

# Hyperflexion sprain of the cervical spine

## Follow-up of 45 cases

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A long-term follow-up study of a series of 45 consecutive patients with a hyperflexion sprain causing anterior subluxation of the cervical spine shows that conservative management is successful in more than 50 per cent of children and adults. In patients under 16 years of age, usually with involvement of the C2-C4 level, kyphosis may persist for months, but later realignment is common. Primary surgical treatment should be restricted to children with a kyphotic angulation of more than 20 degrees.

In adults with injuries commonly at the C4-C7 level, the failure rate of conservative management indicates that primary surgical treatment should be preferred unless kyphotic angulation is less than 10 degrees. Kyphosis may progress during conservative management and may even result in unilateral interlocking. However, none of the patients with a persisting kyphotic angulation had neck complaints. Neurologic involvement when present was mild and reversible. Posterior wiring and fusion may entail inadvertent inclusion of adjacent segments without, however, causing major residual symptoms.

Hyperflexion sprain or anterior subluxation of the cervical spine is characterized by a localized ligamentous disruption of the cervical spine, caused by a distractive flexion force (Allen et al. 1982, Braakman & Penning 1968, 1971, Chagnon & Blery 1982, Evans 1976, Fielding & Hawkins 1976, Pennecot et al. 1984, Scher 1979, 1982, Roy-Camille et al. 1982, Stringa 1963) In addition, the cranial vertebra may be displaced. The lesion is sometimes associated with a minor wedgelike compression of one or two vertebral bodies (Allen et al. 1982, Braakman & Penning 1971, Green, Harle & Harris 1981, Webb et al. 1976). The hyperflexion sprain is a relatively rare injury; the largest series comprises 12 patients (Allen et al. 1982).

We have studied a consecutive series of 45 patients with hyperflexion sprain.

## Patients and methods

The 45 patients of this consecutive series were referred to one of us (R.B.) between 1960 and 1981. All the patients had characteristic signs of hyperflexion sprain. Twenty-eight patients were males and 17 females. Eleven patients were under 16 years of age (Table 1). The patients were treated with one of the three following methods: 1) *Minerva plaster jacket*, as a rule for 3 months, which was usually applied before 1975; 2) between 1975 and 1982, *bed rest* for 4-6 weeks with the head in the hanging position followed by a Somi brace for 6 weeks without subsequent immobilization of the neck; and 3) *operation*, which was performed as primary treatment in cases of severe angulation, particularly when the lesion occurred at levels C4-C7, and as secondary treatment when a progressive kyphosis developed. Surgical management commonly consisted of metallic or mersilene wiring in combination with posterior fusion using iliac bone. Subsequently, the patients were kept in bed for 6 weeks and then ambulated in a Somi brace or, more recently, already the first week in a Halo vest. One patient underwent anterior fusion.

Table 1. Hyperflexion sprain of the cervical spine.

A	B	C	D	E	F	G	H	J	K	L	Outcome
1	m	13	2-3	-	-	6	-	-	-	19	Elongated spin. proc.; C2-C4 immobile
2	m	14	2-3	-	-	-	6	-	s	15	C2-C4 immobile
3	m	13	2-3	-	-	-	8	-	-	2	Progressive kyphosis, no complaints
4	m	13	2-3	3-4	-	6	-	-	-	2	Normal segmental movement, elongated spin. proc. C2
5	m	11	2-3	-	-	-	-	16	-	7	Normal segmental movement, elongated spin. proc. C2
6	m	12	3-4	3-4	-	-	-	12	-	7	Normal segmental movement, elongated spin. proc. C2
7	m	12	3-4	-	-	-	-	16	s	8	C3-C4 immobile
8	m	14	3-4	2-3	-	-	-	12	s	14	C2-C5 immobile
9	m	18	3-4	-	-	-	6	-	-	6	Local kyphosis, C3-C4 immobile, no complaints
10	f	12	3-4	-	-	6	-	-	-	10	C2-C4 immobile; elongated spin. proc. C2
11	f	13	3-4	-	-	-	12	-	-	6	Calcification of ligaments, C3-C4, immobile
12	m	24	4-5	-	-	6	-	-	-	5	Excellent; normal mobility; mild kyphosis
13	f	40	4-5	-	r	-	16	-	-	4	Calcification annulus
14	m	17	4-5	c	-	6	-	-	-	8	Persisting kyphosis; normal mobility
15	f	25	4-5	c	-	-	-	12	-	4	Normal mobility, no complaints
16	f	15	4-5	-	r	-	6	-	-	3	Calcification ant. long. ligament
17	f	19	4-5	-	-	-	-	-	p	8	C3-C5 immobile, no complaints
18	m	19	4-5	c	-	-	4	-	s	8	C3-C5 immobile, no complaints
19	m	24	4-5	-	-	-	-	6	s	1	C3-C5 immobile
20	m	18	4-5	-	-	-	-	-	p	13	C4-C6 immobile
21	m	44	4-5	-	r	-	-	-	p	16	C4-C6 immobile, died 16 years later
22	m	68	4-5	-	r	-	-	12	s	16	C3-C6 immobile, died 16 years later
23	m	59	4-5	-	-	-	-	-	p	5	C3-C6 immobile, died 5 years later
24	f	68	4-5	-	r	6	-	-	-	9	C4-C6 immobile, died 9 years later
25	f	19	5-6	c	-	1	-	-	-	8	Normal mobility, very mild (6°) kyphosis
26	f	37	5-6	-	-	-	6	12	-	9	C5-C6 immobile
27	m	19	5-6	-	-	-	6	-	-	1	Kyphosis, C5-C6 block, misdiagnosed
28	m	72	5-6	-	-	-	-	-	-	2	Severe kyphosis, refused operation, no complaints
29	f	18	5-6	-	-	-	-	-	-	1	Normal movements, normal lordosis
30	m	32	5-6	-	-	-	-	-	p	5	C3-C7 immobile, no complaints
31	m	57	5-6	-	-	-	-	-	p	10	C4-C7 immobile, no complaints
32	m	68	5-6	-	p	2	-	-	s	14	C2-C7 immobile, mild neurological deficit
33	f	38	5-6	fx	-	-	6	-	s	-	C4-C6 immobile, progressive kyphosis
34	f	51	5-6	-	-	1	-	-	s	1	Interlocking after ambulation; C5-C6 immobile
35	f	44	5-6	c	-	4	-	-	s	3	Progressive kyphosis, postoperative alignment, died one year later
36	m	44	5-6	-	-	-	-	12	-	19	Good alignment, normal mobility, died 19 years later
37	f	68	5-6	-	r	-	-	12	s	3	Progressive kyphosis in plaster, postoperative alignment, died 3 years later
38	m	63	5-6	-	-	-	-	-	s	1	C5-C6 immobile
39	m	50	5-6	-	-	-	-	-	p	2	C4-C6 immobile
40	f	23	6-7	-	-	-	-	-	p	6	C6-C7 immobile, graft temporarily displaced
41	m	18	6-7	-	rc	-	-	-	p	5	C5-C8 immobile
42	f	48	6-7	-	rc	-	-	12	-	26	Developed interlocking, died 26 years later
43	m	42	6-7	-	-	-	-	-	p	4	C5-C7 immobile, died 4 years later,
44	f	79	6-7	-	r	-	12	-	-	3	Dementia; died 3 years later; no X-ray
45	m	79	6-7	-	-	+	-	-	-	-	Died after 2 weeks

A case number, B sex, C age, D level, E associated lesion; c=concussion, fx=fracture lower arm, F neurologic injury; pc=progressive central cord lesion, rc=reversible contusion of the cervical cord, r=root lesion, G bedrest (wk), H brace (wk), J plaster (wk) K operation; p=primary, s=secondary, L follow-up (yr).

The operation consisted of metallic or mersilene wiring with posterior fusion using iliac bone in all except three cases; Case 32 laminectomy with lateral posterior fusion, Case 7 only wiring, Case 40 anterior fusion.

At follow-up, 11 patients were found to have died of unrelated causes. In 7 of these 11 patients, however, follow-up information about their condition 3-8 years after treatment was available. The remaining 34 patients were interviewed and examined. In addition, control radiographs were taken in all but 3 patients, who refused radiography. The results were considered to be 1) excel-

lent, in cases of normal lordosis or mild kyphosis (< 8°) with normal mobility at the injured level; 2) good, in cases of normal alignment or a mild kyphosis (< 8°) but with an immobile segment; 3) moderate, in cases of fusion of two or more segments but without complaints; and 4) poor, in cases of progressive kyphosis or unilateral interlocking.

## Results

**Levels C2-C4.** Eleven patients, aged between 11 and 18 years, were injured at the C2-C4 levels. Later, 3 also showed signs of hyperflexion sprain at an adjacent level. None of the 11 patients had a neurologic deficit. All the patients were initially treated conservatively, and the end result was excellent or good in 7 patients; 3 regained normal cervical lordosis and mobility, albeit with the spinous process of C2 elongated caudally (Figure 1). In the other 4 patients, the damaged intervertebral segment lost mobility.

Four patients developed progressive kyphosis and pain, and 2 of these were operated on with moderate results. One patient underwent wiring with an immobile segment as the ultimate outcome (Figure 2), and in the remaining patient, not operated on, kyphosis persisted without complaints; the segment became immobile.

**Levels C4-C7.** Thirty-four patients were injured at the C4-C5, C5-C6, or C6-C7 level. One patient was under 16 and 7 were between 16 and 20 years of age.

Seven patients had a root lesion; 2 had a mild reversible contusion of the cervical cord; and 1 had a progressive central cord lesion. Twenty-four patients were initially treated closed and 10 underwent primary surgery (Table 2).

Seven patients were treated with a Minerva plaster cast. Two had excellent results without loss of mobility in the damaged segment; in 1 the segment became immobile. One patient developed spontaneous unilateral interlocking and spontaneous fusion. In 3 patients the kyphosis increased, and they were operated on.

Bed rest as the primary treatment was chosen for 8 patients. One patient died after 2 weeks; in 4 the result of treatment was excellent or good. One patient was ambulated after 1 week and developed unilateral interlocking; another showed progressive kyphosis when ambulated after 4 weeks. Both of these patients were operated on. The remaining patient (Figure 3), who initially appeared to have no abnormalities on the lateral radiograph, developed a progressive kyphosis with a central cord lesion. He underwent a laminectomy and a posterior fusion. Now, 14 years later, he is well with only mild residual symptoms.

Six patients wore a Somi brace for 6 weeks to 3 months. In 3 the segment became immobile; 2 developed a progressive kyphosis and were subjected to wiring and fusion; in 1 the result is unknown.

Three patients refused treatment. Two developed progressive kyphosis; one refused operation and was well after 2 years despite severe kyphosis; the other patient was operated on. The remaining patient had normal mobility and normal lordosis after 1 year.

Nine patients had a primary operation with fusion of two or three segments in all. In 9 of the 11 patients subjected to secondary fusion, two or more segments became immobile despite the aim of fusing only the damaged segment.

## Discussion

The diagnosis hyperflexion sprain is often missed on initial examination, and especially if the sprain is mild and the radiographs are taken with the patient in the recumbent position. This was the case in 6 of our patients. Muscle spasm is often present initially (Hubbard 1974) causing loss of cervical lordosis or even leading to arcual kyphosis.

Lateral radiography of the cervical spine with the patient sitting and the neck in midposition should be repeated after spasm and pain have disappeared. This will reveal the kyphotic angulation because the gravitational center of the skull is anterior to the vertical axis of the spine (Penning 1968, Webb et al. 1976). Flexion examinations are, however, not necessary. They may be hazardous because the hyperflexion sprain is an unstable injury sometimes causing interlocking, as found in 2 cases.

Slight angulation may result from hyperflexion sprain, but is not a reliable diagnostic criterion, particularly at the C2-C3 level; anterior displacement of C2 over C3 may represent normal variation, such as in pseudosubluxation of the C2-C3 segment (Cattell & Filtzer 1965, Braakman & Penning 1971).

There is a relationship between age and level of injury (Allen et al. 1982). In 16 children with a hyperflexion sprain reported by Chagnon & Blery (1982) and Pennecot et al. (1984), 13 injuries were at the C2-C4 level and only three

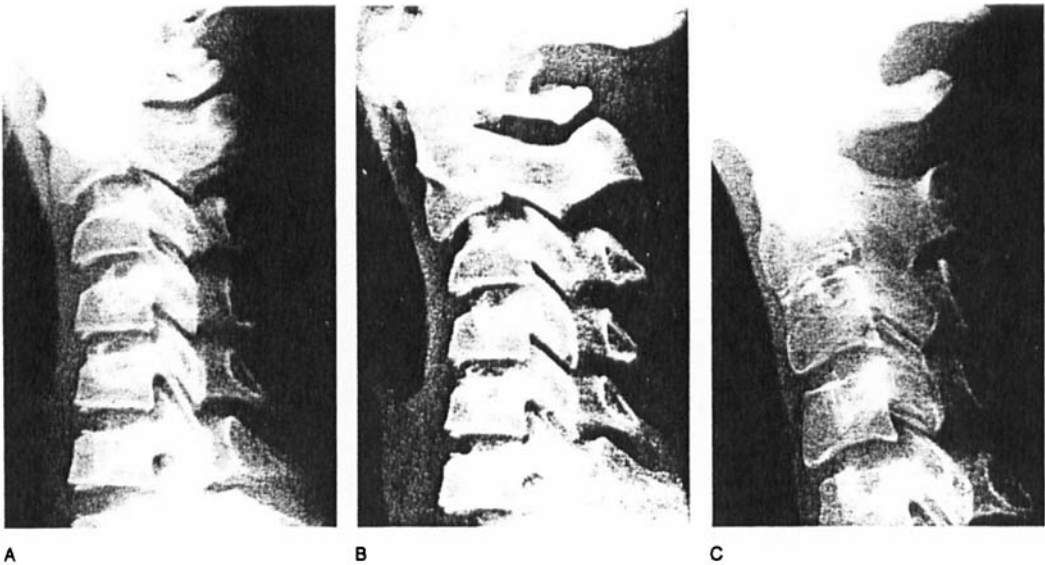


Figure 1. Case 1. Male, aged 13 years, hit his head in a road-traffic accident.

A. On admission. Mild kyphotic angulation at C2-C3.

B. Progressive kyphosis during bed rest. Note the calcification of the interspinous ligaments of C2-C3. The patient was ambulated after 6 weeks of bed rest.

C. 14 years later. The neck in flexion. Fusion of C2-C3 with a caudal elongation of the spinous process of C2. The interfacet joints of C2-C3 are ankylosed and the disc of C2-C3 has almost disappeared.

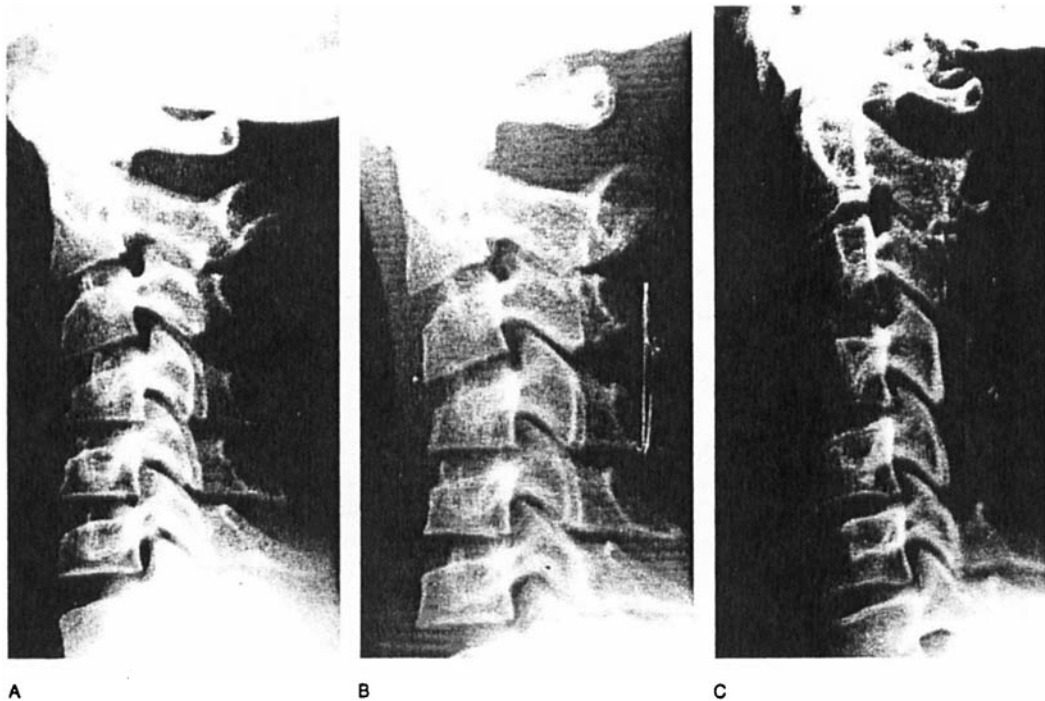


Figure 2. Case 7. Male, aged 12 years, hit his head while diving into shallow water.

A. Kyphotic angulation at C3-C4, with mild wedgelike compression fracture of C4 and C5 (and C6?).

B. Persistent kyphotic angulation after primary wiring of the spinous processes at C3-C4 and wearing a plaster jacket for 4 months.

C. Eight years later: realignment; C3-C4 is immobile.

Table 2. Results of non-operative and operative treatment for hyperflexion sprain of the cervical spine. Number of cases subject to secondary operative treatment in parenthesis

Segment	Non-operative							Operative			
	Excellent		Good	Poor	Un-known	Primary		Secondary			
	normal mobility no angulation	mild kyphosis	immobile	progressive kyphosis		inter locking	1 segm. immobile	2-4 segm. immobile	1 segm. immobile	2-4 segm. immobile	
C2-C4	11	3	5	3(3)					1	2	
C4-C7	34	3	5	9(7)	2(1)	2	1	9	1	7	
Total	45	6	3	10	12	2	2	1	9	2	9

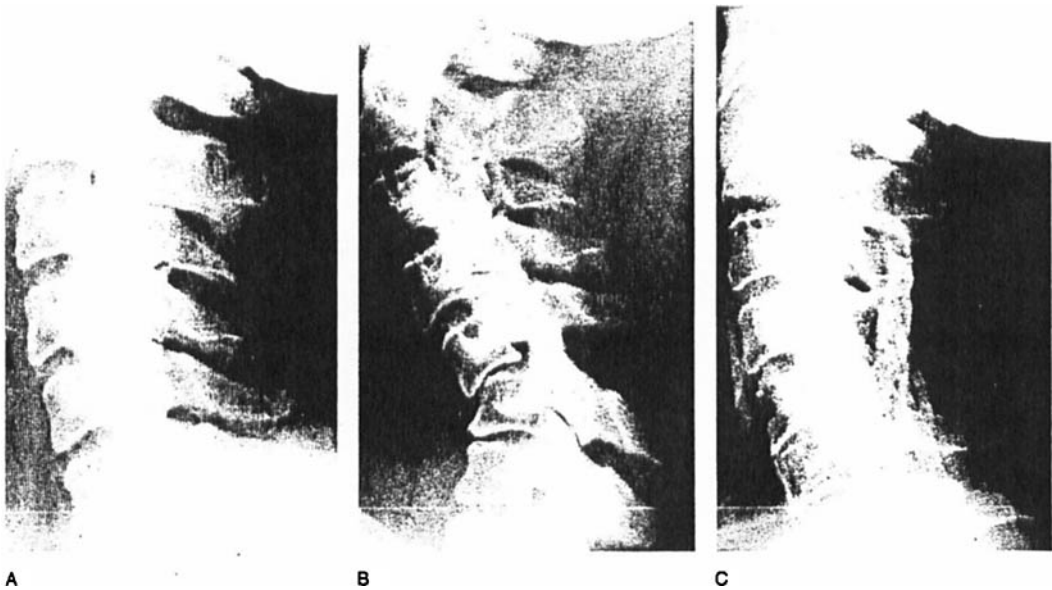


Figure 3. Case 32. Male, aged 68 years. Car accident. Central cervical cord lesion on admission to hospital.

A. On admission. No abnormalities, suggesting a hyperextension injury of the neck.

B. With ambulation after 2 weeks, a marked kyphotic angulation at C5-C6 without interlocking. Subsequent neurologic deterioration. Laminectomy and lateral posterior fusion.

C. 12 years later. Excellent fusion at levels C2-C7. Mild paresis of hands.

below C5. Also in our series there was a close correlation between age and level of injury. All the patients with lesions at the C2-C4 levels were under 18 years of age, whereas the majority (13/20) of those with lesions at the C4-C7 levels were over 40 years of age.

The neurologic injury in hyperflexion sprain is usually mild and reversible (Allen et al. 1982). Only one of our patients had a persistent mild central cord lesion.

Reduction of the angulation of hyperflexion sprain can easily be achieved by placing the

patient with the head hanging over the end of the mattress (Braakman & Penning 1968). The result of this procedure can be checked radiographically. The choice of methods to maintain reduction depends on the extent of ligament damage. Nonoperative management was successful in only 18 of our 32 patients. The result was not related to age or type of closed treatment (Table 2). It is, indeed, questionable whether prolonged bed rest or application of a Minerva jacket or collar is of any use.

In children with C2-C4 injuries, initial anatomic

results of conservative treatment are often disappointing, but long-term results in cases with angulation less than 20° are good, both anatomically and clinically. Gradually, the angulation disappears under partial calcification of the posterior ligaments and elongation of the spinous process of the vertebra above the damaged segment (Figure 1). In the majority of young patients, mobility of the affected segment remains normal. A previous follow-up study (Braakman & Penning 1968) disclosed substantial arrest in the growth of surgically fused vertebrae. Therefore, we consider fusion in patients under 16 years of age indicated only in cases with more than 20° of angulation.

In *adults*, commonly with injuries below C4, acceptable results may be obtained without operation in more than half of the cases. However, in the remaining patients kyphosis reappears or may even increase after months of wearing a Minerva jacket, as was reported by Cheshire (1969). We even observed development of interlocking in 2 patients during bed rest and treatment in a plaster jacket, respectively. There is no later realignment of the cervical spine, as in many children. The failure rate with conservative management in adults is so high that primary fusion by bone grafting, using either the posterior or anterior approach, seems preferable.

## References

- Allen B L Jr, Ferguson R L, Lehmann T R, O'Brien R P. A mechanistic classification of closed, indirect fractures and dislocations of the lower cervical spine. *Spine* 1982 Jan-Feb;7(1):1-27.
- Braakman R, Penning L. The hyperflexion sprain of the cervical spine. *Radiol Clin Biol* 1968;37(6):309-20.
- Braakman R, Penning L. Injuries of the cervical spine. Excerpta Medica Foundation, Amsterdam 1971.
- Cattell H S, Filtzer D L. Pseudosubluxation and other normal variations in the cervical spine in children. A study of one hundred and sixty children. *J Bone Joint Surg (Am)* 1965 Oct;47(7):1295-309.
- Chagnon S, Blery M. Entorses et luxations du rachis cervical chez l'enfant. A propos de 17 cas. *J Radiol* 1982 Aug-Sep;63(8-9):465-70.
- Cheshire D J. The stability of the cervical spine following the conservative treatment of fractures and fracture dislocations. *Paraplegia* 1969 Nov;7(3):193-203.
- Evans D K. Anterior cervical subluxation. *J Bone Joint Surg (Br)* 1976 Aug;58(3):318-21.
- Fielding J W, Hawkins J R. Roentgenographic diagnosis of the injured neck. In: *Instructional Course Lectures, American Academy of Orthopaedic Surgeons, Chicago* 1976;25:149-170.
- Green J D, Harle T S, Harris J H Jr. Anterior subluxation of the cervical spine: hyperflexion sprain. *AJNR* 1981 May-Jun;2(3):243-50.
- Hubbard D D. Injuries of the spine in children and adolescents. *Clin Orthop* 1974 May;100:56-65.
- Pennecot G F, Leonard P, Peyrot Des Gachons S, Hardy J R, Pouliquen J C. Traumatic ligamentous instability of the cervical spine in children. *J Pediatr Orthop* 1984 May;4(3):339-45.
- Penning L. Functional pathology of the cervical spine: radiographic studies of function and dysfunction in congenital disorders, cervical spondylosis and injuries. Excerpta Medica Foundation, Amsterdam 1968.
- Roy-Camille R, Saillant G, Judet T, Mammoudy P. Traumatismes recents des cinq dernieres vertebres cervicales chez l'adulte (avec et sans complication neurologique). *Ann Chir* 1982 Dec;36(9):735-44.
- Scher A T. Anterior cervical subluxation: an unstable position. *AJR* 1979 Aug;133(2):275-80.
- Scher A T. Radiographic indicators of traumatic cervical spine instability. *S Afr Med J* 1982 Oct 9;62(16):562-5.
- Stringa G. Traumatic lesions of the cervical spine, statistical mechanism, classification. In: *Proceedings of the IXth Congress of the International Society of Orthopaedic Surgeons and Traumatology. Imprimerie des Sciences, Brussels* 1963:69-97.
- Webb J K, Broughton R B, McSweeney T, Park W M. Hidden flexion injury of the cervical spine. *J Bone Joint Surg (Br)* 1976 Aug;58(3):322-7.

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