The Pain Clinic, Vol. 11, No. 1, pp. 51–67 (1998)

rct
neck
#3161

Research paper

Pain, muscular tenderness, cervical and shoulder mobility in patients with cervical radiculopathy randomly treated with surgery, physiotherapy or a cervical collar

LISELOTT C. G. PERSSON RPT, MSc* and ULRICH MORITZ MD, PhD†

*Department of Neurosurgery, Lund University Hospital, Lund, Sweden
†Department of Physical Therapy, Lund University Hospital, Lund, Sweden

summary

This prospective, randomised study compares the efficacy of surgery and conservative treatments in patients with cervical radiculopathy. The study group comprised 81 patients with long-lasting cervicaloradiculopathy, with a pain distribution corresponding to a significant nerve root compression, verified by magnetic resonance imaging or computed tomographic myelography. The patients were randomly allocated to surgery, physiotherapy or to wearing a cervical collar. The therapeutic effects were evaluated with respect to pain intensity on a visual analogue scale, pain distribution by pain drawing, and muscle tenderness by manual palpation. Shoulder and cervical range of motion was measured. The controls were performed before treatment, and 4 and 12 months after the start of the treatment. Before treatment, the groups were uniform. After treatment, the surgery and physiotherapy groups reported lower pain intensity and fewer painful areas compared to the collar group. The surgery group showed a reduced tenderness score compared to the two conservatively treated groups, and improved shoulder motion compared to the collar group. However, after 1 year, there were no significant differences between the treatment groups.

The conclusion is therefore that one treatment is as good as any other of the three treatments studied although there is some difference in time when the improvement takes place.

Key words: anterior cervical fusion; cervical radiculopathy; cervical collar; physiotherapy.

introduction

The main symptoms of cervical radicular compression are neck-shoulder-arm pain with paraesthesia and motor deficit corresponding to the involved nerve roots.[1] Pain in the neck-shoulder-arm region can also be caused by referred pain from non-nervous structures such as a disease of spinal facet joints and soft tissue structures.[2,3] Neurogenic and musculoskeletal nociceptive pain often occur combined in patients with cervico-brachialgia.[4] Muscle tenderness is also a frequent finding,[5] but the connection between cervical root compression and muscle tenderness has not been investigated, nor have previous evaluations of interventions included the effect on muscle tenderness.

Neck movements are often provocative of pain in patients with cervical radiculopathy. Stiffness and neck-muscle tension with reduced active neck

Correspondence to: Liselott C. G. Persson, Department of Neurosurgery, Lund University Hospital, Lund, S-221 85 Lund, Sweden.

mobility are common clinical findings.[4] Painful stiffness of the shoulder joint may be found in chronic cases.[6] The outcome of intervention in cervicobrachial pain syndromes may be influenced by external factors such as smoking. There are several studies that show smoking to be a risk factor for the development of back pain[7] and indicate a high prevalence of smokers among patients with cervical disc disease.[8]

Several uncontrolled studies have reported good results of surgery in patients with cervical radiculopathy caused by nerve root compression. Different forms of physiotherapy are often applied in acute as well as in chronic cases of cervical disc disease[9] and many authors advocate a soft or semirigid collar in an initial period.[10] In previous randomised studies, the effect of surgery, physiotherapy and the use of a cervical collar has been evaluated with respect to pain intensity, muscle strength and sensory loss[11] and the patients' well-being (physical, psychological and social) has been measured by the Sickness Impact Profile inventory and mood measured by the Mood Adjective Check List.[12] However, no previous study has included evaluation of joint mobility, muscle tenderness, pain description and the impact of smoking. We therefore considered pain description, muscular tenderness and neck and shoulder mobility to be adequate parameters for evaluation of the results of three classical treatments in a randomised series of patients with cervical radiculopathy.

The aims were:

- to compare the efficacy of surgery, physiotherapy and the use of a cervical collar with respect to the intensity and distribution of pain, muscular tenderness and shoulder and cervical mobility;
- to compare the cervical mobility of the treatment groups with that of a healthy control group;
- to investigate if there was any relationship between pain intensity and muscular tenderness, neck mobility, and smoking habits.

patients and methods

Patients

One hundred and sixteen consecutive patients of both sexes between the age of 28 and 64 years who had experienced cervicobrachial pain for more than 3 months were referred to the Neurosurgery Department, Lund University Hospital, Lund, in order to be considered for surgical treatment. They underwent a full neurological examination by a senior neurosurgeon. Plain X-rays and magnetic resonance tomography (MRT), cervical computed tomography (CT) or myelography of the cervical spine were performed. The clinical examination and the MRT, CT or myelography findings together with the distribution of pain determined the clinical level of radiculopathy. The patients were given written information about the study, which had been approved by the Ethics Committee of Lund University.

The inclusion criteria were clinical and radiological signs that indicated nerve root compression corresponding to the distribution of pain. Exclusion criteria were spinal cord compression, insignificant radiological findings of nerve root compression, whiplash or other traumatic injuries and serious somatic or psychiatric diseases. Of the original 116 patients, 6 did not want to participate in the study. Ten patients showed clinical and radiological signs indicating spinal cord compression and were excluded and referred for surgery. Nineteen patients had no or insignificant radiological findings indicating root compression and were referred for physiotherapy. The remaining 81 patients with clinical and radiological findings indicating nerve root compression corresponding to the distribution of pain constituted the study group. The nerve root compression was caused by spondylotic spurs with or without an additional bulging disc. In the study group, the mean age was 47.5 years (median 49.0, SD 7.9; range 28–64). Thirty-seven (46%) were women.

The patients were randomised by the use of sealed envelopes into the three treatment groups: surgery ($n = 27$), physiotherapy ($n = 27$) and cervical collar ($n = 27$).

Control group

A control group comprising 30 healthy individuals (13 women and 17 men) was used for comparison of the cervical range of motion. The controls were recruited from the hospital staff and matched for sex and age. None of the subjects had a history of neck pain or major injury affecting the neck or upper limbs. The control group was tested on two occasions with an interval of 7–14 days in order to test the intra-reliability of the measurements.

methods

A clinical examination was performed according to a fixed protocol by an experienced physiotherapist before treatment (Control 1) and repeated at the same time of day 12–16 weeks after the surgery or commencement of the conservative treatments (Control 2). A follow-up was made after a further 12 months (Control 3). The physiotherapist performed all examinations but did not take part in the physiotherapy.

The study was carried out in accordance with the 'intention to treat' principle.[13] Three patients randomised to the surgical group rejected surgery because of spontaneous improvement by the time of operation, but the allocation to the surgical group was retained. In the physiotherapy and cervical collar groups, all patients carried out the allocated treatment. No other treatments were given between the first two controls. After a further 12 months (Control 3), some patients had received other treatments than that determined by the randomisation. The following cross-over had taken place between Control 2 and Control 3: in the *surgery group*, 11 patients received physiotherapy (eight patients underwent reoperation at the same or at an adjacent level). In the *physiotherapy group*, one patient used a cervical collar and one patient was operated upon. In the *collar group*, 12 patients received physiotherapy and 5 patients were operated upon.

Drop-outs

At Control 3, one patient in the surgery group had moved and one patient in the collar group did not keep the appointment because she had recovered completely.

measurements

The history, distribution and quality of pain

Social and demographic data of the patients in the groups were recorded by means of a comprehensive case history and a questionnaire (Table I). The questionnaire included questions about the onset, duration, location and quality of pain as well as alleviative and provocative factors. In a pain-drawing, the patients indicated the areas of pain and other sensations. The quality of pain was described by different symbols which could be selected from a fixed set of symbols describing different pain types, such as aching, burning or cutting and other sensations such as numbness, tingling and cramps. Several symbols could be chosen. Instructions were: Draw your pain on the figure; include all areas where you feel pain or other sensations; use

Table I.
Characteristics of the patients and controls

	Surgery ($n = 27$)	Physiotherapy ($n = 27$)	Cervical collar ($n = 27$)	Healthy controls ($n = 30$)
Male (%)	16 (59)	11 (41)	17 (63)	18 (60)
Females (%)	11 (41)	16 (59)	10 (37)	12 (40)
Height (cm)	173 ± 10	171 ± 19	172 ± 7	175 ± 9
Weight (kg)	74 ± 13	75 ± 15	76 ± 12	75 ± 13
Age (years) at examination				
Mean (median)	45 (47)	48 (48)	49 (50)	46 (46)
SD	± 8.5	± 8.1	± 8.5	± 9.7
Range	28–58	31–61	38–64	28–64
Dominant side				
Right hand	24 (89%)	27 (100%)	24 (89%)	28 (93%)
Left hand	3 (11%)	0 (0%)	3 (11%)	2 (7%)
Pain duration (months)				
Mean (median)	34 (15)	40 (31)	28 (21)	
SD	± 34.8	± 32.5	± 24.3	
Range	5–120	6–120	8–120	
Months of sick-leave	($n = 23$)	($n = 18$)	($n = 21$)	
Mean (median)	13 (10)	15 (13)	13 (9)	
SD	± 9.6	± 10.3	± 13.0	
Range	3–45	6–40	1–50	
Affected side (Control 1)				
Right side	12 (44%)	15 (56%)	14 (49%)	
Left side	15 (56%)	12 (44%)	13 (51%)	
Earlier treatment				
Physiotherapy	26 (96%)	22 (81%)	21 (77%)	
Cervical collar	11 (41%)	13 (54%)	10 (37%)	
Affected level*				
C3–C4	1 (4%)	0	0	
C4–C5	2 (7%)	4 (15%)	2 (7%)	
C5–C6	13 (48%)	12 (44%)	15 (56%)	
C6–C7	10 (37%)	10 (37%)	10 (37%)	
C7–TH1	1 (4%)	1 (4%)	0	

*The most affected level based on MRI journals.

the symbols to indicate the types of pain or other sensations. At the examination, the patients were asked to explain the pain-drawing. The pain-drawings were analysed for pain distribution and characteristics according to a technique described by Persson and Moritz.[14] Improvements or impairments of the pain-distribution were calculated in each patient at Controls 1, 2 and 3.

Pain intensity
Pain intensity in the neck-shoulder-arm region was assessed on a Visual Analogue Scale (VAS). Current pain and the worst pain the previous week were filled in on two different scales. Two assessments were performed to get a baseline of pain intensity at each control. The VAS forms were sent to the patients together with the appointment for the clinical examination. The patients were asked to fill in the form and to bring it to the appointment. The pain intensity assessment was repeated at the appointment 8–12 days after the patients had received the first forms by mail. The mean of the current pain intensity and the mean of the worst pain last week on the two occasions were used for statistics.

Muscular tenderness
For grading tender points, nine selected muscles were palpated on each side according to Travell and Simons trigger point manual.[15] The muscles were chosen because they corresponded to the location of the cervicobrachial pain and were easy to find. The muscles chosen and sites for palpation are:

- m trapezius upper portion 2 cm caudal of the external occipital protuberance;
- m trapezius medial portion at the C7 level, 10 cm from the spinal process;
- m levator scapulae at the insertion at the superior angle of the scapulae;
- m supraspinatus at the middle of the supraspinous fossa of the scapula;
- m romboideus medial of the vertebral border of the scapula, at the T5 level;
- m deltoideus, at the posterior part of the deltoid muscles of the humerus;
- m biceps brachii at the distal part of the long head;
- m triceps brachii at the middle of the lateral portion of the long head;
- m extensor carpi radialis longus 1 cm distalt to the origin at the lateral epicondyl.

The degree of tenderness at the palpated sites was assessed according to a four-point scale (16) as follows:

0 = No report of pain and no visible reaction.
1 = Report of light tenderness but no visible reaction.
2 = Report of painful tenderness and visible reaction.
3 = Report of severe pain and marked visible reaction, 'jump sign'.[15]

The patients were placed in a relaxed sitting position. Each muscle site was systematically examined, always in the same order. The palpation was done with the second and third fingers with small, circulating, mildly pressing movements. A total tenderness score was calculated for each patient by adding the score from all palpated muscles from both sides. Thus the maximum total score for each patient was $2 \times 9 \times 3 = 54$.

Cervical mobility
The active range of cervical motion was measured with an inclinometer (Myrin, LIC, Solna, Sweden)[17] in accordance with the recommended procedures of the American Academy of Orthopedic Surgeons.[18] All movements were measured with the subjects seated in a chair with a back support and with the shoulders stabilised to make sure that pure movement of the head took place. The subjects were instructed to rotate their heads actively as far as they could to the right and left in a neutral position, and to flex, extend and bend maximally to the right and left side. Each movement was measured twice and the best value was used for statistics. Each movement as well as the total active range of motion were recorded. The total range of motion was expressed as the sum of the range of motion in the sagittal plane (flexion/extension), in the horizontal plane (rotation to the right and to the left) and in the frontal plane (flexion to the right and to the left).

Shoulder mobility
The active mobility was measured with a goniometer (Medema, Medema Physio AB, Karlsbodav. 13-15, 161 11 Bromma, Sweden) in a standardised protocol according to the American Academy of Orthopedic Surgeons[18] and included arm elevation, abduction and outward rotation.

Smoking habits

Previous and current smoking habits were recorded. Patients who had stopped smoking more than 1 year prior to the start of the study were recorded as former smokers. The number of years of smoking and the number of cigarettes consumed was recorded. The patients were divided into groups of non smokers, light smokers (1–5 cigarettes/day), moderate smokers (6–15 cigarettes/day) and heavy smokers (> 15 cigarettes/day).

treatments

Surgery

The surgery was performed by eight neurosurgeons according to the anterior cervical discectomy technique described by Cloward.[19] The fragments of the protruded disc and the osteophytes were removed and a bone graft from purified bovine bone (Unilab Surgibone. Mississauga, Ontario, Canada) was used for fusion. One of the patients underwent laminectomy by a posterior approach technique. The patients were mobilised on the first postoperative day. A cervical collar was sometimes used postoperatively for 1–2 days. No physiotherapeutic treatment was given between Controls 1 and 2.

Physical therapy

The physical therapy was provided by physiotherapists working in the patients' geographical neighbourhood. They all had documented experience with neck-shoulder-arm pain patients. The treatments were given on 15 occasions, each of 30–45 minutes duration, during a 3-month period. The type of therapy was decided by the physiotherapist according to the patient's symptoms and individual preferences and included mobilisation and flexibility exercises, cervical traction, ergonomics education, isometric strengthening exercises for the neck, heat, electrical stimulation etc. Information about clinical, X-ray and MRI findings was given to the treating physiotherapists by phone or letter. Treatment procedures were recorded and the records returned to the Department of Neurosurgery. The aim of the treatment was to relieve pain, to reduce muscle tension and the load on the neck, to increase strength and endurance and to restore a normal range of motion and function. Chiropractic manipulation or acupuncture was not used.

Cervical collar

In the cervical collar group, several different collars were used. Rigid collars were always shoulder resting and intended to be used during the daytime only (Lundakrage, LIC, University Hospital Lund, 221 85 Lund, Sweden; Miami J collar, Jerome Medical, 102 Gaither Drive, Mount Laurel, New Jersey, USA; Necky, Rehband Anatomiska AB, Box 7044, 191 07 Sollentuna, Sweden; Ortho-collar, Teufel, Box 104862, Stuttgart 10, 700042 Germany; Philadelphia collar, Camp Scandinavia AB, Karbingatan 38, 254 68 Helsingborg, Sweden). A soft collar to be used during the night was supplied if wanted (Adams, Professional products Ltd. Orthopedics, The Braccans, London Road, Bracknell, Berkshire RG 12, 2 AP England; Camp-19, Camp Scandinavia AB, Karbingatan 38, 254 68 Helsingborg, Sweden; Necky, Rehband Anatomiska AB, Box 7044, 191 07 Sollentuna, Sweden). The patients were instructed to wear the collar over a 3-month period. If they had any difficulties with the collar another type could be used.

statistical methods

All protocols of pain drawing, pain intensity, muscle tenderness and active neck and shoulder mobility were coded, analysed separately and blinded. Non-parametric tests were chosen. For between-group comparisons a Kruskal–Wallis one-way analysis of variance was used. If the result was significant, a pairwise comparison with Mann–Whitney's U-test was performed. For comparison within groups before and after treatment, Wilcoxon's matched-pairs signed-ranks test was used. Correlation between variables was analysed with Spearman's rank correlation coefficients. To test the intra-reliability of measurements, Persons' correlation coefficient was used. For all tests, a difference of $P < 0.05$ was considered statistically significant.

results

Pain history

Demographic and pain history data including pain duration, length of sick-leave and type of sick-leave were equally distributed in the treatments groups at Control 1. Several of the patients had received treatment with physiotherapy and/or a cervical collar before the present study (Table I).

A sudden onset of pain was reported by 45 patients while the other 36 patients had a slow onset. In 28 of the patients, the cause was lifting or inappropriate movement during heavy work. Ten of the patients woke up in the morning with neck-shoulder-arm pain, 1 developed radiating pain after cervical manipulation, 1 after general anaesthesia with intubation, and 6 could not describe any distinct cause. Of the 45 patients, 19 had had earlier neck pain with full recovery. The pain was more or less constant and in 35 of the 81 patients not experienced at any specific hour. Provocative factors for pain were: working, arms over 90°, sitting for a long time, the head unsupported and movements of the head. Extension and rotation of the neck were the most painful head movements. Alleviating factors for neck pain were: rest, a neck pillow, heat, gentle neck and shoulder movements, forward bending of the head, massage and traction of the neck.

Smoking

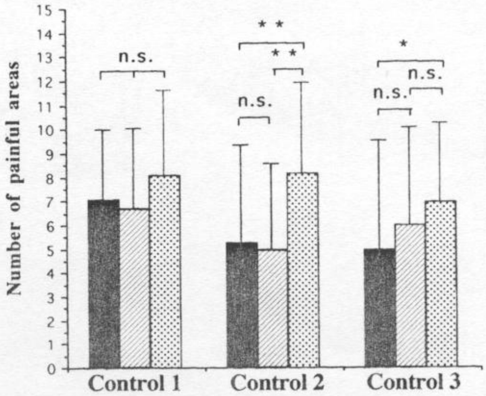
In the treatment groups the number of smokers was high (65 per cent, as compared to 10 per cent in the control group). The mean daily consumption among the smokers in the surgery, physiotherapy and collar groups was 18, 15 and 15 cigarettes respectively.

Pain distribution and pain characteristics

Between-group comparison: all patients had marked pain in the neck-shoulder-arm area. Pain in the thoracic area and in the back of the head was indicated by 33 and 29 patients, respectively. On the pain drawing, among the symbols used to indicate pain, aching was frequently chosen. Pain symbols indicating burning and cutting pain had been chosen by 36 and 19 of the patients, respectively. There was no significant difference between the type of symbols with regard to intensity of pain according to VAS.

The total number of marked painful areas was similar in the treatment groups before treatment Control 1 (Fig. 1). A significantly lower number of painful areas was seen in the surgery group compared to the collar group at Control 2 and 3 (at Control 2 $P < 0.01$ and at Control 3 $P < 0.05$) and in the physiotherapy group compared to the collar group at Control 2 ($P < 0.01$). No difference was seen between the surgery and the physiotherapy group at Control 2 or 3 (Fig. 1). When the number of disappeared, added or identical painful areas was calculated for each patient, similar results were seen, except that there was no difference between the three groups at Control 3.

Within group comparisons: the number of painful areas was significantly reduced at Controls 2 and 3 compared to Control 1 in the surgery group, and at Control 2 compared to Control 1 in the physiotherapy group (Fig. 1).



	Control 1	Control 2	Control 3
■ Surgery	7.1 (7) ± 2.9	5.3 (5) ± 4.1	5.0 (4) ± 4.6
▨ Physiotherapy	6.7 (6) ± 3.3	4.9 (5) ± 3.6	6.0 (6) ± 4.1
▩ Collar	8.1 (7) ± 3.5	8.1 (7) ± 3.8	6.9 (7) ± 3.3

Figure 1. Mean total number of painful areas in the different treatment groups at Control 1, Control 2 and Control 3. Below the diagram, the mean, (median) and standard deviation in the different treatment groups are given (* = $P < 0.05$, ** = $P < 0.01$, n.s. = not significant).

Pain intensity

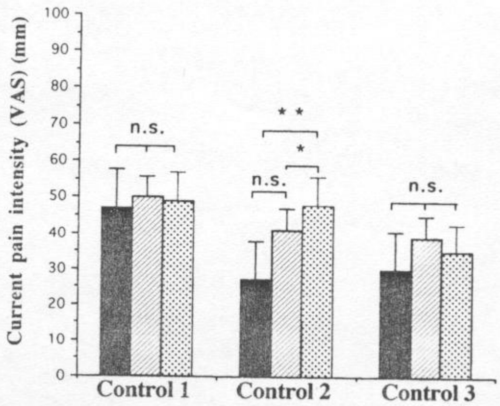
Between-group comparisons: the intensity of pain did not differ between the treatment groups before treatment (Control 1) (Figs 2a and 2b). At Control 2, there was a significant improvement in the surgery group compared to the collar group regarding both 'current pain' and 'worst pain last week' ($P < 0.01$). The physiotherapy group reported less 'current pain' than the collar group ($P < 0.05$). No significant difference was seen between the surgery and physiotherapy groups. At Control 3 no difference in neither 'current pain' or in 'worst pain last week' was seen between the groups (Figs 2a and 2b).

Within groups: all groups had improved when the 'worst pain last week' was compared between Controls 1 and 3 ($P < 0.01$), but the improvements took place according to a somewhat different time schedule. The surgery group showed improvements when measured as 'current pain' and mean 'worst pain' last week at Control 2 ($P < 0.001$) (Figs 2a and 2b) while there was no difference between Controls 2 and 3. The patients treated with physiotherapy improved in 'worst pain last week' at Control 2. In the collar group, no improvement was seen at Control 2, but between Controls 2 and 3, significant improvements in both 'current pain' and 'worst pain last week' took place ($P < 0.01$) (Figs 2a and 2b).

Muscle tenderness

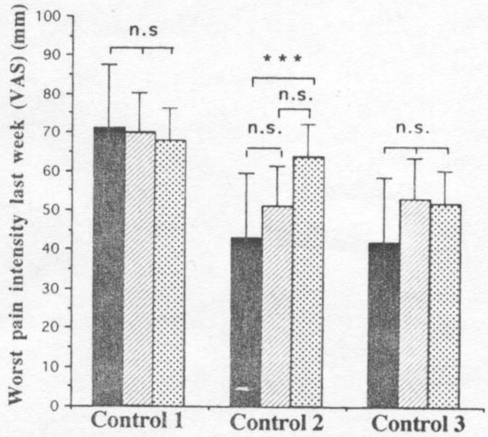
Before treatment (Control 1) there was no difference in the tenderness score of patients affected on the right and the left side. The average score of all patients was 12.5, representing 23 per cent of the maximal total score (Table II).

Between-group comparison: before treatment (Control 1), there was no difference between the groups. At Control 2, the surgery group showed a reduced total tenderness score compared to both the physiotherapy group ($P < 0.05$) and the cervical collar group ($P < 0.01$) (Fig. 3). The tenderness score in the upper portion of the trapezius, levator scapulae muscles and



	Control 1	Control 2	Control 3
Surgery	47 (55) ± 26	27 (28) ± 23	30 (25) ± 28
Physiotherapy	50 (50) ± 21	41 (37) ± 26	39 (39) ± 26
Collar	49 (51) ± 17	48 (54) ± 23	35 (38) ± 24

Figure 2a. Mean 'current pain' in the different treatment groups at Control 1, Control 2 and Control 3. Below the diagram, the mean, (median) and standard deviation in the different treatment groups are given (* = $P < 0.05$, ** = $P < 0.01$, *** = $P < 0.001$, n.s. = not significant).



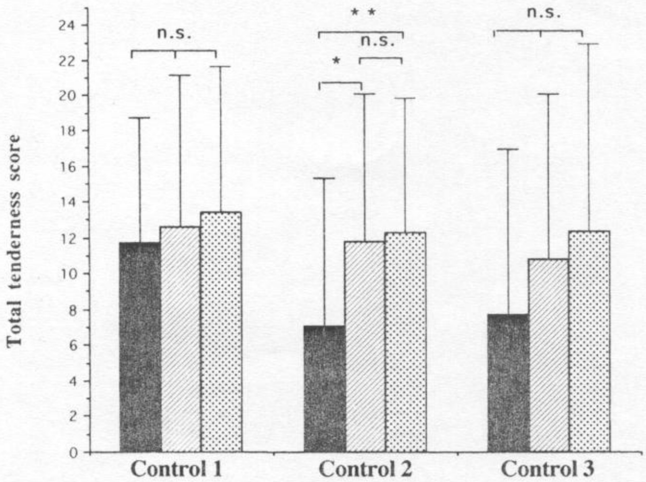
	Control 1	Control 2	Control 3
Surgery	72 (74) ± 21	43 (37) ± 36	42 (48) ± 28
Physiotherapy	70 (68) ± 18	51 (26) ± 29	53 (51) ± 29
Collar	68 (71) ± 17	64 (65) ± 22	52 (62) ± 22

Figure 2b. Mean 'worst pain last week' in the different treatment groups at Control 1, Control 2 and Control 3. Below the diagram, the mean, (median) and standard deviation in the different treatment groups are given (* = $P < 0.05$, ** = $P < 0.01$, *** = $P < 0.001$, n.s. = not significant).

extensor carpi radialis muscles in the surgery group was significantly lower compared to the collar group and in the levator scapulae muscles compared to the physiotherapy group. At Control 3 no difference was seen in the total tenderness score between the three treatment groups (Fig. 3) but the levator scapulae muscles were still less tender in the surgery group than in the two conservatively treated groups.

Table II.
The value of muscle tenderness on both sides (score 0–6) in the different muscles of all patients ($n = 81$) at Control 1 (before treatment)

	Mean	Median	SD	Range
M trapezius (upper portion)	2.19	2	1.78	0–6
M trapezius (middle portion)	2.36	2	1.35	0–5
M levator scapulae	2.12	2	1.57	0–5
M supraspinatus	1.21	1	1.36	0–4
M rhomboideus major	1.53	0	1.98	0–6
M deltoideus	0.92	0	1.43	0–6
M biceps brachii	0.20	0	0.72	0–4
M triceps	0.88	0	1.56	0–6
M extensor carpi rad.	2.00	0	1.81	0–6
Total score	12.45	12	7.59	0–35



	Control 1	Control 2	Control 3
Surgery	**11.7 (10) ± 7.0**	**7.1 (4) ± 8.2**	**7.7 (4) ± 9.2**
Physiotherapy	**12.6 (11) ± 8.6**	**11.8 (12) ± 8.3**	**10.8 (10) ± 9.3**
Collar	**13.4 (13) ± 8.3**	**12.3 (11) ± 7.6**	**12.4 (10) ± 10.6**

Figure 3. Mean total tenderness score in the different treatment groups at Control 1, Control 2 and Control 3. Below the diagram, the mean, (median) and standard deviation in the different treatment groups are given (* = $P < 0.05$, ** = $P < 0.01$, n.s. = not significant).

Within groups: after surgery a reduced total tenderness score was seen at Controls 2 and 3 compared to Control 1 ($P < 0.01$, and $P < 0.05$, respectively). A significantly lower tenderness score was seen in the upper portion of the trapezius muscles, the levator scapulae muscles and in the rhomboid muscles. No significant improvements were seen within the two conservatively treated groups (Fig. 3).

Neck mobility
In the healthy control group, the intra-reliability of neck mobility measurents was high ($r = 0.61–0.93$) on the two test occasions. The patient groups showed a lower cervical range of motion compared to the controls (Table III).

Between-group comparison: at Control 1 there was a significant difference between the physiotherapy group and the cervical collar group in the total range of motion ($P < 0.05$), but no difference between the surgery group

Table III.
Cervical range of motion in patients and controls before treatment (Control 1)

Neck mobility (degrees)	Patients (n = 81)			Controls (n = 30)			P value
	Mean	Median	SD	Mean	Median	SD	
Flexion	53	(55)	15	64	(60)	12	< 0.01
Extension	41	(45)	17	63	(62)	17	< 0.001
Lateral flexion right	30	(30)	8	37	(35)	7	< 0.05
Lateral flexion left	29	(30)	9	35	(34)	5	< 0.01
Rotation right	51	(55)	17	72	(70)	10	< 0.001
Rotation left	54	(55)	14	70	(70)	9	< 0.001
Total range of motion	257	(260)	63	338	(332)	42	< 0.001

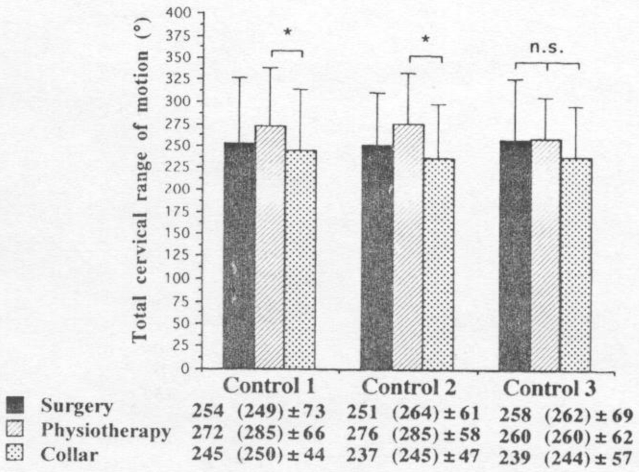


Figure 4. Total active cervical range of motion in the different treatment groups at Control 1, Control 2 and Control 3. Below the diagram, the mean, (median) and standard deviation in the different treatment groups are given (* = $P < 0.05$, n.s. = not significant).

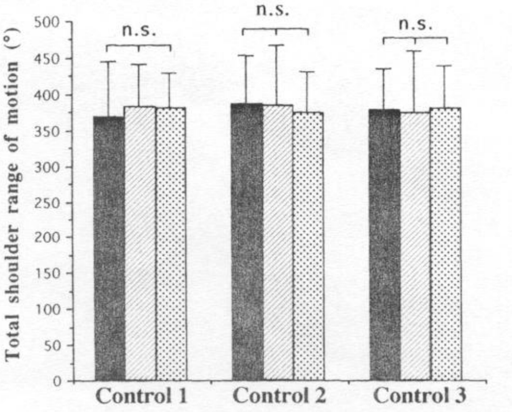
and the other two groups (Fig. 4). At Control 2, the same difference was seen between the physiotherapy and the collar group. At Control 3, there was no difference between the groups.

Within-group comparison: the physiotherapy group lost in total range of motion between Controls 2 and 3 and between Controls 1 and 3 (Fig. 4). The difference was mainly due to a significant impairment in flexion/extension. No significant difference was seen in the surgery or the cervical collar groups.

Shoulder mobility

The affected side had a significantly impaired shoulder mobility compared to the non-affected side before treatment (e.g. forward elevation $P < 0.001$, ratio affected side/non-affected side = 0.89).

Between-group comparison: there was no difference on the affected side between the three treatment groups before treatment (Control 1) (Fig. 5). At Control 2 there were no differences between groups, but a minor but significant improvement in the surgery group compared to the collar group in total range of shoulder motion in the affected side, especially as regards forward elevation ($P = 0.023$). No significant difference was seen between the physiotherapy and the collar group or the surgery and the physiotherapy



	Control 1	Control 2	Control 3
Surgery	**369 (395) ± 76**	**387 (410) ± 67**	**380 (400) ± 49**
Physiotherapy	**385 (410) ± 57**	**385 (410) ± 82**	**375 (405) ± 85**
Collar	**380 (400) ± 49**	**375 (385) ± 56**	**382 (395) ± 56**

Figure 5. Total active range of shoulder motion in the different reatment groups at Control 1, Control 2 and Control 3. Below the diagram, the mean, (median) and standard deviation in the different treatment groups are given (* = $P < 0.05$, n.s. = not significant).

group. At Control 3, no difference was seen between the treatment groups (Fig. 5).

Within-group comparison: the surgery group improved in total shoulder mobility on the affected side at Control 2, especially in the forward elevation. In the physiotherapy group, improvements were seen at Control 2 in forward elevation but not in the total range of shoulder mobility. No changes were seen in the collar group. At Control 3, after a further 12 months, no difference was seen within any of the groups compared to pre-treatment measurements.

Correlations

In all patients there was a significant correlation ($P < 0.01$) between the tenderness score and 'current pain' intensity measured by VAS, the correlation coefficient being $r = 0.43$ at Control 1, $r = 0.50$ at Control 2 and $r = 0.36$ at Control 3. A significant correlation was seen between the number of painful areas and the 'current pain' intensity at Control 1 ($r = 0.32$, $P < 0.01$), Control 2 ($r = 0.56$, $P < 0.001$) and at Control 3 ($r = 0.37$, $P < 0.01$). The total range of motion of the neck correlated negatively with 'current pain' intensity at Control 1 ($r = -0.43$, $P < 0.001$) and at Control 3 ($r = -0.41$, $P < 0.001$). No correlation was seen at Control 2. A negative correlation was also seen between pain intensity and the total range of shoulder mobility. At Control 1 the correlation was $r = -0.51$ ($P < 0.001$), at Control 2, $r = -0.27$ ($P < 0.05$) and at Control 3 $r = -0.25$ ($P < 0.05$). No significant correlation between pain intensity (VAS) and smoking habits was noticed before (Control 1) or after treatments (Controls 2 and 3).

discussion

In this study, the surgically treated patients showed greater improvement compared to the conservatively treated patients when examined shortly after treatment. At the follow-up after 1 year, however, there were no significant differences between the surgically and the non-surgically treated groups. This was valid for pain distribution, pain intensity, muscle-tenderness, neck-mobility and shoulder mobility. We also performed a statistical analysis based on individual differences, which led to similar results except for a minor advantage in the surgery group in pain distribution at Control 3. Similar results have been found in two other reports on the same patients, with respect to muscle strength, sensory loss[11] and the patients' well-being (physical, psychological and social) as measured by the Sickness Impact Profile inventory and mood measured by the Mood Adjective Check List.[12] To our knowledge, no other prospective, randomised treatment study has compared surgical with non-surgical treatment in patients with cervical radiculopathy with respect to muscle tenderness and cervical range of motion.

This clinical study was carried out according to the 'intention to treat' principle,[13] which means that after randomisation the patients kept their allocation even if the treatment could not be performed. The fact that 3 patients in the surgery group spontaneously improved enough to decline surgery can be balanced by similar spontaneous improvements in the other two groups.

The Department of Neurosurgery performing the operations was the only one in southern Sweden, and is responsible for 1.5 million inhabitants. The patients lived spread out in the district and on account of this it was not possible to maintain the allocated treatment methods for more than 4 months. Thus, some patients had changed the assigned treatment to another treatment, or undergone re-operation during the 1-year period between the second (Control 2) and third post-treatment evaluation (Control 3). A certain cross-over between groups must be accepted, and is a sign of the patient's dissatisfaction with the original treatment. A separate analysis revealed that the mean values of pain intensity were not notably influenced by whether or not the patients receiving additional treatment were included in the allocated groups.

The physical therapy was given by several therapists and surgery was performed by several neurosurgeons. This is how it usually works in clinical practice. All surgeons and therapists were experienced and well trained.

VAS has been documented as a valid measure of perceived pain intensity[20] and a reliable measurement in patients with chronic cervicobrachial pain.[14] Palpation has been shown to be a specific and sensitive method of examination of muscle tenderness and is commonly used to evaluate fibromyalgia and headache of tension type.[21,22] As has been done in the present study, other investigators have scored tenderness by manual palpation in a given region.[21–23] When scoring muscular tenderness, a standardised pressure is desirable. A new instrument (palpometer) has recently been introduced,[24] but was not on the market at the time of the study. The palpometer allows for a stable and measurable pressure. Bendtsen *et al.*[25] have reported that the total tenderness score measured manually showed a good intra-reliability and showed a high correlation with total tenderness score measured by means of the palpometer. The most common tender muscles in our study were the trapezius, levator scapulae, supraspinatus, rhomboideus major and extensor carpi rad. muscles. The proximal part of the brachioradialis has been reported to be a tender spot even in healthy persons, and might therefore sometimes be misdiagnosed. The finding of a significant correlation between tenderness and the intensity of pain in the present study is in line with other studies.[22,23,25] In patients with occupational cervicobrachial disorders, the pain pressure thresholds were found to be significantly lower in the trapezius and the levator scapulae region compared to healthy subjects.[26] Pain and local tenderness may possibly depend on generally increased pain sensitivity. This has been contradicted by Jensen *et al.*,[23] who found normal pain thresholds in patients with tension-type headaches, and suggest that pain and muscular tenderness are due to the different reactions of an abnormal muscle.

The purpose of pain drawing in this study has been to estimate the patients' total situation by including symptoms such as paraesthesia, or pain in the leg, to measure changes over time, and to distinguish between pain form nerve root compression and muscular pain.[27]

Before treatment, all patients indicated a radiating pain in the upper limb of the affected side. About a third of the patients also marked pain in the opposite shoulder. Whether this is due to a referred pain from other spinal levels or is a muscular phenomen is an open question. Several patients also reported an aching pain between the shoulders, which is a common site of pain both for overloaded muscles[28] and for referred pain from the cervical spinal levels.[3] An advantage of the paindrawing is that it reveals newly developing symptoms and whether or not the pain is radiating.

Cervical spine mobility is complex. With increasing age, the cervical flexibility decreases. Several factors may influence the flexibility in the neck, such as neck pain, muscular tension and spondylosis. The recording of active neck movement is a common means of assessing the condition of the neck and to quantifying the efficacy of various treatments.[29] Inclinometers have been found reliable for measuring neck movements.[17] Several factors will affect the reliability and the validity of measurement. We found a good intra-reliability when measuring a healthy age and sex-matched control group on two occasions with an interval of 1 week. The active cervical range of motion in the healthy control group was significantly better than in the treatment groups. It is still unclear whether increased neck mobility causes a reduction of pain or a diminished pain causes an increase in neck mobility. Several of our patients reported increased pain after certain head movements. In our study, we found an inverse correlation between pain intensity and neck motion before treatment. Movements of the head may mechanically compress the nerve roots. Some authors consider immobilisation and fusion of the cervical spine the cause of success in Cloward's operation. Reduction of the spinal mobility either by means of surgery or with a cervical collar alleviated the symptoms and improved the prognosis for patients for cervical spondylotic myelopathy.[30] In the present study, no changes in total cervical mobility at Control 2 were seen, either after immobilisation with a collar or after surgery. Motion in adjacent levels may have been compensatorily increased after surgery.[31]

Increased physical activity and decreased pain are likely to increase the cervical range of motion. Stretching and flexibility exercises for shortened neck muscles are common for physiotherapy of cervical disc diseases. Mobilisation treatments such as stretching, flexibility exercises or cervical traction were part of the physiotherapy used in this study and described elsewhere[11] but did not significantly influence the active cervical motion. The pain might have had an inhibitory effect on the cervical motion. It should be observed that the majority of the patients in the physiotherapy group had previously been treated by physiotherapists without lasting improvement. A few studies have proved the efficacy of exercise on pain and function of the neck.[32] Highland *et al.*[33] found reduced pain intensity, increased neck muscle strength and an improvement in neck mobility in patients with degenerated disc disease, but no improvement in the cervical range of motion in patients with a cervical herniated disc disease after 8 weeks of training. Pain improvement has also been noted after active and traditional rehabilitation programmes in patients with musculoskeletal disorders of the neck.[34] In a recent uncontrolled study evaluated by way of a questionnaire, excellent or good results were seen in 83 per cent of the patients with cervical radiculopathy treated with aggressive physical rehabilitation and a collar.[35]

Restriction of the neck in a cervical collar for 3 months may be expected to impair the neck mobility. How much a collar restricts the neck motion has been discussed in several studies.[36] In this study, we did not know the exact effective time the collar was used. In our study, the pain intensity and pain distribution did not change immediately within the collar group, and treatment with a collar might serve more as a reminder to avoid painful movements and a way to reduce mechanical stress and pressure on the nerves. Active shoulder movement is often reported as provocative of pain in patients with cervical radiculopathy, and there may be reason to measure shoulder mobility. In our study, an impaired active shoulder mobility was seen on the affected side. An inverse correlation between pain intensity and shoulder mobility was noted before treatment. The only improvement of shoulder mobility was found after 4 months in the surgery group, in forward elevation. The improved mobility may be due to a combination of reduced neck-shoulder-arm pain and improved muscular strength.

The high proportion of smokers is notable. The prevalence of smoking in Sweden for the corresponding age and sex was about 26 per cent in 1994, compared to our findings of 52–78 per cent. It is a well known fact that smoking is also more common among patients with back pain[7] and cervical disc disease.[8] A higher risk of disc degeneration in the lumbar spine,[37] pseudoarthrosis after laminectomy and fusion[38] and adverse effects on allograft interbody fusion[39] have also been reported. In this study, we found no correlation between smoking habits and pain intensity.

In patients with cervicobrachial pain the differential diagnoses must be considered. Muscular pain and connective tissue pathology or pain from cervical joints may induce a referred pain, obscuring the clinical picture.[2,15] It is difficult to differentiate between neurogenic and nociceptive pain of myofascial origin, which sometimes occur together.[4] Some of these patients may also develop a faulty posture with the head in forward flexion to reduce pain. Extension of the head often elicits pain symptoms.[40] The foraminal diameter increases in flexion, which might reduce the pressure on the nerve structure.

conclusions

Pain intensity, the number of painful areas and muscle tenderness improved in all treatment groups. The improvement was faster in the surgery group. The conservatively treated groups had a slower improvement and after 1 year there was no significant difference between the groups. Thus, the three treatment methods were found to be equally effective although there are differences in the improvement rate.

acknowledgements

This investigation was supported by grants from Vårdalsstiftelsen. We thank Professor C.-A. Carlsson Department of Neurosurgery, University Hospital Lund for initiating and continuously supporting the study.

references

1. Fager CA. Identification and management of radiculopathy. *Neurosurg Clin N Am* 1993; **4**: 1–12.
2. Feinstein B, Langton JNK, Jameson RM, Schiller F. Experiments on pain referred from deep somatic tissues. *J Bone Joint Surg* 1954; **36** (Am): 981–97.
3. Wells P. Cervical dysfunction and shoulder problems. *Physiotherapy* 1982; **68** (3): 66–72.
4. Rosomoff HL, Fisherbain D, Rosomoff RS. Chronic cervical pain: radiculopathy or brachialgia. Noninterventional treatment. *Spine* 1992; **17** (10): 362–6.
5. Viikari-Juntura E. Interexaminer reliability of observation in physical examinations of the neck. *Phys Ther* 1987; **67**: 1526–32.

6. Ahlgren BD, Garfin SR. Cervical radiculopathy. *Orthop Clin N Am* 1996; **27** (2): 253–63.

7. Boshuizen HC, Verbeek JHAM, Broersen JPJ, Weel ANH. Do smokers get more back pain? *Spine* 1993; **18** (1): 35–40.

8. An HS, Silveri CP, Simpson JM, File P, Simmons C, Simeone FA, Balderstone RA. Comparison of smoking habits between patients with surgically confirmed herniated lumbar and cervical disc disease and controls. *J Spinal Disord* 1994; **7** (5): 369–73.

9. Ellenberg MR, Hornet JC, Treanor WJ. Cervical radiculopathy. *Arch Phys Med Rehabil* 1994; **75**: 342–52.

10. Garvey TA, Eismont F. Diagnosis and treatment of cervical radiculopathy and myelopathy. *Orthopaedic Review* 1991; **20**: 595–603.

11. Persson LC, Moritz U, Brandt L, Carlsson C-A. Cervical radiculopathy. Pain, muscle weakness and sensory loss in patients with cervical radiculopathy treated with surgery, physiotherapy or cervical collar. A prospective controlled study. *Eur Spine J* 1997; **6** (4): 254–66.

12. Persson LCG, Carlsson CA, Carlsson JY. Long-lasting cervical radicular pain treated with surgery, physiotherapy or a cervical collar. A prospective randomized study. *Spine* 1997; **22** (7): 751–8.

13. Altman DG. *Practical Statistics for Medical Research*. London: Chapman & Hall, 1992: 440–6.

14. Persson LC, Moritz U. Pain-drawing: a quantitative and qualitative model for pain assessment in cervico-brachial pain syndrome. *The Pain Clinic* 1994; **7** (1): 13–22.

15. Travell JG, Simons DG. *Myofascial Pain and Dysfunction. The Trigger Point Manual*. Baltimore: Williams & Wilkins, 1983: 1–102.

16. Langemark M, Olesen J. Pericranial tenderness in tension headache. A blind controlled study. *Cephalalgia* 1987; **7**: 249–55.

17. Balogun JA, Abereoje OK, Olaogun MO, Obajuluwa VA. Inter- and intratester reliability of measuring neck motion with tape measure and Myrin gravity-reference goniometer. *J Orthop Sport Phys Ther* 1989; **10** (7): 248–53.

18. American Association of Orthopedic Surgeons. *Joint Motion. Methods of Measuring and Recording*. Edinburgh: Churchill Livingstone, 1966.

19. Cloward RB. The anterior approach for ruptured cervical discs. *J Neurosurg* 1958; **15**: 602–17.

20. Carlsson AM. Assessment of chronic pain. Aspects of the reliability and validity of the visual analogue scale. *Pain* 1983; **16**: 87–101.

21. Jacobs JWG, Geenen R, van der Heide A, Rasker JJ, Bijlsma JWJ. Are tender points scores assessed by manual palpation in fibromyalgia reliable? *Scand J Rheumatol* 1995; **24**: 243–7.

22. Langemark M, Jensen K, Jensen TS, Olesen J. Pressure pain threshold and thermal nociceptive thresholds in chronic tension-type headache. *Pain* 1989; **38**: 203–10.

23. Jensen R, Rasmussen BK, Pedersen B, Olesen J. Muscle tenderness and pressure pain threshold in headache. A population study. *Pain* 1993; **52** (2): 193–9.

24. Bendtsen L, Jensen R, Jensen NK, Olesen J. Muscle palpation with controlled finger pressure: new equipment for the study of tender myofascial tissues. *Pain* 1994; **59**: 235–9.

25. Bendtsen L, Jensen R, Jensen NK, Olesen J. Pressure-controlled palpation: a new technique which increases the reliability of manual palpation. *Cephalalgia* 1995; **15**: 206–10.

26. Takala E-P. Pressure pain threshold on upper trapezius and levator scapulae muscles. *Scand J Rehab Med* 1990; **22**: 63–8.

27. Uden A, Landin LA. Pain drawing and myelography in sciatic pain. *Clin Orthop* 1987; **216**: 124–30.

28. Griegel-Morris P, Larson K, Mueller-Klaus K, Oatis C. Incidence of common postural abnormalities in the cervical, shoulder and thoracic regions and their association with pain in two age groups of healthy subjects. *Phys Ther* 1992; **72** (6): 425–30.

29. Riddle DL. Measurements of assessory motion; critical issues and related concepts. *Phys Ther* 1992; **72**: 865–74.

30. Barnes MP, Sanders M. The effect of cervical mobility on the natural history of cervical spondylotic myelopathy. *J Neurol Neurosurg Phychiatry* 1984; **47**: 17–20.

31. Baba H, Furusawa N, Imura S, Kawahara N, Tsuchiya H, Tomita K. Late radiographic findings after anterior cervical fusion for spondylotic myeloradiculopathy. *Spine* 1993; **18** (15): 2167–73.

32. Rodriquez AA, Bilkey WJ, Agre JC. Therapeutic exercise in chronic neck and back pain. *Arch Phys Med Rehabil* 1992; **73**: 870–3.

33. Highland T, Dreisinger TE, Vie LL, Russell GS. Changes in isometric strength and range of motion of the isolated cervical spine after eight weeks of clinical rehabilitation. *Spine* 1992; **17** (6): 77–82.

34. Ekeberg K, Björkquist B, Malm P, Bjerre-Kiely B, Axelsson O. Controlled two years follow up of rehabilitation for disorders in the neck and shoulders. *Occup Environ Med* 1994; **51**: 833–8.

35. Saal JS, Saal JA, Yurth EF. Nonoperative management of herniated cervical intervertebral disc with radiculopathy. *Spine* 1996; **21** (16): 1877–83.

36. Askin V, Eismont FJ. Efficacy of five cervical orthoses in restricting cervical motion. A comparison study. *Spine* 1997; **22** (11): 1193–8.

37. Battie MC, Videman T, Gill K, Moneta GB, Nyman R, Kaprio J, Koskenvuo M. Smoking and lumbar intervertebral disc degeneration; an MRI study of identical twins. *Spine* 1991; **16** (9): 1015–21.

38. Brown CW, Orme TJ, Richardson HD. The rate of pseudoarthrosis (surgical nonunion) in patients who are smokers and patients who are non smokers: A comparison study. *Spine* 1986; **11** (9): 942–3.

39. Bishop RC, Moore KA, Hadley MN. Anterior cervical interbody fusion using autogeneic and allogenic bone graft substrate: a prospective comparative analysis. *J Neurosurg* 1996; **85**: 206–10.

40. Farmer JC, Wisneski RJ. Cervical spine nerve root compression. An analysis of neuroforaminal pressures with varying head and arm positions. *Spine* 1994; **19** (16): 1850–5.