

M. P. Koivikko · P. Myllynen · M. Karjalainen
M. Vornanen · S. Santavirta

Conservative and operative treatment in cervical burst fractures

Received: 23 March 1999

Abstract The aim of this study is to compare the results of non-operative and anterior operative treatment of cervical burst and flexion teardrop fractures. Sixty-nine consecutive patients treated during 1980 to 1995 were reviewed retrospectively. Thirty-four of them had been treated with skull traction or halo-vest and 35 with anterior decompression, bone grafting and fixation by an anterior Caspar plate. Neurological functioning on admission and at the end of the follow-up was assessed by using Frankel's classification. Kyphosis and spinal canal encroachment by retracted fragments were measured radiographically. Operatively treated patients recovered more often with at least one Frankel grade ($P = 0.027$) and presented less narrowing of the spinal canal ($P = 0.0006$) and kyphotic deformity ($P = 0.00003$) at the end of the follow-up. In comparison with the conservative methods, the operative Caspar technique provided superior decompression and fixation as well as promoted the healing of cord injuries caused by burst and flexion teardrop fractures.

Introduction

Burst and flexion teardrop fractures belong to the most serious lesions of the cervical spine as they are often accompanied by spinal cord injuries. The management of these injuries includes an attempt to limit the spinal cord injury by a prompt reduction of compressing elements, this being traditionally done by skull traction.

In recent years, the treatment of cervical spine injuries has increasingly inclined towards surgical methods. Since

an anterior surgical decompression of neural elements in the cervical spine carries the hazard of increased instability, additionally either external or internal fixation is required. A biomechanical evaluation of different stabilization methods has raised doubts about the capacity of anterior plating to produce a sufficiently rigid construct [9]. However, other reports have shown that the cervical spine can successfully be stabilized by different fixation techniques [1, 3]. With increasing surgical experience, the role of conventional conservative methods for cervical compressive force injuries is becoming a controversial issue [7, 8].

We compared our results of conservative treatment with anterior surgical treatment of cervical burst and flexion teardrop fractures.

Table 1 Characteristics of the patients

	Conservative treatment	Operative treatment
Patients (male:female)	34 (27:7)	35 (29:6)
Age (years)	30.3 (range 15–64)	32.9 (range 17–83)
Mechanism of injury:		
Motor vehicle crash (%)	53	46
Diving (%)	24	26
Other (%)	23	28
Neurological status on admission, Frankel:		
A – Complete motor and sensory loss	9	13
B – Preserved sensation only	7	5
C – Non-functional motor activity	3	4
D – Functional motor activity	1	2
E – Complete neurological recovery	14	11
Associated injuries:		
Head	2	5
Spine		2
Chest	2	1
Abdomen	1	
Pelvis	1	2
Extremities	5	13

M. P. Koivikko (✉) · P. Myllynen · M. Vornanen · S. Santavirta
Department of Orthopaedics and Traumatology,
Helsinki University Central Hospital, Topeliuksenkatu 5,
FIN-00260 Helsinki, Finland
e-mail: Mika.Koivikko@helsinki.fi, Tel.: +358-(0)9-670990

M. Karjalainen
Department of Orthopaedics and Traumatology, Peijas Hospital,
Sairaalakatu 1, FIN-01400 Vantaa, Finland

Table 2 Number of complications during the primary hospital stay and follow-up

	Conservative treatment		Operative treatment	
	Hospital stay	Follow-up	Hospital stay	Follow-up
Cardiac	2		4	
Respiratory	12	1	10	1
Urologic	7	6	8	5
Gastrointestinal	2		4	
Deep venous thrombosis	4			2
Pulmonary thromboembolism	2			
Decubitus ulcers	3	6	5	5
Loosening of the screws				2
Local pain at pin sites		1		1
Other	6		2	
Total patient-years	5.2 ^a	67.4 ^b	4.5 ^a	39.7 ^b

^aCalculated from admission to discharge

^bCalculated from discharge to the end of follow-up

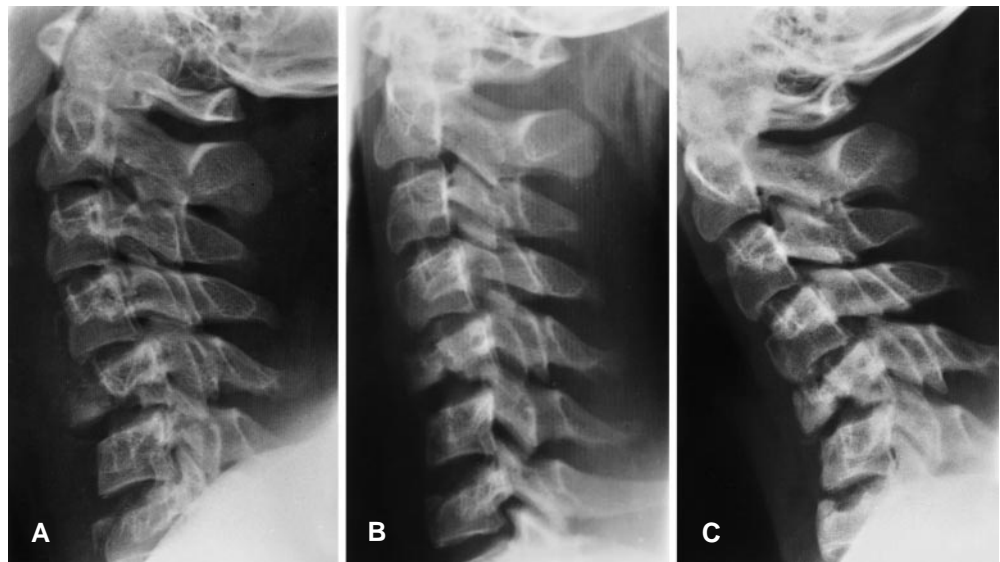
Table 3 Frankel's classification at the end of the follow-up by classification on admission

Neurological status on admission	Neurological status at follow-up									
	Conservative group					Operative group				
	A	B	C	D	E	A	B	C	D	E
A	9					8	2	2		
B		4		1			1	1	3	
C				2	1				3	1
D				1					1	1
E					13					11

Patients and methods

We reviewed retrospectively the files of 69 consecutive patients with unstable cervical burst and flexion teardrop fractures who were treated and followed up in the Department of Orthopaedics

Fig. 1 A–C A 17-year-old man sustained a C5 burst fracture in a motorcycle accident. He was tetraplegic (Frankel grade A). **A** On the lateral radiograph a C5 burst fracture with an anterior teardrop fragment could be seen. Also, the seventh vertebra was compressed and had an anterior fragment. **B** The injury was treated with skull traction for 6 weeks, and a partial reposition was observed. On the follow-up 2 years later, the patient was able to move by wheelchair. No neurological recovery could be seen (Frankel grade A). **C** On the lateral radiograph a marked kyphotic deformity had developed



and Traumatology at Helsinki University Central Hospital during the years 1980–1995. The inclusion criteria were an age of at least 15 years and either conservative treatment with skull traction or halo-vest or alternatively anterior decompression followed by iliac bone grafting and fixation by the anterior Caspar plate [3]. A follow-up of at least 6 months was also required. Exclusion criteria were known malignant processes and ankylosing spondylitis.

A total of 69 patients met the inclusion criteria. On the basis of the treatment applied, the patients were divided into conservative and operative groups. Thirty-four of the patients were treated conservatively: 29 with skull traction (average duration 5 weeks) and 5 with a halo-vest (average duration 8 weeks). Afterwards, a collar (Camp Philadelphia, Cervical Collar Company, Westville, New Jersey, USA) was applied for 8 weeks on the average. The surgically treated group consisted of those 35 patients who were treated with primary reduction by skull traction followed by anterior decompression, iliac bone grafting and anterior fixation by the use of the Caspar plate (Aesculape, Tuttlingen, Germany). In the surgically treated group a collar was used for a mean period of 11 weeks. The neurological status on admission was assessed by using Frankel's five-grade classification of neurological functioning. The neurological status on admission, demographic data and associated trauma are summarized in Table 1.

In 67 of the cases, the fifth, sixth or seventh cervical vertebra was fractured. Displacement of the posterior vertebral body cortex towards the spinal canal and kyphosis at the level of the injury were measured from the lateral view radiographs obtained on admission. In order to exclude the effect of magnification and inter-patient variations in size, the displacement was expressed in percentage of the sagittal diameter of the adjacent superior vertebral body. On admission, the mean posterior displacement of the posterior cortex was 24% in the conservative treatment group and 24% in the operative treatment group. The average kyphosis was 6.6 and 8.0 deg, respectively. On the basis of the hospital records, we evaluated the neurological status and the radiographic measures also at the time of dismissal and the end of follow-up. The average follow-up was 28.9 months (range 6 months–14 years) in the conservative treatment group and 15.9 months (range 6 months–3 years) in the operative treatment group.

The chi-square test was used for statistical testing of proportions and the Mann-Whitney rank sum test for continuous non-parametric variables.

Results

Three patients of the conservatively treated group died: one (53 years old, Frankel grade B) of pneumonia 7 days

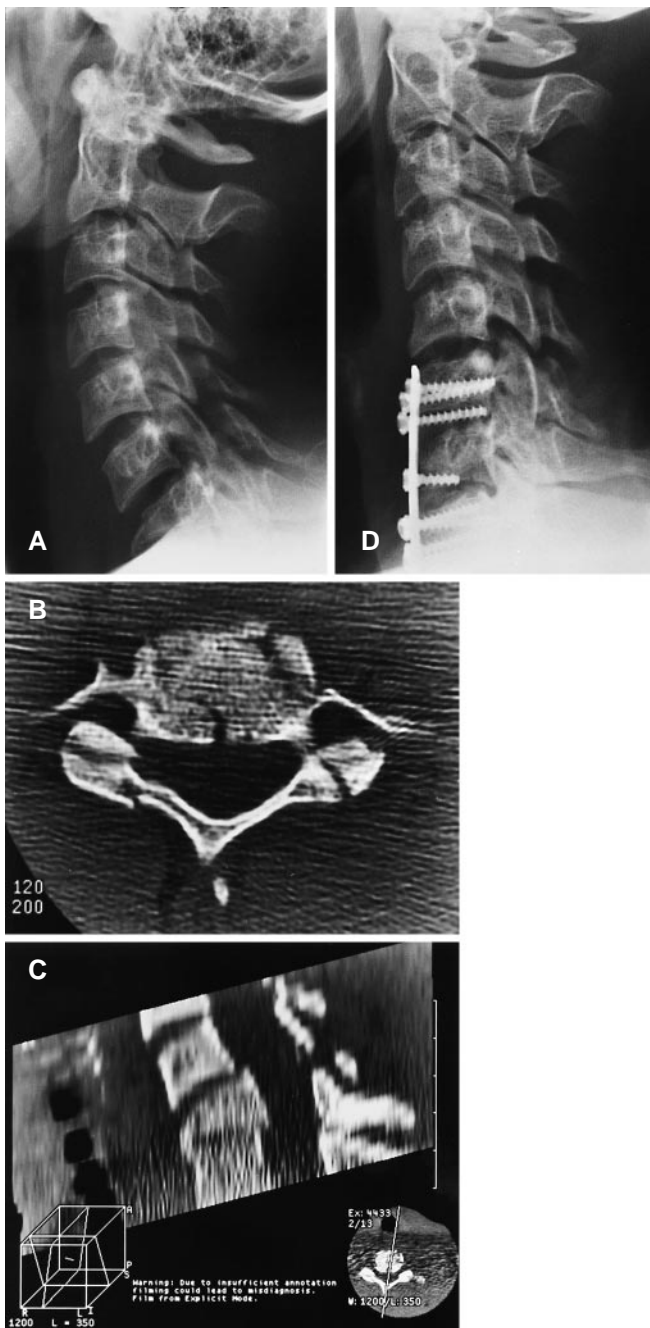


Fig. 2 A–D A 21-year-old man sustained a C7 burst fracture in an automobile accident. He had a total loss of motor and sensory functions below the injured level (Frankel grade A). **A–C** On admission, the radiological examination revealed a C7 burst fracture and retropulsion of bony fragments into the spinal canal. The patient underwent an anterior decompression and Caspar plate fixation. On the follow-up 11 months later, the patient was capable of moving by wheelchair and had limited motor functioning in the lower extremities (Frankel grade C). **D** The lateral radiograph showed preservation of the alignment and no kyphotic deformity

after the injury, one (83 years old, Frankel grade B) of myocardial infarction 82 days after the injury, and one (43 years old, Frankel grade E) of pneumonia 99 days after the injury. One patient (33 years old, Frankel grade A)

in the operatively treated group died of respiratory insufficiency 96 days after the injury. Complications during the treatment and the follow-up (Table 2) occurred almost exclusively among patients graded Frankel A, B and C. Three patients in the conservatively treated group underwent later surgical stabilization (2, 5 and 10 months after the injury). In the operative treatment group two patients had to be operated on for a second time: one because of loosening of a screw and the other because excessively long screws were used in the first operation.

The neurological recovery of the patients can be seen in Table 3. In the conservatively treated group, 4 of the 18 patients who were graded from Frankel A to D on admission improved by at least one grade during the follow-up. Similarly, in the operatively treated group, from the total of 23 patients graded from A to D, 13 improved at least one grade, whereas 10 did not ($P = 0.027$, chi-square test). None of the patients in either group deteriorated neurologically. Although two patients in the conservatively treated group and 14 patients in the operatively treated group had received high-dose methylprednisolone therapy, this did not improve the probability of neurological recovery compared with those who did not receive corticoids.

The size of the posterior displacement of the vertebral body fragments seen on admission did not correlate with the neurological outcome. However, those 17 patients who recovered one or more Frankel grades had significantly less displacement at the end of the follow-up than those 24 who did not recover (mean 7.2% vs 18.3% of the sagittal vertebral body diameter, $P = 0.0006$, Mann-Whitney rank sum test). A similar trend can be seen both among the conservatively treated (17.1% vs 23.4%, $n = 18$, $P = 0.22$) and the surgically treated (3.9% vs 12.6%, $n = 23$, $P = 0.049$). Those patients who were treated operatively had at the end of the follow-up significantly less displacement than those treated conservatively (7.4% vs 21.5%, $P = 0.0001$).

At the end of the follow-up, the conservatively treated patients had more kyphosis at the injured level (mean 12.6 deg of kyphosis, SD 10.0 deg in the conservative treatment group, 2.2 deg of lordosis, SD 13.9 deg in the operative treatment group, $P = 0.00003$, Mann-Whitney rank sum test) (Figs. 1, 2). Between dismissal and the end of the follow-up, the kyphotic deformity progressed 5 deg or more in 8 patients in the conservative treatment group and in 4 surgically treated patients.

Discussion

Comparative studies between conservative and surgical modes of treatment have remained few, and because of ethical reasons, the desired prospectively planned and randomized study will apparently remain undone.

Although the Frankel scale for neurological evaluation lacks the sensitivity and accuracy of more sophisticated methods, it is widely used for clinical studies. An improvement of one grade means a major improvement in the patient's capabilities.

The severity of the cord injury is determined by the force of the initial impact and the persistent compression [5]. In this study the radiographic status on admission did not correlate with the initial neurological status or the outcome. This supports the experimental observations that in burst fractures the post-injury occlusion of the spinal canal underestimates and poorly correlates with the corresponding measures during impact [4]. Those neurologically compromised patients who were treated surgically recovered better than their conservatively treated counterparts. Within both treatment groups it can be seen that the perfect reduction of retropulsed vertebral body structures was to some extent associated with the healing of the spinal cord injury, which is in harmony with earlier studies [5, 10]. By conservative means, the reduction of retropulsed fragments was often incomplete. This finding is consistent with experimental evidence that when the spinal canal is subject to an encroachment of less than 35%, indirect reduction by distracting the posterior longitudinal ligament is unlikely [6]. A delay after the trauma may also influence the result of the reduction.

High-dose corticoid therapy did not seem to modify the neurological outcome in the small number of patients who received the therapy. Even if the efficiency of methylprednisolone is unquestionable [2], the effect is possibly not powerful enough to cause a substantial improvement in the Frankel grading.

The number and profile of complications were quite similar in both of the treatment groups. The complications were strongly associated with motor impairment and immobilization. Of the observed complications 94% occurred in the patients with Frankel grade A-C spinal cord injury. This association overwhelms the possible differences between the two treatments. However, during the hospital stay 4 conservatively treated patients with total motor loss had deep venous thrombosis. No thrombosis was observed in the surgically treated patients. This difference can probably be explained by anticoagulation therapy, and it reflects the limitations of the study setting used. During the follow-up 2 surgically treated patients (Frankel grade B and D) had deep venous thrombosis.

Several conservatively treated patients developed late kyphotic deformity. Even more worrying is that in many of these patients the deformity progrediated during the follow-up. Whether this will in the course of time cause significant degenerative changes or stenosis remains unsolved. In conclusion, compared with conservative methods, anterior decompression and Caspar plating provided a superior decompression and a more rigid fixation, promoting the healing of cord injuries caused by burst and flexion teardrop fractures.

Acknowledgement We would like to acknowledge Ms Johanna Kunttu for her assistance in preparing the manuscript.

References

1. Aebi M, Zuber K, Marchesi D (1991) Treatment of cervical spine injuries with anterior plating. Indications, techniques, and results. *Spine* 16:S38-45
2. Bracken MB, Shepard MJ, et al (1992) Methylprednisolone or naloxone treatment after acute spinal cord injury: 1-year follow-up data. Results of the second National Acute Spinal Cord Injury Study. *J Neurosurg* 76:23-31
3. Caspar W, Barbier DD, Klara PM (1989) Anterior cervical fusion and Caspar plate stabilization for cervical trauma. *Neurosurgery* 25:491-502
4. Chang DG, Tencer AF, et al (1994) Geometric changes in the cervical spinal canal during impact. *Spine* 19:973-980
5. Guha A, Tator CH, et al (1987) Decompression of the spinal cord improves recovery after acute experimental spinal cord compression injury. *Paraplegia* 25:324-339
6. Harrington RM, Budorick T, et al (1993) Biomechanics of indirect reduction of bone retropulsed into the spinal canal in vertebral fracture. *Spine* 18:692-699
7. Lind B, Sihlbom H, Nordwall A (1988) Halo-vest treatment of unstable traumatic cervical spine injuries. *Spine* 13:425-432
8. Murphy KP, Opitz JL, et al (1990) Cervical fractures and spinal cord injury: outcome of surgical and nonsurgical management. *Mayo Clin Proc* 65:949-959
9. Sutterlin CE 3rd, McAfee PC, et al (1988) A biomechanical evaluation of cervical spinal stabilization methods in a bovine model. Static and cyclical loading. *Spine* 13:795-802
10. Yablon IG, Palumbo M, et al (1991) Nerve root recovery in complete injuries of the cervical spine. *Spine* 16:S518-521