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Treatment of Stable Burst Fracture of the Atlas (Jefferson Fracture) With Rigid Cervical Collar

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Study Design. A retrospective review of a clinical series.

Objective. To evaluate the use of a rigid cervical collar alone as the treatment for stable Jefferson fracture, and to devise an algorithm for treatment of Jefferson fracture with or without an associated cervical injury.

Summary of Background Data. The traditional treatment for Jefferson fracture, if there is no indication for surgery, is immobilization by halo vesst. Because halo vest placement is associated with intracranial infection and a significant degree if patient discomfort, slightly less rigid forms of external immobilization may be useful for the treatment of stable Jefferson fractures. No standard protocol calling for the use of one form of stabilization device has been reported.

Materials. The medical records and radiographs of 16 consecutive patients with Jefferson fracture during a 2-year period were reviewed. Each patient underwent a complete cervical radiograph series and a computed tomographic scan. The mean C1 lateral mass displacement was 1.8 mm. Cervical spine radiographs, including lateral flexion–extension views were obtained 10 to 12 weeks after injury before the removal of an external immobilization device.

Results. Of these 16 patients, 1 sustained a complete injury, and 7 sustained an incomplete injury. Eight patients were neurologically intact. Twelve patients sustained a stable Jefferson fracture and were treated with a rigid cervical collar (Miami-J collar [Jerome Medical, Moorestown, NJ]) alone from 10 to 12 weeks. The patient sustaining the complete neurologic injury died of multisystem trauma. All 15 live patients showed no instability on their follow-up plain radiographs before the removal of an external stabilization device. Six patients underwent further plain radiographs approximately 1 year after the fracture and similarly demonstrated no instability.

Conclusions. Isolated stable burst fracture of the atlas can be treated effectively with a rigid cervical collar alone for 10 to 12 weeks with good neurologic recovery and segmental stability. Unstable Jefferson fractures with concurrent unstable fracture of other cervical vertebrae, especially C2, requires surgical stabilization. [Key words: atlas fracture, cervical collar, immobilization, Jefferson fracture, spinal trauma] **Spine 1998;23:1963–1967**

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Since the original report of the burst fracture of the atlas by Jefferson,[12] various fracture patterns and issues of stability have been described in the literature.[1,2,7,9] Jefferson fractures now represent a spectrum of injuries from bilateral ring fractures, to lateral mass fracture, to the pathognomonic four-point fracture (both anterior and posterior arches) of the C1 ring that the fracture was originally named for.

To determine stability in patients who have such a fracture, Spence et al[21] proposed a rule by measuring the total C1 lateral mass displacement on the open-mouth view of the upper cervical radiograph. C1 lateral mass displacement totaling more than 7 mm was associated with a higher incidence of instability. Isolated Jefferson fracture can be treated effectively with external immobilization. The traditional mode of cervical immobilization is the halo vest.[14,23] Halo placement may be associated with superficial and intracranial infections and other well-known complications.[1,3,5,6] Some stable fractures have recently been treated with the Minerva jacket or a rigid cervical collar.[13] The criteria for the use of less rigid forms of immobilization than Halo is not well established, because practices vary greatly, even within the same institution.[13,23]

The current report is of a series of 12 consecutive patients with stable Jefferson fracture treated at the authors' institution. The treatment rationale and outcome attained with use of the cervical collar are reviewed. No halo vest was used in patients with an isolated stable Jefferson fracture. Other reported series of treatment for Jefferson fractures are reviewed, and a treatment algorithm is proposed.

Materials and Methods

The medical records and radiographs of sixteen consecutive patients (age range, 6 to 77 years) with Jefferson fracture admitted to Jackson Memorial Medical Center from January 1994 to December 1996 were reviewed. Most patients were young adults or elderly (> 70 years of age). All 16 patients sustained blunt trauma. Three patients sustained the injury after a falls and two after diving accidents. The remaining 11 patients were involved in motor vehicle accidents. Each patient underwent a complete cervical radiograph series and a computed tomographic scan. Subtypes of fractures were classified according to Landells and Van Peteghem.[14] Type I involves the anterior or posterior ring only. Type II crosses the equator to

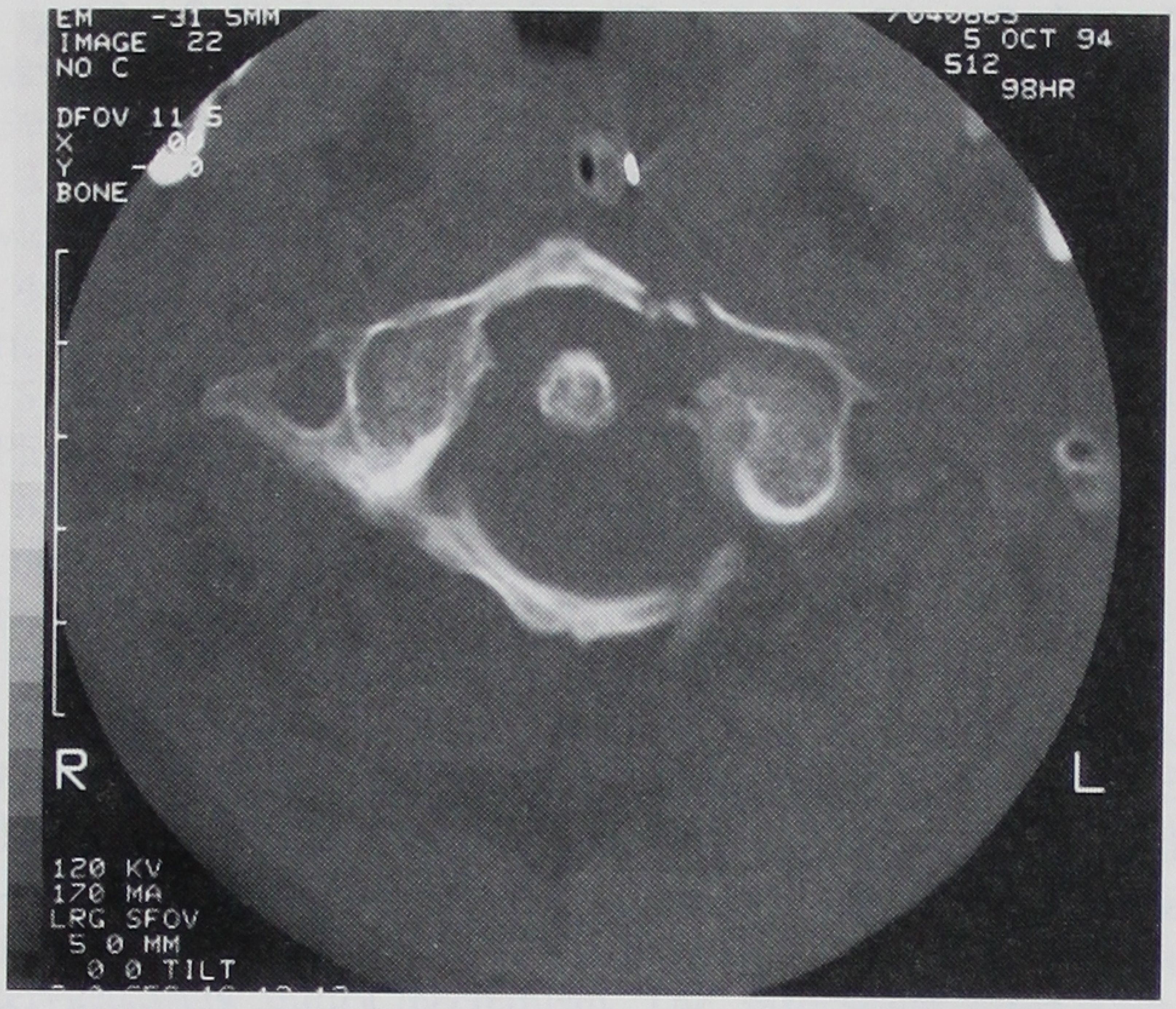

Figure 1. Preoperative axial computed tomographic scan showing a 7-mm preodontoid interval. The patient sustained a Type III Jefferson fracture associated with a Type II odontoid fracture. A posterior C1–C2 fusion was performed, and the patient remained in a rigid collar for 10 weeks after surgery.

involve both the anterior and posterior rings (Figure 1). Type III involves the lateral mass, which could be associated with ring fracture(s). Total lateral mass displacement was measured from the open-mouth odontoid view of the plain radiograph. Magnetic resonance imaging was obtained in a patient with neurologic deficit or other associated cervical fracture. The Frankel grades and ASIA scores were calculated for the 15 surviving patients from the initial complete examination within 24 hours of the injury. All patients with complete (n = 1) and incomplete (n = 7) neurologic injury received a high-dose intravenous 30-mg/kg loading dose of methylprednisolone and then 5.4 mg/kg per hour for 23 hours.

Surgical indications included associated unstable Type II odontoid fracture and transverse ligament avulsion, and C1–C2 subluxation as the result of instability. Three patients required a posterior C1–C2 fusion, but one was not medically and neurologically stable enough for general anesthesia. He was placed in a halo vest and treated conservatively.

Clinical follow-ups were obtained 10 to 12 weeks after injury, and then annually. Cervical spine radiographs, including lateral flexion–extension views with the patient not wearing the collar were obtained 10 to 12 weeks after injury before the permanent removal of the cervical collar (Figure 2, A and B). Another complete set of cervical spine radiographs was obtained when signs or symptoms referable to the cervical spine were reported. These patients were observed clinically from 12 to 24 months. If no clinical follow-up was available within 12 months, a telephone interview with the patient was used to determine the most recent Frankel grade. The clinical grades (Frankel and ASIA scores) were taken from the initial neurologic examination, and the most recent clinical assessment. The clinical outcomes were considered good when at least a 1-grade Frankel score improvement was achieved and there was no incapacitating suboccipital and neck pain.

■ Results

Three patients sustained a concurrent subaxial cervical fracture. Eight patients sustained a C2 fracture. Of the eight with C2 fractures, three patients had a Type II odontoid fracture and two had a hangman's fracture. Seven patients sustained a head injury, and seven patients sustained other systemic trauma. The mean total C1 lateral mass displacement was 1.8 mm. No patient had a total lateral mass displacement of 7 mm or more. Computed tomographic scan evaluation showed that 6, 4, and 6 patients had Types I, II, and III Jefferson fractures, respectively. The subtypes of Jefferson fractures are described by Landells and Van Peteghem.[14]

Of the 16 patients, 8 were neurologically intact. One patient had a complete neurologic injury. No associated cervical fracture was found, and sagittal alignment was normal. He was medically unstable for surgical intervention, remained in a cervical collar, and died within 1

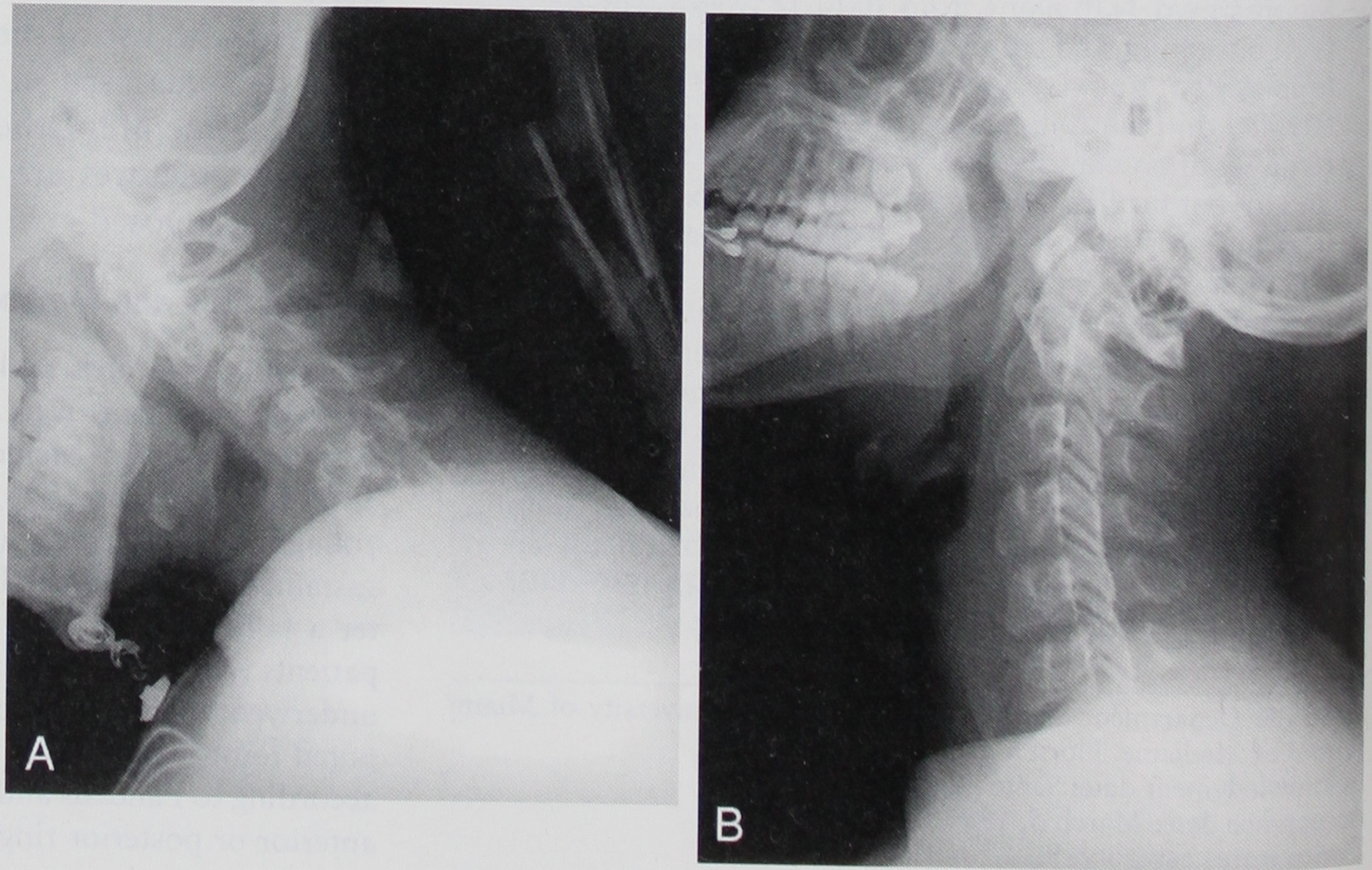

Figure 2. Flexion (**A**) and extension (**B**) lateral cervical spine radiographs of a patient with a Type I Jefferson fracture shows no segmental instability on follow-up.

Table 1. Patient Data

Patient No.	Age (yr)	Sex	Type*	LMD (mm)	Other Spine Fracture	Spine Surgery	Halo	Initial Frankel	Follow-up Frankel	Initial ASIA	Follow-up ASIA
1	17	F	I	0	N	N	N	E	E	96	99
2	19	F	I	2	N	N	N	E	E	93	100
3	37	F	III	2	C2,C7	N	N	E	E	91	98
4	76	M	I	1	C2	N	N	A	NA	2	NA
5	19	F	II	0	C2	N	N	E	E	84	97
6	25	M	III	3	N	N	N	D	E	80	94
7	30	F	II	4	C2	Y	N	B	D	4	84
8	33	M	III	2	C2,C3	N	N	C	D	57	78
9	77	M	II	3	C2	N	Y	C	D	48	72
10	24	M	I	2	C2,C3	N	N	C	D	40	77
11	20	F	II	0	T1	N	N	C	E	26	76
12	76	M	III	3	C4	N	N	E	E	93	99
13	70	F	III	4	C2	Y	N	E	E	89	96
14	22	M	I	3	N	N	N	E	E	90	98
15	33	F	III	4	T11	N	N	D	E	42	50
16	6	M	I	0	N	N	N	E	E	98	99

* Per the definition of Landells and Van Peteghem[10]: Type I Jefferson fracture is the bilateral single-arch fracture of C1 (does not cross the equator of atlas); Type II is the concurrent anterior and posterior ring fractures of C1; Type III fracture is the lateral mass fracture of C1.
LMD = total lateral mass displacement measured from the plain radiograph open-mouth view; NA = not applicable.

week of admission of multisystem trauma and medical complications. The remaining seven patients sustained an incomplete neurologic injury. The admission and follow-up Frankel grades are reported in Table 1. The seven patients with incomplete neurologic injury improved an average of 1.28 grades at their most recent clinical assessment ($P < 0.005$; analysis of variance). The average admission ASIA score was 68.7, which improved to an average follow-up ASIA score of 87.9 ($P < 0.005$, analysis of variance). One patient sustained a concurrent lower thoracic fracture and resultant complete paraplegia.

Of the 15 surviving patients, 12 sustained a stable Jefferson fracture and underwent external immobilization with a rigid collar (Miami-J collar) alone. Two patients underwent posterior cervical fusion because of a concurrent unstable Type II odontoid fracture (Figure 1). Both patients had a C1–C2 subluxation visible on plain radiograph, underwent cervical traction for reduction–alignment, and stabilized posteriorly. Another elderly patient also sustained a Type II odontoid fracture with a 5-mm C1–C2 subluxation. Reduction was achieved by halo ring traction, and the patient was placed in a halo vest subsequently because of concurrent head trauma and multiple medical conditions. A cervical spine series of radiographs were obtained 10 to 12 weeks after the injuries and showed no segmental instability in any patient to that date. Cervical radiographs were obtained in six patients approximately 1 year after injury for symptoms that were possibly referable to the cervical spine. Similarly, these patients had no segmental instability.

Excluding the patients with complete injury and the patient with a concurrent thoracic fracture and resultant complete paraplegia, the initial Frankel grade and ASIA scores in the predefined types of Jefferson fracture were not significantly different (Table 1). The average follow-up Frankel grade and ASIA score did not differ significantly. No patient reported incapacitating neck or suboccipital pain with ordinary daily activity during the available follow-up interval. All 15 live patients had a good clinical outcome, as defined.

■ Discussion

Since the original description of the classical four-point fracture of the C1 ring, several Jefferson variants have been observed. In fact, few of Jefferson's originally reported series had fractures at all four sites. Presently, three general types of Jefferson fractures are described.[14] Type I involves bilateral single-arch (anterior or posterior, but not both) fractures. Type II is the concurrent anterior and posterior arch fractures, which include the classic four-point break Jefferson fracture. Type III is the lateral mass fracture of C1, which may extend into the anterior or the posterior osseous arch. No prognostic significance has been attached to the different types of Jefferson fracture.[14] A nondisplaced Jefferson fracture is considered stable.[20] Jefferson fracture is frequently associated with axis and subaxial cervical spine fractures, as observed in the current series. The advent of the computed tomographic scan has improved the visualization of Jefferson fracture, but congenital malformation in the face of acute trauma may mimic a Jefferson fracture.[7,8]

Jefferson fracture classically results from axial loading on the atlas and is generally associated with minimal neurologic deficit and good prognosis for neurologic recovery.[9] This injury occurs predominantly in the young adult population in a motor vehicle accident or in the elderly population in a fall or motor vehicle accident.[4] This unusual fracture is frequently associated with axis (C2) fractures, including Type II odontoid fracture, hangman's fracture, and lateral mass fracture.[2,11,14] The

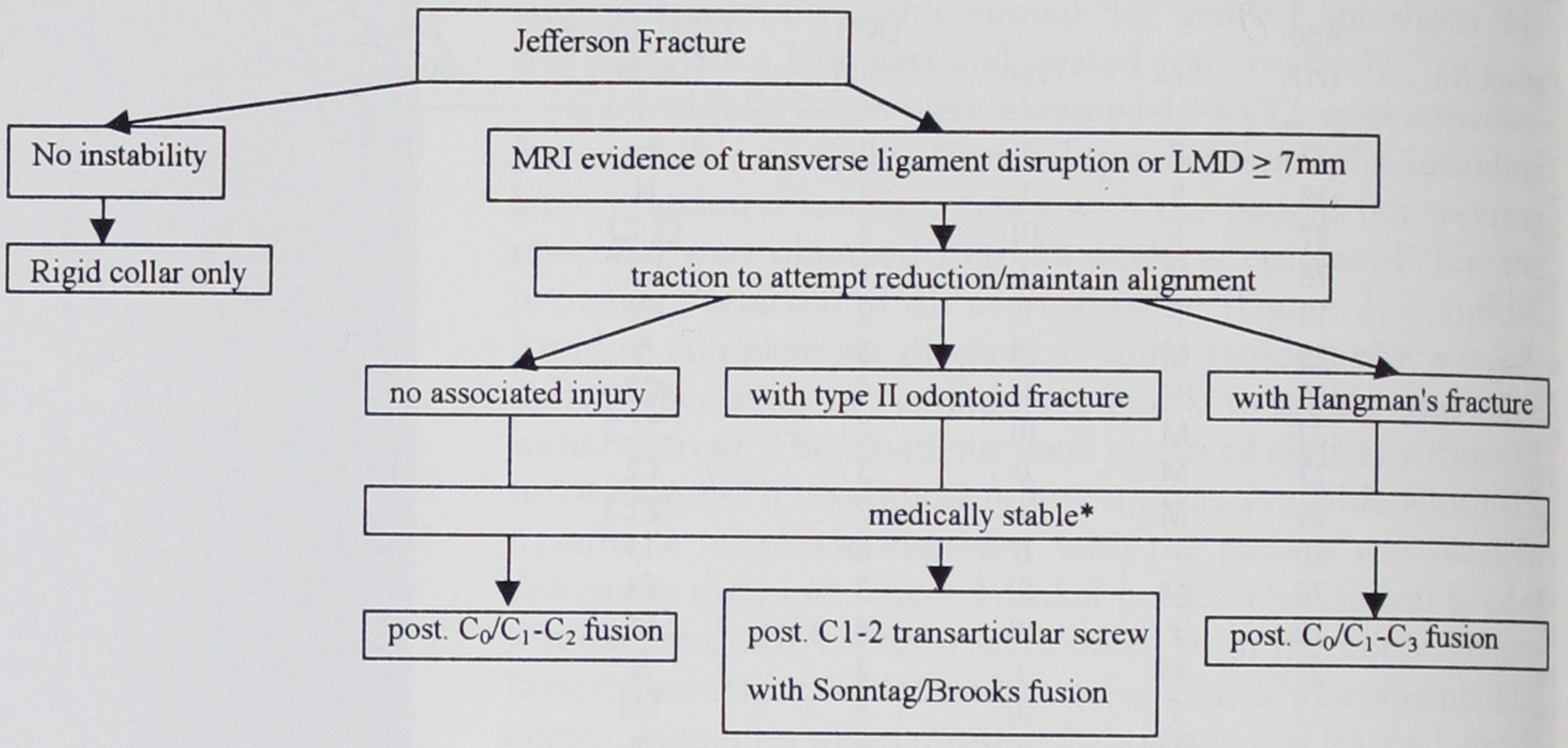

Figure 3. Proposed treatment algorithm for Jefferson fracture with or without associated axis fracture after evaluation with plain radiograph series, computed tomographic scan, and if necessary, magnetic resonance imaging.

Jefferson fracture alone is considered stable if the combined lateral mass displacement totals less than 7 mm,[16,20,21] implying that the transverse ligament portion of the cruciform ligament is intact. However, its association with an unstable Type II or III odontoid fracture or hangman's fracture may require that surgical intervention be directed at the latter[2,11,17] (Figure 3). Similarly, if the total lateral mass displacement is 7 mm or more, transverse ligament disruption is likely,[15,22] and most advocate C1–C2 or occiput-to-axis (C0–C2) fusion[17] (Figure 3). Cervical traction is used in patients with malalignment on plain radiograph[10] before definitive posterior surgical stabilization. The decision to incorporate the occiput into the fusion depends on the stability of the C1 posterior ring. If bilateral posterior ring displaced fractures are identified, an occiput-to-axis fusion is generally performed.

Increased flexion–extension flexibility with Jefferson fracture has been demonstrated in human cadaveric specimens; therefore, external immobilization seems prudent.[18,20] The traditional treatment of stable Jefferson fracture is halo external immobilization.[14,23] More recently, the Minerva jacket or Philadelphia collar have been used by some investigators.[10,13] No standard practice for an external mobilization device has been used for this fracture. For patients who sustained a concurrent subaxial cervical fracture, the treatment is generally for the subaxial fracture[4] (Table 2), unless the Jefferson fracture itself is unstable. In this clinical study, 12 patients with a stable Jefferson fracture were treated with a rigid collar alone for 10 to 12 weeks to assess the efficacy of a rigid collar. All patients improved neurologically. None had disabling neck pain, and follow-up radiographs showed no instability. In the population with a stable Jefferson fracture not associated with other unstable upper cervical injury, a rigid collar system alone should suffice for external immobilization (Figure 3). Although considered to be the gold standard for cervical spine immobilization, the halo has been reported to cause cutaneous, skull, or intracranial infections[1,3,5,6] and possibly cerebrospinal fluid leak and brain injury. Pin loosening, nerve injury, severe pin site discomfort, disfiguring scars, and loss of reduction are other possible complications. In the current investigators' experience, the minimal increase of the immobilization achieved by halo vest compared with that of rigid cervical collar does not warrant its use in patients with stable burst fracture of the atlas. Furthermore, the Miami-J collars that were used in this series of patients were associated with satisfactory immobilization and less patient discomfort in results of a recent study.[19]

Table 2. Proposed Treatment Algorithm for Concurrent Jefferson and Subaxial Cervical Fracture

Subaxial Fracture	Jefferson Fracture	
	Stable	Unstable
Stable	Rigid cervical collar	Posterior C_0/C_1–C_2 fusion with postoperative collar
Unstable	Internal fixation of subaxial fracture and collar	Combined reduction and stabilization for both

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