptomatic and asymptomatic side respectively. After injection the mean changed to 138.7° (SD : 23.9) and 149.3° (SD : 17.8) on symptomatic and asymptomatic side respectively. Horizontal abduction/adduction : The pre-injection values of horizontal cross body abduction/adduction were 126.2° (SD : 43.2) and 150.6° (SD : 28.5) on the symptomatic and asymptomatic side respectively. The post-injection values were 144° (SD : 30.6) and 157.6° (SD : 20.1) on the symptomatic and asymptomatic side respectively.

We further analysed the results after excluding five patients without radiographical evidence of degenerative joint disease in ACJ. On the symptomatic side, there was improvement in the range of motion in all planes after the injection. On the asymptomatic side there was slight difference in the range of movement two weeks after the first assessment.

DISCUSSION

FASTRAK is a small, portable unit, suitable for clinics. The sensors are easy to mount and therefore suitable to study shoulder movements during simple and combined tasks. The assessment relies on patient cooperation and the bony landmarks chosen. There can be some error in measurements due to the effect of skin motion during various joint movements. However, the sensors mounted on the skin can accurately measure scapular motion *(11)*. FASTRAK is relatively quick, cheaper than optoelectronic devices with similar accuracy, non invasive, and without risk of exposure to ionising radiation. The system can be used as an electrogoniometer, and also provides data on real time motion of the sensors, which can help to detect abnormal movement patterns. The trunk movement measured by the sternal sensor can be subtracted. This is particularly useful, as patients with pain around the shoulder tend to compensate by leaning their trunk to one side. To our knowledge, there are no published data on the use of FASTRAK or similar devices to assess the shoulder of patients with isolated ACJ arthropathy.

We studied subjects with unilateral, isolated ACJ arthropathy and used the asymptomatic shoulder as an internal control. Injection of the ACJ with Bupivacaine and Triamcinolone significantly improved pain score ($p < 0.001$) at two weeks. The pain relief lasted for an average of 14.3 weeks after the injection. Other studies have shown similar short term benefit in the form of pain relief from ACJ injection *(4)*. Injection of corticosteroid in the ACJ improved pain score in all patients at two weeks. Injecting the ACJ is a useful diagnostic test in patients in whom the nature of pain is atypical,

especially in the presence of multiple pathologies around the shoulder joint. This has been shown to improve diagnostic accuracy and point towards the most appropriate surgical procedure *(16)*.

The mean range of all movements improved after the injection of the symptomatic ACJ, but this difference was statistically not significant except for the range of extension ($p < 0.05$). There was a significant difference ($p < 0.01$) in the range of movement in all four planes between the symptomatic and asymptomatic shoulder before the injection. This difference was statistically significant after the injection, except for extension. However, the statistical significance of this difference was reduced ($p < 0.05$) for abduction in the 45° plane and horizontal flexion. This suggests that injection of the ACJ mainly improved the range of shoulder extension.

We further analysed the data after excluding the patients who had no radiological evidence of degenerative joint disease of the ACJ. The range of movement of the symptomatic shoulder was significantly reduced in all four planes as compared to the asymptomatic shoulder in all patients before the injection ($p < 0.01$). Two weeks after the injection, there was significant increase in the range of extension, horizontal flexion and total range of flexion on the symptomatic side ($p < 0.05$). On the asymptomatic side there was no significant change ($p > 0.05$) in the range of movements in any plane, two weeks after the first measurements were taken. Horizontal flexion measured in the cross body abduction elicits pain arising from the ACJ *(15)*. We observed significant improvement in horizontal flexion after injection of the ACJ in patients with degenerative disease of the ACJ, but this was not seen when the ACJ pain was due to other reasons i.e. weightlifter's clavicle and ACJ disruption.

The difference between the range of movement of the asymptomatic side two weeks after injection of the ACJ was not significant for all measurements. This suggests that FASTRAK measurements are consistent. The ability of FASTRAK to detect differences in movement between symptomatic and asymptomatic side ($p < 0.01$) suggests that it is a reliable method of measurement of shoulder movement in ACJ involvement.

This preliminary study suggests that ACJ injection with corticosteroid provides short term pain relief and improves the range of motion of the shoulder (extension and horizontal flexion). This favours the general view that painful horizontal flexion of the shoulder may indicate that the ACJ is the source of pain. Shoulder extension significantly improved after the injection in this study group. It may be suggested that restricted and painful shoulder extension can be used as one of the clinical indicators suggesting ACJ as site of pain. Our study is relatively small and not randomised, but we think that it could serve as the basis for better understanding of the changes in the shoulder movement pattern in patients with ACJ arthropathy.

REFERENCES

1. **Barnett ND, Duncan RDD, Johnson GR.** The measurement of three dimensional scapulohumeral kinematics- a study of reliability. *Clin Biomech* 1999 ; 14 : 287-290.
2. **Barrett CJ, Singer KP, Day R**. Assessment of combined movements of the lumbar spine in asymptomatic and low back pain subjects using a three-dimensional electromagnetic tracking system. *Man Ther* 1999 ; 4 : 94-99.
3. **Day JS, Murdoch DJ, Dumas GA.** Calibration of position and angular data from a magnetic tracking device. *J Biomech* 2000 ; 33 : 1039-1045.
4. **Jacob AK, Sallay PI.** Therapeutic efficacy of corticosteroid injections in the acromioclavicular joint. *Biomed Sci Instrum* 1997 ; 34 : 380-385.
5. **Johnson GR, Anderson JM.** Measurement of three-dimensional shoulder movement by an electromagnetic sensor. *Clin Biomech* 1990 ; 5 : 131-136.
6. **Jordan K, Dziedzic K, Jones PW *et al.***. The reliability of the three-dimensional FASTRAK measurement system in measuring cervical spine and shoulder range of motion in healthy subjects. *Rheumatology* 2000 ; 39 : 382-388.
7. **Karduna AR, McClure PW, Michener LA, Sennett B.** Dynamic measurements of three-dimensional scapular kinematics : a validation study. *J Biomech Eng* 2001 ; 123 : 184-190.
8. **Kumar VP.** Biomechanics of the shoulder**.** *Ann Acad Med Singapore.* 2002 ; 31 : 590-592.
9. **Lea RD, Gerhardt JJ.** Range-of-Motion measurements. *J Bone Joint Surg* 1995 ; 77-A : 784-798.
10. **Mannion A, Troke M.** A comparison of two motion analysis devices used in the measurement of lumbar spinal mobility. *Clin Biomech* 1999 ; 14 : 612-619.
11. **McClure PW, Michener LA, Sennett BJ, Karduna AR.** Direct 3-dimensional measurement of scapular kinematics

during dynamic movements in vivo. *J Shoulder Elbow Surg* 2001 ; 10 : 269-277.

12. **Meskers CGM, Fraterman H, Van der Helm FCT *et al.*** Calibration of the 'Flock of Birds' electromagnetic tracking device and its application in shoulder motion studies. *J Biomech* 1999 ; 33 : 629-633.
13. **Pearcy MJ, Hindle RJ.** New method for the non-invasive three dimensional measurement of human back movement. *Clin Biomech* 1989 ; 4 : 73-79.
14. **Pearcy MJ.** Measurement of back and spinal mobility. *Clin Biomech* 1986 ; 1 : 44-51.
15. **Rockwood CA, Matson FA.** *The Shoulder*, 2nd edition. WB. Saunders Company, Philadelphia, 1998, pp 191.
16. **Shaffer BS**. Painful conditions of the acromioclavicular joint. *J Am Acad Orthop Surg* 1999 ; 7 : 176-188.
17. **Sopov V, Fuchs D, Bar-Meir E, Groshar D.** Stress-induced osteolysis of distal clavicle : imaging patterns and treatment using CT-guided injection. *Eur Radiol* 2001 ; 11 : 270-272.
18. **Van der Wall H, McLaughlin A, Bruce W *et al.*** Scintigraphic patterns of injury in amateur weight lifters. *Clin Nucl Med* 1999 ; 24 : 915-920.
19. **Van Herp G, Rowe P, Salter P, Paul JP.** Three-dimensional lumbar spinal kinematics : a study of range of movement in 100 healthy subjects aged 20 to 60+ years. *Rheumatology* 2000 ; 39 : 1337-1340.
20. **Vermeulen HM, Stokdijk M, Eilers PH *et al.*** Measurement of three dimensional shoulder movement patterns with an electromagnetic tracking device in patients with a frozen shoulder. *Ann Rheum Dis* 2002 ; 61 : 115-120.
21. **Youdas JW, Carey JR, Garrett TR, Suman VJ.** Reliability of goniometric measurements of active arm elevation in the scapular plane obtained in a clinical setting. *Arch Phys Med Rehabil* 1994 ; 75 : 1137-1144.