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Fusion or stabilization alone for acute distractive flexion injuries in the mid to lower cervical spine?

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Abstract Long-term pain problems and residual restricted mobility were evaluated for patients sustaining acute distractive flexion injuries to the cervical spine. To assess which of two alternative surgical approaches gives better long-term outcomes, 58 patients were studied, 29 in each group. The results of posterior wire stabilization without fusion according to Brandt were contrasted with those of the Cloward technique. We found significantly more late pain problems and restricted neck mobility in the group treated with wiring without fusion than in those managed with anterior fusion. We conclude that this contin-

uing pain may be due to residual mobility in the damaged degenerated non-fused motion segment, and that the difference between the two groups may reflect the difference in the quality and rate of fusion achieved by the two surgical approaches.

Key words Cervical spine · Trauma · Fusion · Stabilization

Introduction

Distractive flexion injuries, i.e. lesions with predominantly posterior element disruption, in the cervical spine can be treated surgically using an anterior, posterior or combined approach. In our institution operative treatment of cervical spine injuries started in the 1960s. Cloward's anterior fusion was used in the beginning and posterior wiring was done only sporadically, in patients who had dislocations that could not be reduced in skull traction. In the early 1980s posterior wiring became the method of choice, because the postoperative stability was much better than that achieved using the Cloward procedure. This was also shown by Capen [4]. Another paper argued that the Cloward technique alone, without internal fixation, is not suitable in distractive flexion injuries since, in addition to the posterior element disruption, the anterior column is also destabilized [12]. However, combined with

internal fixation, the Cloward technique is useful, especially in individuals where anterior pathology has to be addressed.

Posterior stabilization and fusion according to Rogers [11] or modifications of this method, have been standard in many centres for decades, and seen from a biomechanical perspective posterior wiring provides a high degree of stability in distractive flexion injuries [13]. Whether fusion is necessary in addition to the stabilization procedure is controversial. Some authors believe that wires provide enough initial stability for healing of the disco-ligamentous structures or spontaneous fusion [3, 7, 10]. Consequently there should be no need for bone transplantation. However, one of these reports showed that many patients who underwent posterior wiring without fusion had long-term problems with local neck pain and restricted cervical range of motion [7]. Some of these patients showed less mobility than in the adjacent segments and no signs of bony union at the damaged level at follow-up. Thus, the

question is whether the damaged motion segment, healed by fibrous union and allowing some motion, can be a source of pain, and if so, whether bony fusion will prevent late pain and restricted mobility.

In the present retrospective study we compare the long-term results of 29 patients treated with anterior interbody fusion according to Cloward, using a bicortical autograft from the iliac crest, to the results of 29 similar patients managed with posterior wiring without fusion according to Brandt et al. [3].

Material and methods

Anterior Cloward fusions and posterior wirings according to Brandt et al. were conducted in a total of 58 patients between 1977 and 1987. There were 29 patients in each treatment category (group 1, posterior; group 2, anterior). Group 1 comprised a consecutive series of patients with distractive flexion injuries operated on with posterior wiring without fusion according to Brandt, between 1981 and 1987 [3]. Group 2 comprised a consecutive series of patients with similar injuries operated on with the Cloward technique, between 1977 and 1987, using autologous bone from the iliac crest [6]. Skeletal lesions were classified according to Allen et al. (Table 1) [1]. Neurologic injury was classified according to a modified version of Frankel's score, presented in Table 2 [7]. Table 3 gives detailed patient data.

Segmental motion was measured on routine lateral flexion and extension studies, while kyphosis and spondylolisthesis were determined based on routine static lateral radiographs. Kyphosis was defined as the angle between the posterior margins of the vertebral bodies of the damaged segment. Spondylolisthesis was assessed as a percentage value. Measurements were performed with conventional measurement tools (ruler and protractor). Bony fusion was defined as a shadow or a bony bridge between adjacent vertebrae on the lateral radiograph. Disc height was given as a percentage of the average disc height in the adjacent segments.

Clinically, the cervical range of motion was measured with a gravity goniometer (Myrin). The total active range of motion was measured in flexion, extension, lateral bending and rotation, with the patient seated straight up, right against the chair. The patients' shoulders were fixed by the investigator to avoid unwanted movements. Pain was graded by the patients on a visual analogue scale (0–10) [5].

Table 1 Allen's classification of the skeletal injuries appearing in our series of 56 patients (*DF* indicates a distraction-flexion injury)

DF1	Anterior subluxation
DF2	Unilateral facet dislocation
DF3	Bilateral facet dislocation
DF4	Floating vertebra (complete discoligamentous instability)

Table 2 Modification of Frankel's classification of neurologic injury used in this study

A	Complete quadriplegia
B	Incomplete quadriplegia with useless motor function
C	Incomplete quadriplegia with useful motor function
D	Root signs or symptoms
E	Intact

Preoperative treatment

Fifty-five of the patients with ligamentous injuries were initially placed on a Stryker frame with skull traction. Three patients who had subluxations (DF1 injuries according to the Allen classification) had a stiff collar only. Fourteen individuals with locked facets were managed with traction forces sufficiently increased to unlock the facet joints. Fourteen patients in group 1 had open reductions conducted simultaneously with their posterior stabilizations, while two group 2 patients were treated with closed reduction for their locked facets. Immediate surgery aimed at decompression of the spinal cord or nerve roots was not performed. In patients who had minor changes on plain radiographs, the spinal

Fig. 1 A Postoperative radiograph after reduction and posterior wiring without fusion, according to Brandt. B Follow-up radiograph after 52 months

Fig. 2 A Postoperative radiograph after reduction and interbody fusion according to Cloward. B Follow-up radiograph after 62 months. Note the degenerative disc changes at the level below the fused vertebrae

canal was evaluated using contrast myelography, in the early period. In the late period CT and/or MRI were used.

Operative techniques

Group 1

Posterior wirings were conducted according to the technique described by Brandt et al. [3] (Fig. 1). With the patient on a Stryker frame and skull traction, a posterior midline incision is made, and the spinous processes and the laminae of the involved vertebrae are exposed by subperiosteal dissection. In cases of unreduced dislocation, reduction is achieved by manual traction in the upper spinous process. In cases of one-level instability, a hole is made through the base of the upper spinous process with a towel clip. A metal pin 3 cm long, and 3 mm in diameter is inserted. One or two 0.8-mm wires are looped around the upper and lower spinous process ventral to the Rissler pin and tightened until no movement can be seen in the damaged segment. Care is taken not to tighten the wire too much, because of the risk of forcing disc material into the spinal canal or to compress the nerve roots. In the case of a spinous process fracture, the closest available intact process is chosen for a stable osteosynthesis. No bonegraft is used; postoperatively, these patients are mobilized with a semirigid collar for 6–8 weeks [3].

Group 2

Anterior procedures follow the Cloward protocol, using bicortical iliac crest autograft (Fig. 2). A transverse skin incision is made on the right side of the neck. The platysma muscle fibres are cut vertically. The sternocleidomastoid and omohyoid muscles are dissected and retracted, the cleavage plane between the carotid artery and the oesophagus is opened by blunt dissection, and the anterior surface of the spine is exposed with self-retaining retractors. The lacerated disc is removed with curettes and disc rongeurs. A drill hole is 12 or 14 mm in diameter is made through the disc space to a preset depth. An autologous dowel graft is obtained from the ileum and inserted in the drill hole. The cortical endplates lateral to the dowel are perforated and the interspace is packed with bone; postoperatively, these patients are mobilized with a hard collar for 10–12 weeks [6].

Follow-up

All 58 patients had a follow-up (Table 3). Some radiographs from the time of the accident were not available. Clinical and radiographic patient data, including follow-up data, were respectively reviewed by independent physiotherapists and radiologists. A questionnaire was also administered by an independent observer.

Statistics

Statistical comparison between the groups was performed with the use of chi-square analysis and the Student *t*-test. A value of $P < 0.05$ was considered to indicate that a difference was significant.

Results

Clinical follow-up

No patient with initial complete spinal cord lesion (no preserved sensory and motor function) had any useful motor function at follow-up. Fifteen patients with incomplete cord injuries and/or root symptoms demonstrated neuro-

logical improvement. Seven were in group 1, and eight were in group 2. There was no significant difference in neuralgic recovery between group 1 and 2.

Group 1 had significantly more restricted range of neck motion than group 2. Five patients in group 1 and 15 patients in group 2 were free of symptoms. Twenty-three patients in group 1 and seven patients in group 2 had residual pain in some form. The patients in group 1 had significantly higher pain scores (Table 3).

Radiographic follow-up

The patients in group 1 had less kyphosis ($P = 0.04$) than group 2 individuals, but there was no significant difference in the degree ofolisthesis in the two populations. Furthermore, 11 patients in group 1 showed no evidence of bony fusion: indeed 6 demonstrated residual mobility at the injured motion segment, while 8 exhibited broken wires. In group 2, no patient had any residual mobility in the injured motion segment, and all had radiographic evidence of solid anterior bony fusion. Additionally, there was evidence of accompanying spontaneous posterior fusion in 23 of these 29 individuals.

Regarding degenerative changes at the adjacent levels, the first mobile disc below the damaged motion segment in group 2 patients was the only disc level to demonstrate degenerative changes that differed significantly between the two groups (Fig. 2B). Hypermobility ($< 25^\circ$) was observed in the segment above the fused vertebrae in two patients in group 2, and in the segment below in one. No similar hypermobility was noted in the posterior wiring group.

Neurologic complications

There was no increase in postoperative myelopathy in either group, but four patients did exhibit new radicular deficits. For the two group 1 patients, although improvement occurred, deficits remained permanent. In contrast, those observed in two group 2 patients were transient, and fully resolved.

Discussion

We compared the 29 group 1 patients with the 29 group 2 patients and found that there were significantly more late pain problems and restricted range of neck motion in group 1. The motion segment in this group of patients with ligament injuries treated with wire stabilization only, and without bony fusion, probably heals by fibrous union, allowing a certain amount of residual segmental motion. This contrasts with the bony healing that occurred in all group 2 patients who were managed with anterior fusions.

Table 3 Detailed data for all 58 patients operated for acute distractive flexion injuries to the cervical spine

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB
1	1	4	23	15	47	2	1	56	1	4		2	56	1	4	18	15	56	-5	-10	18	5	1	1	4	4	3
2	1	6	4	24	43	1	2	67	1	4		2	67	1	4	10	20	67	0	0	0	0	4	4		4	6
3	1	2	13	11	28	1	1	67	1	4		2	67	1	4	10	5	67	-12	-5	0	0	3	1		4	3
4	1	3	2	9	76	2	1	56	1	4		2	56	1	4	6	10	56	-6	0	0	0	2	1		5	4
5	1	4	1	15	33	1	1	34	1	5		2	34	4	5	11	5	34	0	0	12	0	1	1	6	5	1
6	1	2	2	12	28	1	1	67	1	5		2	67	4	5	9	0	67	-4	0	0	0	1	1	4	5	3
7	1	2	21	8	10	2	2	34	1	5		2	34	4	5	23	20	34	0	0	0	0	1	1		5	0
8	1	3	3	10	74	1	2	45	1	5		2	45	4	5	20	25	45	-8	0	8	5	1	1		5	0
9	1	1	13	8	37	2	1	56	1	5		2	56	2	4	22	5	56	-9	-10	0	0	1	1		4	3
10	1	6	6	13	18	1	3	56	1	5		2	56	4	5	5	5	56	-4	0	5	0	1	1	21	5	1
11	1	6	11	12	19	2	2	71	1	4		2	71	1	4	19	5	71	0	0	15	0	3	1		5	3
12	1	1	13	7	32	1	2	67	1	4		2	67	1	4	10	15	67	0	0	0	0	1	1		4	2
13	1	2	1	5	57	1	2	67	2	4		2	67	1	4	18	10	67	0	0	12	0	4	1		5	3
14	1	4	9	14	34	1	4	45	2	5		2	45	4	5	19	50	45	-10	0	-10	0	4	4		5	2
15	1	4	12	25	53	2	1	67	2	3		2	67	1	3	7	25	67	0	0	0	0	4	4		3	5
16	1	3	14	45	37	2	1	67	2	4		2	67	1	4	17	20	67	-12	0	0	0	1	4		4	7
17	1	2	8	9	30	2	1	67	2	5		2	67	2	4	0	15	57	-9	0	0	0	1	4		4	3
18	1	2	4	8	14	1	1	45	2	5		2	46	4	5	7	30	46	-3	0	7	0	1	1	2	5	3
19	1	3	26	45	69	1	1	67	3	3		2	67	1	3	0	50	67	0	0	0	0	4	4		3	2
20	1	4	6	13	17	1	3	45	3	5		2	45	4	5	13	50	45	-5	0	16	0	4	1		5	0
21	1	2	8	28	64	1	1	67	3	1		2	67	1	1	0	50	67	-16	0	-12	0	3	1		2	0
22	1	2	6	26	19	2	1	67	3	1		2	57	3	1	20	50	57	0	0	11	10	3	3		2	7
23	1	4	8	39	36	1	2	67	3	1		2	57	3	1	5	50	57	-8	0	0	0	4	4		1	0
24	1	4	6	23	28	1	3	56	3	1		2	46	1	1	0	40	46	0	0	3	10	1	1	3	1	4
25	1	2	6	19	59	2	1	67	3	2		2	57	1	2	18	40	57	-11	-15	-7	-10	1	3		3	1
26	1	2	1	11	86	1	1	56	3	3		2	56	1	3	15	40	56	0	0	10	0	1	1		3	0
27	1	4	10	23	35	1	2	56	3	3		2	56	1	3	27	50	56	-5	-5	-4	-5	4	4		4	1
28	1	2	4	11	47	1	2	45	4	1		2	45	3	1	0	100	45	-13	0	-7	0	4	1		1	3
29	1	2	9	21	59	1	2	67	4	1		2	67	3	1	0	75	67	0	0	0	0	3	1		1	4
30	2	12	8	34	42	1	1	56	1	4		2	56	1	4	10	15	56			15	0	4	4		4	2
31	2	6	30	20	43	1	2	45	2	5		2	45	4	5	10	25	45	0	0	10	0	4	3		4	4
32	2	10	11	10	53	1	1	67	2	4		2	67	4	5						0	0	4	3		4	0
33	2	6	24	13	35	2	1	45	1	5	1	2	45	4	5	10	20	45	0	0	0	0	4	1		5	2
34	2	12	7	15	59	1	1	56	2	1		2	56	1	2						0	0	4	4		1	0
35	2	12	0	12	38	2	1	45	1	5		2	45	4	5						10	0	4	4		5	0
36	2	6	10	16	28	2	1	67	2	4		2	67	1	4	5	15	67	0	0	0	0	4	4		5	0
37	2	10	6	13	59	1	1	56	1	4		2	56	4	5						5	0	4	4		5	0
38	2	5	4	14	69	1	1	45	1	5	1	2	45	4	5	10	25	45	0	0	5	10	4	4		5	0
39	2	10	5	11	49	1	1	56	2	5		2	56	2	4	10	20	56			7	0	4	4		5	0
40	2	11	10	13	72	1	2	56	1	4		2	56	4	5						7	0				5	0
41	2	9	7	26	51	1	4	34	1	3	< 1	2	34	1	3						12	10	4	4		4	5
42	2	7	15	12	45	1	3	45	1	5		2	45	4	5	25	25	45	0	0	10	0	4	1		5	0
43	2	9	24	17	71	2	2	67	3	3	504	1	67	1	3	10	50	67	0	0	5	30	4	4		3	0
44	2	10	3	13	20	1	1	34	2	5		2	34	4	5	0	20	34	0	10	10	0	4	4		5	0
45	2	6	5	12	28	2	2	67	1	1		2	67	1	1						0	0				1	2
46	2	7	8	14	49	1	1	34	2	5		2	34	4	5	0	25	34	0	0	5	0	4	4		5	0
47	2	5	4	10	43	2	2	67	1	5	< 1	2	67	4	5	15	20	67	-10	0	-5	0	4			5	0
48	2	4	5	12	28	1	1	67	1	5	1	2	67	2	4	10	0	67	0	0	10	0	4	4		5	0
49	2	9	15	23	49	1	4	56	1	2		2	56	1	2						0	-10	4			3	0
50	2	7	28	13	19	1	1	56	2	5		2	56	4	5	10	30	56	0	0	15	0	4	4		5	0
51	2	5	10	15	66	1	1	45	3	4	6	1	45	1	4	6	50	45	7	15	5	10	4	4		4	2
52	2	11	5	16	17	1	1	34	1	5		2	34	4	5						0	0	4	4		5	0
53	2	10	9	45	18	1	1	45	2	2	1	2	45	1	2	5	20	45	5	10	7	0	4	4		5	0
54	2	10	26	31	50	1	2	56	1	4		2	56	1	4						0	0	4	4		5	0
55	2	5	9	15	55	1	1	67	3	5	5	2	67	4	5	20	40	67	0	-10	0	0	4	4		5	0
56	2	9	7	76	27	1	1	45	1	1	< 1	2	45	3	1	12	10	45	0	0	0	0	4	4		1	0
57	2	3	18	17	74	1	4	56	1	4	< 1	2	56	1	4	5	15	56	0	0	15	10	4	4		5	0
58	2	9	10	20	59	1	2	56	2	5	< 1	2	56	4	5	29	30	56	0	0	25	0	4	4		5	4

◀ Key to data

Chart data

- A Operation category: 1 = wiring; 2 = anterior dowel fusion with autograft
- B Follow-up time (years)
- C Time from injury to surgery (days)
- D Duration of hospital stay (days)
- E Age at accident (years)
- F Sex: 1 = male; 2 = female
- G Cause of injury: 1 = traffic accident; 2 = fall; 3 = dive; 4 = other
- H Injury level (71 = C7-T1)
- I Type of injury (allen class, see Table 1): 1 = DF1; 2 = DF2; 3 = DF3; 4 = DF4
- J Neurologic status on admission (modified Frankel score, see Table 2): 1 = A; 2 = B; 3 = C; 4 = D; 5 = E
- K Time from application of skull traction to skeletal reduction (hours)
- L Closed reduction under radiographic control: 1 = yes; 2 = no
- M Fusion and/or stabilization level
- N Neurologic change at discharge: 1 = improved; 2 = worse; 3 = unchanged; 4 = deficit
- P Neurologic status at discharge (see J)

Radiographic data (data from the primary radiographs)

- Q Preoperative kyphosis (degrees)
- R Preoperativeolisthesis (millimetres)
- S Segment fused/stabilized
- T Postoperative kyphosis (degrees)
- U Postoperativeolisthesis (millimetres)

Follow-up (data from the follow-up radiographs)

Injured level

- V Kyphosis (degrees)
- W Olisthesis (millimetres)
- X Signs of anterior fusion: 1 = none; 2 = shadow; 3 = bridge; 4 = solid
- Y Signs of posterior fusion: 1 = none; 2 = shadow; 3 = bridge; 4 = solid
- Z Residual segmental mobility (degrees)

Clinical data

Clinical follow-up

- AA Neurologic status (see J)
- AB Pain graded on a visual analogue scale (0–10)

The explanation for why spontaneous posterior fusion seems to be rather exceptional is most likely that distractive flexion injuries have only a minor or no fracture component.

Residual segmental motion may contribute to late pain and subsequent restricted range of motion in these patients. Two studies describe histologically the development of facet arthrosis and other degenerative changes after internal spinal fixation without bony fusion [8, 9]. Other factors could be fibrosis after the more extensive surgical approach and a direct effect of the osteosynthetic material.

In one study the authors suggested that bony fusion in addition to wiring in this patient population might improve long-term results regarding late pain and function [7]. In another study, bony fusion in addition to the wiring procedure was recommended [2]. However, a third report did not recommend bony fusion for cervical spine trauma, because this procedure may increase morbidity [10].

Two factors besides the surgical procedure itself may have contributed to the difference in late pain problems between the two patient groups:

1. The length of follow-up. In group 2, the time lapse from injury to follow-up was longer, which may have contributed to reduced residual pain problems.

2. Severity of the initial injury. In patients with more clear evidence of distraction with total ligament rupture, the posterior approach has probably been considered the more logical and attractive. This may imply a more significant initial trauma, from which more late pain problems would be expected.

Neither of the described techniques are standard procedures at the present time. However, the two different surgical approaches both seem to give acceptable long-term results. Each of the techniques has drawbacks; however, these would not significantly jeopardise long-term functional recovery. When summarizing the recent literature it seems that internal fixation and autologous bony fusion is the surgical treatment concept used in most centres today. At present, posterior wiring without fusion according to Brandt is the preferred method in our institution. This study indicates that results regarding long-term pain and restricted neck mobility may be improved by adding fusion to the stabilization procedure. Consequently, a prospective study will be designed to compare the long-term results after posterior stabilization to the results achieved by posterior stabilization and with autologous bony fusion.

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