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[Intervention Review]

Scapular fixation in muscular dystrophy

Richard W Orrell¹, Stephen Copeland², Michael R Rose³

¹Department of Clinical Neurosciences, University College London Institute of Neurology, London, UK. ²Reading Shoulder Unit, Berkshire Independent Hospital Reading, Reading, UK. ³Department of Neurology, King's College Hospital, London, UK

Contact address: Richard W Orrell, Department of Clinical Neurosciences, University College London Institute of Neurology, Royal Free Campus, Rowland Hill Street, London, NW2 3PF, UK. r.orrell@ucl.ac.uk.

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ABSTRACT

Background

Winging of the scapula is caused by weakness of the thoracoscapular muscles, which allows the scapula to lift off the chest wall during shoulder movements. In facioscapulohumeral muscular dystrophy (and occasionally in other muscular dystrophies) there is selective weakness of the thoracoscapular muscles which may spare other shoulder muscles such as the deltoid muscle. This imbalance results in significant winging and loss of shoulder function. Historically, a number of different surgical and non-surgical interventions have been used to achieve scapular stability. This review examines the evidence available for the use of all scapular fixation techniques in muscular dystrophy, especially facioscapulohumeral muscular dystrophy.

Objectives

To examine the evidence for the relative efficacy of scapular fixation techniques in muscular dystrophy (especially facioscapulohumeral muscular dystrophy) in improving upper limb function.

Search methods

We searched the Cochrane Neuromuscular Disease Group Trials Specialized Register (20 July 2009), The Cochrane Central Register of Controlled Trials (The Cochrane Library Issue 3, 2009) Medline (1966 to July 2009) and EMBASE (1980 to July 2009) for randomised trials. We also contacted authors of trials and other experts in the field.

Selection criteria

All reports of scapular fixation for muscular dystrophy, including quasi-randomised or randomised controlled trials, comparing any form of scapular fixation (surgical and non-surgical) in people (of all ages and of all severity) with scapular winging due to muscular dystrophy. Our primary outcome measure was objective improvement in shoulder abduction. Our secondary outcome measures were: patient-perceived improvement in performance of activities of daily living, cosmetic results, subjective improvement in pain and proportion of patients with significant postoperative complications.

Data collection and analysis

We collated and summarised studies on the treatment of scapular winging in muscular dystrophy.

Main results

No randomised trials were identified. We therefore present a review of the non-randomised literature available.

Authors' conclusions

There is no evidence from randomised trials to support the suggestion from observational studies that operative interventions produce significant benefits. However, these have to be balanced against postoperative immobilisation, need for physiotherapy and potential complications. We conclude that a randomised trial would be difficult, but a register of cases and the use of a standardised assessment protocol would allow more accurate comparison of the disparate techniques.

PLAIN LANGUAGE SUMMARY**Surgical operations for winging of the shoulder blade in muscular dystrophy**

Winging of the scapula (shoulder blade) in muscular dystrophy is caused by weakness of the muscles which attach the scapula to the chest and help raise the arms. Non-surgical interventions involve casts or slings to support the shoulders. Surgical operations involve fixing the scapulae to the ribs using screws or wire. No randomised controlled trials were found. Small case series suggest that surgical operations might produce significant benefits in some people. These need to be balanced against loss of mobility, need for physiotherapy and possible complications including failure of the fixing material or reduced breathing capacity.

BACKGROUND

Winging of the scapula is caused by weakness of the thoracoscapular muscles, which allows the scapula to lift off the chest wall during shoulder movements. The weakness may be due to either nerve (for example, trauma to the long thoracic nerve) or muscle disease (for example, muscular dystrophy). In the majority of muscle diseases in which this may happen, weakness of the thoracoscapular muscles is associated with generalised weakness of all the shoulder muscles. Consequently the winging is mild and without any specific additional consequences. However in some patients with facioscapulohumeral (FSH) muscular dystrophy there is early selective weakness of the thoracoscapular muscles with relative preservation of the deltoid (Landouzy 1884; Fitzsimons 1999). When shoulder elevation is attempted using the deltoid the scapula rotates and lifts off the chest wall, losing strength at the glenohumeral joint. This results in the person being unable to sustain shoulder abduction or flexion. Tasks such as combing hair, brushing teeth, shaving and reaching up become difficult if not impossible. In addition to loss of function, such marked winging of the scapula is often painful and may cause cosmetic deformity. These patients have relatively preserved strength in other muscle groups, thus in FSH muscular dystrophy there is a rationale for attempting to prevent scapular winging so as to allow more effective deltoid function and an improved quality of life. Occasionally in other muscular dystrophies there may be relative preservation of shoulder muscles compared with thoracoscapular muscles. In these cases, scapular fixation might also be considered.

Historically, a number of different interventions have been used to achieve scapular stability. Bracing with orthotic devices (orthopaedic body casts) may be used in neurogenic cases where function may return (Marin 1998), but is often poorly tolerated (Wiater 1999), and can be cumbersome. Surgical muscle transfer is useful in treating patients with prolonged neurogenic palsy (Truong 1979; Perlmutter 1999), and gives good functional improvement. However, muscle transfer techniques are inappropriate for muscular dystrophy as muscle atrophy will progress during the course of the disease, affecting the transferred muscle itself (Post 1995). Therefore the two main types of operation applicable to muscular disease are scapulodesis and scapulopexy. In scapulodesis the scapula is fixed to the thoracic wall with screws, wires or plates with or without bone graft to produce a solid fusion (Howard 1961; Copeland 1978; Letournel 1990; Kocalkowski 1991; Bunch 1993; Jakab 1993; Twyman 1996; Andrews 1998; Copeland 1999). In scapulopexy fascial or synthetic slings are used to improve scapular fixation (Rinaldi 1964; Ketenjian 1978; Heller 1996). In both procedures the aim is to achieve long-term stability of the scapula with maximal glenohumeral movement and abolish pain while minimising complications.

This review examines the evidence available for the use of all scapular fixation techniques in muscular dystrophy, especially FSH muscular dystrophy.

OBJECTIVES

The objective of this review is to examine the evidence for the efficacy and durability of surgical and non-surgical techniques of scapular fixation in scapular winging due to muscular dystrophy.

METHODS

Criteria for considering studies for this review

Types of studies

We searched the literature for all randomised and non-randomised trials and reports involving fixation (surgical and non-surgical) of the scapula in muscular dystrophy.

Types of participants

We included children and adults with all degrees of severity of scapular winging. We included cases due to any form of muscular dystrophy. Participants had relative preservation of shoulder elevation versus thoracoscapular muscles, i.e. people with muscle disease who were judged by the surgeon to have a reasonable prospect of improving shoulder elevation through surgery.

Types of interventions

We included both surgical and non-surgical treatment of scapular winging:

- orthotic device bracing;
- muscle transfer;
- scapulopexy with fascial or synthetic slings;
- scapulodesis with grafts and/or screws.

Types of outcome measures

Primary outcomes

The primary outcome measure was objective improvement in shoulder abduction measured at more than one year.

Secondary outcomes

Secondary outcome measures were:

- (1) patient-perceived improvement in performance of activities of daily living (ADL);
- (2) cosmetic results;
- (3) subjective improvement in pain;
- (4) proportion of patients with significant postoperative complications:
 - (a) pneumothorax/haemothorax;
 - (b) pain;
 - (c) infection;
 - (d) non-union/fracture;
 - (e) long-term significant reduction in vital capacity.

Measures 1,2,3, 4(d) and 4(e) would have been measured at one year or more. Measures 4(a), 4(b), 4(c) would have included immediate postoperative complications only.

Search methods for identification of studies

We searched the Cochrane Neuromuscular Disease Group Trials Specialized Register (20 July 2009) for muscular dystrophy and scapula or winging or scapulodesis or scapulopexy or orthotic devices. We also searched The Cochrane Central Register of Controlled Trials (The Cochrane Library Issue 3, 2009), MEDLINE (January 1966 to July 2009) and EMBASE (1980 to July 2009). We checked the bibliographies in all reports, retrieved relevant papers and contacted the authors and other experts in the field to identify additional published or unpublished data.

Data collection and analysis

Selection of studies

Two reviewers checked the titles and abstracts identified. We obtained the full text of all potentially relevant studies for assessment. If any randomised controlled trials had been identified, we would have decided which trials fitted the inclusion criteria and graded their methodological quality. Disagreement about inclusion criteria would have been resolved by discussion between the reviewers.

Data extraction and management

Data extraction would have been performed by both reviewers using a data extraction form. Missing data would have been obtained from the authors whenever possible.

Assessment of risk of bias in included studies

There were no studies to assess. In future updates of this review we will assess the risk of bias according to the methods described in the latest version of the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2008).

Data synthesis

Outcome measures would have been analysed with the Review Manager software (RevMan). Differences in proportions would have been summarised as relative risks and differences between means would have been summarised as weighted mean differences. If meta-analysis had been possible, a test for heterogeneity would have been performed. If heterogeneity had been found, a sensitivity analysis would have been undertaken on the basis of methodological quality.

Subgroup analysis and investigation of heterogeneity

We would have conducted analyses for the following subgroups of interest:

1. facioscapulohumeral muscular dystrophy versus other forms of muscular dystrophy;
2. type of procedure used (scapulodesis versus scapulopexy versus muscle transfer versus bracing).

RESULTS

Description of studies

No randomised controlled trials (RCTs) were identified from the register or from other sources. We therefore describe the studies reported, but cannot present any statistical evidence on the relative merit of the different techniques.

Risk of bias in included studies

No studies were included.

Effects of interventions

We found no randomised or quasi-randomised trials of scapular fixation techniques in muscular dystrophy.

DISCUSSION

No RCTs have been performed assessing treatment for scapular winging. We are therefore unable to assess the relative merit of the treatments available, but present a review of the reports in the literature on surgical and non-surgical techniques in muscular dystrophies. Table 1 summarises the reports of scapular fixation for FSH reviewed (FSH being the muscular dystrophy where scapular fixation is usually applied).

(1) ORTHOTIC DEVICES

Orthotic devices are used in various situations to assist limb function, for example ankle/foot orthosis in foot drop. The main advantage is that surgery and its potential complications can be avoided. In neurogenic scapular winging various orthotic techniques have been used such as spica casts (Berkheiser 1937; Marin 1998), sling supports (Mackenzie 1930) and support via a pelvic rest (Horwitz 1938). These have the common aim of resting the involved musculature to assist potential recovery. Unfortunately, in muscle disease deterioration rather than recovery is the rule. In addition orthoses can be cumbersome, imposing an additional burden on an already weakened shoulder. The paucity of relevant literature reflects the current lack of popularity of such techniques in muscular dystrophy. The one published case (Barnett 1995) described orthotic use in a 14-year-old girl with FSH muscular dystrophy. The aim was to design a comfortable device that could support arm abduction by applying a diffuse load to the scapula, functionally fixing it to the thorax. They used a moulded spinal jacket with an incorporated pneumatic device that, when inflated, filled any cavities between jacket and scapula. This was deformable thus reducing point contact pressures but gave sufficient support to improve function. In addition the subject was in control of the device. Objective measures of improved function were reported in shoulder elevation. There was also a subjective improvement in tasks such as combing hair, with the participant continuing to use the orthosis at one-year follow-up. No long-term follow up was reported.

The duration of benefit of orthotic techniques has to be questioned in a progressive disorder, and the amount of residual function present in order for the technique to help needs to be defined. This technique may, however, be useful in patients where surgery is not suitable for other medical reasons.

(2) SURGICAL TECHNIQUES

(a) SCAPULOPEXY

Scapulopexy uses slings to surgically anchor the scapula to the thorax. Rinaldi (Rinaldi 1964) described scapulopexy in a case of Erb's muscular dystrophy. He fixed the scapula to the thorax by passing a fascial band round the vertebral spinous processes and then through a hole in the spine of the scapula. No objective outcome measurements were reported. Ketenjian (Ketenjian 1978) described five shoulder operations in three patients with FSH muscular dystrophy. He used fascia, mersilene or dacron strips, tied around the ribs through holes drilled in the medial scapula. Postoperatively the arm was held in a sling and passive exercises performed from day two to three. All patients showed significant improvement in shoulder abduction and activities of daily living (ADL). One person was able to resume guitar playing; another could return to a secretarial job. There is some experimental work examining the optimum biomechanical use of slings in cadaveric

scapulae (Heller 1996). However, the results have not yet been applied clinically.

In each study initial function was good but deteriorated with time due to stretching of the fascial slings. The aim is to provide firm fixation without inhibiting chest wall movement, thus preventing reduction in vital capacity. However, none of the studies reported vital capacity measurements to substantiate this claim. The procedure is less rigid than scapulodesis, and requires a shorter period of postoperative shoulder immobility, which may reduce postoperative morbidity. The technique is therefore perhaps more suited to individuals with impaired respiratory function or for whom prolonged immobility would be particularly high risk.

(b) SCAPULODESIS

In scapulodesis the scapula is fixed to the thoracic wall with screws, wires or plates with or without bone graft to cause a solid fusion. Howard (Howard 1961) designed a method of thoracoscaphular fusion using tibial and iliac crest bone grafts with screw fixation and demonstrated bony union in three participants. However prolonged postoperative immobilisation and rehabilitation were necessary. Bunch (Bunch 1973) presented a case report of a 17-year-old with FSH dystrophy. Postoperative immobilisation in a spica was for three months. Objective improvement was shown and functional activities such as combing hair, dressing and feeding were easier. The patient requested a second operation on the other shoulder, which was also successful. After the unilateral operation, vital capacity dropped from 94% of that predicted to 85%. After the second operation vital capacity was 74% of that predicted. No other complications were reported.

Copeland and Howard (Copeland 1978) developed the technique further and reported 11 operations on six patients diagnosed as having FSH muscular dystrophy. One person was described as having both FSH dystrophy and scapuloperoneal dystrophy. One had additional congenital heart disease and deafness. The operation involved scapulothoracic fusion using tibial bone strut grafts fixed with screws, and iliac bone grafts inserted between the scapula and ribs. A staged immobilisation was implemented to minimise the time before active physiotherapy. Postoperatively the patients could perform sustained manoeuvres involving the shoulder, and tasks such as dressing and cooking. Three regained the ability to wash their hair or back. Objective improvement in shoulder movement was reported. This study along with several others reported that the greatest subjective improvement was an ability to sustain abduction or flexion of the arm. Two people were severely affected at follow-up by disease progression, but were still able to use their arms and keep their jobs. Minimal loss of vital capacity was reported with no associated functional disability. Five of the six patients returned to have the other shoulder operated on, a measure of operative success.

A further report involved three of the above patients and another 10 patients using a modified procedure. There were 20 fusions in all. The later ones involved screwing the scapula to the ribs and packing with iliac bone chips (Copeland 1999). Eight patients had FSH dystrophy. One had limb girdle muscular dystrophy causing weakness of the deltoid and shoulder subluxation. One patient had Duchenne muscular dystrophy. Results were excellent for at least four years. Maximal functional improvement was seen at least six months postoperatively. Early complications were similar to the previous series (Table 1). No lung function testing was performed

as none had symptoms of respiratory insufficiency. This was the only report in the literature to use a scoring system (Constant 1987). This derives a composite score of functional status and patient satisfaction from ratings of pain, activities of daily living, range of shoulder motion and power. Unfortunately Copeland et al. (Copeland 1999) only reported the scores pre-operatively.

Bunch and Siegel (Bunch 1993) used a combination of wire and bone grafts in 12 patients (17 shoulders) to fix the scapula to the ribs. In all but one operation solid fusion was reported, with improved stability, strength and range of movement though no objective measures were given. Similarly Jakab and Gledhill (Jakab 1993) used bone graft and wires for scapulothoracic fixation in three patients (four shoulders) with FSH muscular dystrophy. The use of wires was claimed to allow immediate fixation obviating the need for postoperative immobilisation and rehabilitation. The immobilisation period was much shorter (sling for three to four days), and it was claimed that active abduction was possible three weeks later without needing physiotherapy. No significant postoperative complications were reported. Objective and subjective improvement were reported (Table 1). All patients could raise their arm and hand above their head. However, there was a reduction in vital capacity (VC) in spite of the short immobilisation period. Twyman et al. (Twyman 1996) used a similar method in six patients with FSH muscular dystrophy, fixing the ribs to the scapula with wires. Again the arm was supported in a sling. Active exercises began on the second day after the operation to try to prevent muscle atrophy. On review 11 out of 12 joints were fused. Abduction and flexion increased and subjective measures were significantly improved. However, there was a significant reduction in vital capacity, though none of the patients were symptomatic as a result of this. Complications are listed in Table 2. In addition, one patient developed a brachial plexus palsy postoperatively, thought to be due to traction on the plexus. This did not improve over a six year follow-up period. Andrews (Andrews 1998) reported 10 operations on six patients using the same technique as Bunch and Siegel. In this series, they used prolonged immobilisation in a spica (12 weeks) with physiotherapy afterwards. In nine out of 10 shoulders a sustained improvement of 46.5 degrees abduction and 60.5 degrees flexion was seen. The most dramatic improvements were in activities involving use of hands at high levels. Dressing and feeding were also improved. Interestingly, there was no evidence of reduction in respiratory function postoperatively. Four of the six patients were pleased with the results.

Krishnan et al. (Krishnan 2005) retrospectively described 22 patients (24 shoulders), five with FSH muscular dystrophy, and others with secondary scapular winging due to multiple previous surgery (11), isolated serratus anterior palsy (3), painful scapular crepitation (2), cleidocranial dysostosis (1), and spinal accessory nerve palsy (1). All fusions used a plate and wire fixation along the medial border of the scapula, with autologous bone graft. Specific details for FSH muscular dystrophy patients were not given, but all five patients were said to be satisfied with their clinical outcome, and on this basis the authors offer scapulothoracic arthrodesis to patients with FSH muscular dystrophy and incapacitating scapulothoracic dysfunction. For all 22 patients, 46% experienced pulmonary complications (including pneumothorax and pleural effusion) and 29% developed a pseudoarthrosis at the fusion site. Other complications included broken wires, and pain and numbness in an intercostal nerve dermatomal distribution. The authors conclude that despite the significant complication rate in

the total patient group, nearly all experienced improvement in pain, although the statistical assessment of pain was not significant ($P > 0.05$). There was also a reduction in functional disability, in passive anterior elevation ($P = 0.004$) and passive external rotation ($P = 0.04$), but the difference was not statistically significant for similar active movements ($P > 0.05$).

An alternative technique has involved cutting a window in the scapula and passing the rib through, thus fixing it to the chest wall (Spira 1948). Letournel et al. (Letournel 1990) used a similar procedure in nine people (16 operations) with FSH muscular dystrophy. The scapula was wired to the ribs using a three-plate construct and a window cut in the scapula. Immobilisation was for three months either in a cast or sling and bandage. Abduction and flexion improved. All participants reported an increase in ability to perform activities of daily living. One was unhappy with the cosmetic result. One had marked progression of disease and 30% decrease in forced expiratory volume (FEV); no other significant alteration in lung function was reported. In those participants followed up for several years the disease had progressed but abduction of shoulder was preserved.

Occasionally patients have requested both shoulders be operated on simultaneously, in spite of the inevitable loss of independence while recovering. Kociałkowski et al. (Kociałkowski 1991) reported a case of a 28-year-old with FSH muscular dystrophy who underwent a one-stage bilateral scapulothoracic fusion. Screw fixation and cancellous bone allografts were used. Postoperatively she was immobilised in a bilateral shoulder pica for seven weeks. The cosmetic result was good and an increase in abduction was reported (Table 1).

In summary, there have been several methods used for scapulodesis. Attempts have been made to reduce the rehabilitation time using wires rather than bone graft. This may be advantageous in patients where one wishes to avoid enforced immobility, and also reduces the operative sites. Graft operations involve harvesting of the graft in some cases from the iliac crest, in others also from the tibia as immobility and less graft site should reduce operative morbidity. However, this technique offered no clear benefit in terms of respiratory compromise. Wires frequently broke postoperatively, though this was not reported to cause functional problems. Operations involving bone graft did not appear to be consistently associated with increased morbidity. One factor requiring consideration is the possible thinning of the scapula in muscular dystrophy (Letournel 1990, Kociałkowski 1991). If this is the case, then the use of wires or screws without additional bone graft insertion could weaken the scapula and

could have led to some of the episodes of non-union or fracture. The degree of scapular thinning should be assessed prior to intervention.

The majority of operations reported have involved fusion of the scapula to the chest wall, perhaps reflecting the preference of surgeons involved in these cases. It appears that the most stable results have been attained using scapulodesis, but the lack of published data on the alternative techniques makes comparison difficult. Most complications have been reported using this technique, but this may just be a reflection of the larger number of reports published.

AUTHORS' CONCLUSIONS

Implications for practice

There have been no randomised trials of surgical or non-surgical treatment in patients with scapular winging in muscular dystrophy. Nevertheless, case reports and case series suggest that operative interventions can produce significant benefits, but these have to be balanced against postoperative immobilisation, need for physiotherapy and potential complications such as reduced vital capacity after scapulodesis, or material failure in scapulopexy. Not all patients will be able to undergo the major surgery involved. Objective assessment pre- and postoperatively is of paramount importance. Surgical expertise is probably a critical factor in the success of these operations. Few surgeons are trained in such procedures.

Implications for research

A randomised controlled trial is probably not feasible in this small patient population. However a register of cases and standardised assessment and follow-up would clarify matters such as the longevity of scapulopexy and the complication rates associated with scapulodesis. The use of a standardised assessment protocol in case series would allow more accurate comparison of the different techniques used.

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ADDITIONAL TABLES

Table 1. Summary of reports on scapular fixation in FSH muscular dystrophy

Paper	No. of subjects	Fixation method	Details	Shoulder Abduction	ADL	Cosmesis	Pain	Follow-up	Material failure
Barnett 1995	1	Orthosis	Pneumatic jacket	Improved	Improved	N/A	N/A	12 months	No
Dickson 1937	2	Scapulopexy	Muscle transfer and fascial slings	Not reported	Not reported	Not reported	Not reported	Not reported	Slings stretching
Rinaldi 1964	1	Scapulopexy	Fascial band through scapula spine	Improved	Not reported	Not reported	Not reported	Not reported	Slings stretching
Ketenjian 1978	3	Scapulopexy	Fascia or synthetic strips through scapula to ribs	Improved	Improved	Improved	Improved	34(20-60) months	1 partial loss of abduction after fall on shoulder 3 weeks post-operatively
Howard 1961	1	Scapulodesis	Bone grafts and screws	Improved	Not reported	Not reported	Not reported	Not reported	Not reported
Bunch 1973	1	Scapulodesis	Wire and bone grafts	Improved	Improved	Improved	Not reported	30 months	0
Copeland and Howard 1978	6	Scapulodesis	Bone grafts	Improved	Improved	Improved	Gradual improvement	6-264 months	1 ununited, secondary graft with iliac cancellous bone
Copeland 1999	13	Scapulodesis	Bone grafts.Used scoring system to rate function status and patient satisfaction	Improved	Improved	Improved	Not reported post-op	12-528 months	2 late screw revision
Bunch and Siegel 1993	12	Scapulodesis	Wire and bone grafts	Improved	Improved	Not reported	Not reported	36-252 months	0
Jakab and Gledhill 1993	3	Scapulodesis	Wire and bone grafts	Improved	Improved	Improved	Improved	35 months	0
Twyman 1996	6	Scapulodesis	Wire fixation of ribs to scapula	Improved	Improved	Improved	Improved	12-80 (49) months	1 symptomatic nonunion requiring revision

Table 1. Summary of reports on scapular fixation in FSH muscular dystrophy *(Continued)*

Andrews, Taylor and Patterson 1998	6	Scapulodesis	Bunch and Siegel technique	Im- proved	Im- proved	Im- proved	Improved	28-120 months	0
Spira 1948	2	Scapulodesis	Rib through window in scapula	Not re- ported	Im- proved	Not re- ported	Not reported	12-24 months	Not reported
Letournel 1990	9	Scapulodesis	Wiring through a window in scapula	Im- proved	Im- proved	Im- proved in 8/9	Not reported	24-133 months	0
Kocialewski 1991	1	Bilateral scapulodesis	Screw fixation and grafts	Im- proved	Not re- ported	Im- proved	Not reported	30 months	0
Krishnan 2005	5 (and 17 non muscu- lar dys- trophy)	Scapulodesis	Plate, wire and bone graft between scapula and ribs	Not re- ported	Not re- ported	Not re- ported	No statistical- ly significant improvement	2-9.5 years	Not reported

Table 2. Post operative complications in FSH reports

Paper	a	b	c	d	e
	Pneumothorax/haemothorax	Pain	Infection	Non-union/fracture	Long-term reduction in vital capacity
Barnett 1995	N/A	N/A	N/A	N/A	N/A
Dickson 1937	Not reported	Not reported	Not reported	Not reported	Not reported
Rinaldi 1964	Not reported	Not reported	Not reported	Not reported	Not reported
Ketenjian 1978	0	0	0	0	Not measured
Howard 1961	Not reported	Not reported	Not reported	Not reported	Not reported
Bunch 1973	Not reported	Not reported	Not reported	0	74% predicted after bilateral
Copeland and Howard 1978	0	4	0	3	Not measured
Copeland 1999	1	4	0	3	Not measured
Bunch and Siegel 1993	0	1	Not reported	0	Not measured
Jakab and Gledhill 1993	0	0	0	0	VC reduced by 0.2L after unilateral; further reduction of 0.05L after bilateral
Twyman 1996	1	1	0	2	VC 79% predicted
Andrews, Taylor and Patterson 1998	1	0	2	0	No significant change
Spira 1948	Not reported	Not reported	Not reported	Not reported	Not reported
Letournel 1990	3	0	0	3	1 subject 30% decrease in FEV1; others no change
Kocialewski 1991	Not reported	Not reported	Not reported	0	Not reported
Krishnan 2005	Not reported for muscular dystrophy	Not reported for muscular dystrophy	Not reported for muscular dystrophy	Not reported for muscular dystrophy	Not reported

APPENDICES

Appendix 1. MEDLINE (OvidSP) search strategy

1 randomized controlled trial.pt.
2 controlled clinical trial.pt.
3 randomized.ab.
4 placebo.ab.
5 drug therapy.fs.
6 randomly.ab.
7 trial.ab.
8 groups.ab.
9 or/1-8
10 (animals not (animals and humans)).sh.
11 9 not 10
12 Muscular Dystrophies/
13 Muscular Dystrophy, Facioscapulohumeral/
14 muscular dystroph\$.mp.
15 12 or 13 or 14
16 scapula\$.mp.
17 Orthopedic Procedures/
18 (scapulodesis or scapulopexy).mp.
19 Orthotic Devices/
20 orthotic device\$.tw.
21 or/16-20
22 11 and 15 and 21

Appendix 2. EMBASE (OvidSP) search strategy

1 crossover-procedure/
2 double-blind procedure/
3 randomized controlled trial/
4 single-blind procedure/
5 (random\$ or factorial\$ or crossover\$ or cross over\$ or cross-over\$ or placebo\$ or (doubl\$ adj blind\$) or (singl\$ adj blind\$) or assign\$ or allocat\$ or volunteer\$).tw.
6 or/1-5
7 human/
8 6 and 7
9 nonhuman/ or human/
10 6 not 9
11 8 or 10
12 Muscular Dystrophies/
13 Muscular Dystrophy, Facioscapulohumeral/
14 muscular dystroph\$.mp.
15 12 or 13 or 14
16 Scapula/ or scapula.tw.
17 Orthopedic Surgery/
18 (scapulodesis or scapulopexy).mp.
19 Orthosis/
20 orthotic device\$.mp.
21 or/16-20
22 11 and 15 and 21

Appendix 3. CENTRAL search strategy

#1 "muscular dystrophy" and (winging or scapula or scapulodesis or scapulopexy or "orthotic device*")

WHAT'S NEW

Date	Event	Description
11 May 2011	Amended	Additional acknowledgement included.

HISTORY

Protocol first published: Issue 4, 2001

Review first published: Issue 3, 2003

Date	Event	Description
10 November 2009	New citation required but conclusions have not changed	Change in authors
7 September 2009	New search has been performed	Change in authors. Updated with new search to 20 July 2009. No new trials found. New retrospective study included in discussion.
14 May 2008	Amended	Converted to new review format.
17 March 2004	New search has been performed	The search of the Neuromuscular Disease Group specialised register was updated in March 2004. Supplementary searches were also run on MEDLINE (January 2002 to March 17 2004) and EMBASE (January 2002 to March 17 2004). No randomised trials were identified.
14 May 2003	New citation required and conclusions have changed	Substantive amendment

CONTRIBUTIONS OF AUTHORS

Dr Michael Rose conceived the review. Mr Stephen Copeland provided expert opinion on the orthopaedic procedures used. Dr Richard Orrell contributed to the update of the review.

DECLARATIONS OF INTEREST

One author (Mr Stephen Copeland) has co-ordinated several trials of surgical interventions reporting a beneficial effect of scapular fixation in neuromuscular disease.

INDEX TERMS

Medical Subject Headings (MeSH)

Muscular Dystrophies [surgery]; Muscular Dystrophy, Facioscapulohumeral [*surgery]; Orthopedic Procedures [methods]; Scapula [*surgery]

MeSH check words

Humans