Non-Operative Management of an Unstable Jefferson Fracture Utilizing a Cervical Collar

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Study Design.
A case report with review of the literature.

Objective.
To discuss the management of unstable Jefferson fractures and to present a case that was successfully managed non-operatively with a cervical collar.

Summary of Background Data.
The management of unstable Jefferson fractures is controversial. Unstable Jefferson fractures have been managed successfully with either surgical intervention or immobilization with halo traction or a halo vest. There are no prior reports of treatment of an unstable fracture with a cervical collar.

Methods.
A 62-year-old man slipped on the ice and sustained an unstable burst fracture of the atlas. He delayed treatment for 1 week and was neurologically intact. Plain films and CT scan revealed a 14mm overlap of the C1-2 lateral masses with a bony avulsion suggestive of a transverse ligament rupture. Flexion and extension films showed no aberrant motion at C1-C2, with an atlanto-dens interval of 3mm. He was managed non-operatively in a rigid cervical collar with frequent clinical examinations and flexion-extension radiographs.

Results.
Twelve months after treatment of his unstable Jefferson fracture with a rigid cervical collar, the patient achieved painless union of his fracture. A lateral flexion-extension radiograph and C-spine CT scan confirmed complete healing of C1, ankylosis at C1-C2, and no evidence of subluxation at C1-C2.

Conclusions.
The successful management of the fracture in the case study is in concordance with prior studies that have treated unstable Jefferson fractures non-operatively. Additionally, the successful results emphasize that the most reliable way of assessing C1-C2 stability in unstable Jefferson fractures is by measuring the presence and extent of anterior subluxation on lateral flexion and extension views. Cervical immobilization in a rigid collar is an acceptable method of nonoperative treatment in patients with subacute presentations of unstable Jefferson fractures who demonstrate clinical and radiographic evidence of atlantoaxial stability.

Key words:
Jefferson fracture, atlas, cervical, burst fracture, rigid cervical collar, transverse ligament rupture. Burst fractures of the atlas (Jefferson fractures) are injuries of the cervical spine that are usually caused by an axial force to the vertex of the skull, with the subsequent transmission of force through the occipital condyles to the atlas. Most are not associated with neurologic deficits and can be treated by external immobilization with satisfactory results. Unstable Jefferson fractures are a more severe injury of the atlas that occurs when the transverse ligament is also ruptured, secondary to the extent of spread of the C1 arch. These fractures are more difficult to manage because they are associated with atlantoaxial instability. Most surgeons recommend operative stabilization of unstable Jefferson fractures. We present the case of a patient with an unstable Jefferson fracture who was successfully treated non-operatively with a Miami-Jackson collar. At twelve months follow-up, he had achieved painless healing of C1 with an accompanying ankylosis of C1-C2, with resumption of full pre-morbid activities.

CASE REPORT

A sixty-two year old man slipped on the ice and struck the back of his neck. He denied loss of consciousness and complained only of neck pain. The day after the injury, he noted a change in his voice, transient chest tingling, and the inability to lift his head off his chest without the assistance of his hands.

He did not seek medical evaluation until five days later, when he presented to his chiropractor. The patient's chiropractor obtained radiographs of the patient's neck (Figure 1). Once they were determined to be negative, the chiropractor subsequently performed a cervical manipulation on his cervical spine. Post-manipulation, the patient reported significant nausea and his wife described him as "ashen" in color.

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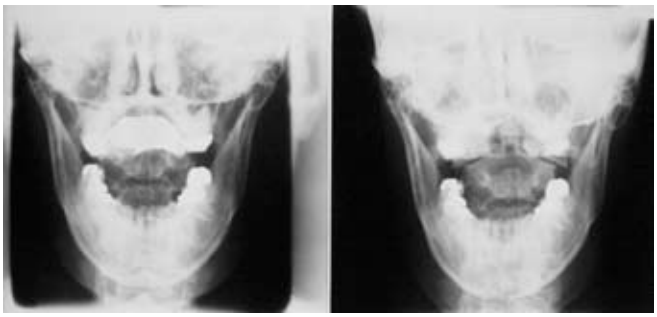

Figure 1a-b. (a- left) Inadequate open mouth anteroposterior view, taken 2 days after the injury. (b-right) Open mouth anteroposterior view, taken 4 days after the injury. The repeat radiograph shows a total of 14mm of bilateral offset of the lateral masses, indicating an unstable Jefferson fracture.

Figure 2a: CT scan in the coronal plane reveals 12mm lateral mass separation, confirming the diagnosis of an unstable Jefferson fracture.

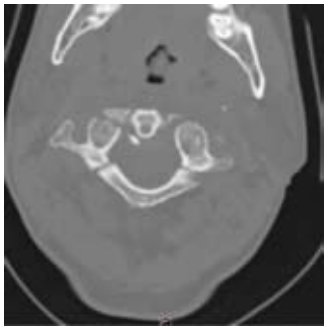

Figure 2b: CT scan in the plane of CI demonstrating the four fractures of the ring, two anterior and two posterior. The avulsion of the transverse ligament is evident on the right (arrow head).

He returned to his chiropractor the next day. Before performing a second manipulation, the chiropractor re-examined the patient's neck and obtained a second open mouth view of the patient's cervical spine (Figure 1). The chiropractor identified the atlas (C1) fracture, and the patient was ultimately transferred to our hospital for evaluation and treatment.

On physical examination, he was non-tender to direct palpation of his cervical spine. He was hesitant to actively flex and extend his neck. Motor and sensory testing were intact and he had normal reflexes in his extremities. Plain films taken from the chiropractor were reviewed and showed a 14mm overlap of the C1-2 lateral masses, confirming the diagnosis of an unstable Jefferson fracture (Figure 1). A CT scan confirmed an overlap of 12mm, and axial views demonstrated a bony avulsion suggestive of a transverse ligament rupture (Figure 2). Because he had been ambulating without a cervical orthosis prior to his ER presentation, flexion and extension films were attempted. The films showed no aberrant motion between C1 and C2, with an atlanto-dens interval of 3mm. There was no movement identified between the occiput and the posterior arch of C1.

The x-rays and CAT scans were reviewed with the patient, and the nature of his injuries explained. However, the patient was strongly opposed to operative management of the fracture, preferring to wait and see if the C1-2 instability pattern developed after healing of the C1 fracture. He was placed in a Miami-Jackson collar and observed closely with monthly clinical examinations, quarterly CT scans, and flexion-extension views at 6 months and one year post-injury.

Figure 3: CT scan in axial and coronal planes demonstrates progression of healing of the C1 Jefferson fracture with partial bony fusion along the left anterior, right anterior, and left posterior rings. There is mild shift of C1 to the left and mild deformation of the atlas ring. There is evidence of transverse ligament calcification.

At three months follow-up, the decision was made to continue non-operative treatment, allowing the patient to mobilize his neck and to wean the use of the collar. Physical examination at that time revealed that he was able to flex his neck within three fingerbreadths of his chest with extension to neutral only. He laterally rotated to the left approximately 30 degrees and to the right only 15 degrees. His neck was stiff and his motor testing remained normal. CT scan showed evidence of healing of the posterior arch on the left with 11mm overlap of the C1-2 lateral masses. Flexion and extension films showed no motion across the occipitocervical junction nor was there a demonstrable increase in the atlanto-dens interval.

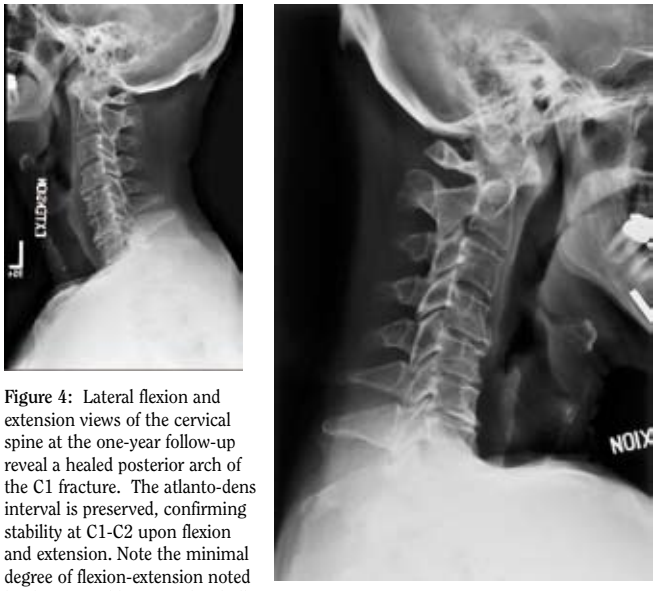

Figure 4: Lateral flexion and extension views of the cervical spine at the one-year follow-up reveal a healed posterior arch of the C1 fracture. The atlanto-dens interval is preserved, confirming stability at C1-C2 upon flexion and extension. Note the minimal degree of flexion-extension noted by the interval between the skull and the posterio arch of C1.

At his one-year follow-up evaluation, the patient had discontinued the use of his collar completely and continued to be pain-free. Physical examination revealed he had extension to neutral only, 30 degrees of lateral neck rotation bilaterally, and flexion to within two fingerbreadths of this chest. A lateral flexion-extension radiograph and C-spine CT scan showed complete healing of C1, ankylosis at C1-C2, and no evidence of subluxation at C1-C2 (Figures 3 and 4). Overall, the patient reported feeling well and was very satisfied with the non-operative management of his fracture.

DISCUSSION

Jefferson fractures are an important minority of atlas fractures. These fractures occur when an axial force is translated across the occipital–cervical junction, causing the ring shaped atlas to be compressed between the angulated articular surface

of the axis and the occipital condyles. The sum of the forces on impact results in an outward spread of the lateral masses of C1, supporting the definition of a burst pattern. The resulting four-part atlas fracture, with two in the posterior arch and two in the anterior arch, is what is classically referred to as the Jefferson fracture. [1]

Classic presentation of patients with Jefferson fractures includes pain localized to the cervical or occipital region, cervical muscle spasm, and limitation of neck movement. Other symptoms can include alterations in voice, neuralgia in the occipital region or pain with swallowing, due to associated injuries to the glossopharyngeal and greater or lesser occipital nerves, accordingly. In general, Jefferson fractures are not associated with neurologic deficit because the neural canal diameter is relatively wide at the C1 level and the lateral masses splay away from the cord. Jefferson fractures are best visualized on antero-posterior (AP) open-mouth radiographs of the odontoid. The absence of neurologic injury, in combination with the difficulty of diagnosing the fracture on simple plain views of the cervical spine, can delay proper diagnosis, as occurred with our case example.

Appropriate diagnosis and management of Jefferson fractures is imperative because mismanagement can lead to acute or chronic myelopathy, or sudden death. Instability at the atlantoaxial joint and subsequent subluxation can occur with further axial loading or unprotected flexion and extension movements. The degree of subluxation is demonstrated on flexion and extension views by measuring a change in the atlanto-dens interval; an interval greater than 2-3mm in adults and 4-5mm is deemed abnormal.

Stability at C1-C2 is maintained primarily by the transverse ligament, a thick ligament that spans between the bases of the each lateral mass of the C1 articular process. This ligament is primarily responsible for holding the odontoid against the anterior arch of the atlas. With significant axial loading and subsequent force, considerable separation of the lateral masses can occur, and the transverse ligament can be torn. Based on Spence's clinical and radiographic assessment in cadavers, transverse ligament rupture occurs with lateral mass separation less than 6.9mm.[1] Adjusting for magnification artifact in radiographs, transverse ligament rupture can be inferred with lateral mass separation greater than 8.1mm on open odontoid views.[2] Jefferson fractures with torn transverse ligaments are inherently unstable at the C1-C2 joint and are referred to as *unstable Jefferson fractures*.

Although there is a general agreement on the treatment of stable Jefferson fractures, the management of unstable Jefferson fractures remains controversial. Non-union of stable Jefferson fractures is rare; immobilization with a halo vest or rigid cervical collar is the standard treatment.[3-7] In the rare case of non-union, surgical stabilization at C1-C2 is indicated. Successful management of unstable Jefferson fractures must preserve rotation at the atlantoaxial joint and maintain alignment of the spine to allow healing of the atlas. Treatment must also address atlantoaxial instability due to an incompetent transverse ligament. Unstable Jefferson fractures have been managed successfully with both surgical intervention and immobilization with halo traction or a halo vest. To our knowledge, a patient never before has been successfully treated with a cervical collar and close observation, as in our case example.

Many authors argue that most Jefferson fractures heal satisfactorily with immobilization in halo traction or halo vest without requiring surgery.[8-12] Advocates of treatment with a halo vest argue that it provides traction to align the splayed lateral masses through ligamentotaxis and reduces any impaction below C1 and C2, thereby preventing subluxation and promoting healing. Han and Zimmerman both reported good clinical results with 9 to 10 weeks of treatment in a halo vest.[3,4] Treatment with a halo vest prevents a number of the negatives associated with halo traction: the expense of prolonged hospitalization and the increased risk of pneumonia and deep venous thrombosis from extended bedrest. Levine, however, asserts that immobilization with a halo vest does not maintain sufficient alignment of the upper cervical spine and that at least initially, halo traction is necessary in the treatment of unstable fractures.[8,9] In addition, Koch has shown that in some circumstances a halo vest can cause axial compression of the cervical spine.[10] For these reasons, Levine and others advocate initial reduction of the fracture with 20 to 25 lbs of halo traction for 6 to 8 weeks, followed by another 4 to 6 weeks of halo vest treatment.[8,9]

Critics of non-operative immobilization cite high rates of non-union and persistent post-traumatic pain syndrome as reasons to instead perform surgical stabilization.[13,14] However, the source of the residual pain has not been clearly identified and might be related to the initial injury rather than the residual "instability." Multiple surgeons recommend initial immobilization for 4-8 weeks in a halo vest to allow healing of the atlas, followed by C1-C2 fusion to stabilize the joint once the residual instability is documented through flexion-extension studies.[15,16] Hein, instead advocates for immediate surgical stabilization, warning that repairing the dislocation after long-term immobilization can lead to irreversible incongruence of the atlantoaxial joint, followed by arthrosis and increasing neck pain.[17] Kesterson et al recommended primary occipitocervical stabilization of Jefferson fractures, however; others have instead recommended transfacet screw fixation at C1-C2 to maintain the optimal amount of motion between the occiput and C1.[18] Ruf preserved C1-C2 rotation, obtained anatomic reconstruction of the atlas, and achieved reliable bony fusion of the fracture fragments using transoral reduction and osteosynthesis of C1.[19] McGuire recommends primary stabilization using the Magerl transfacet screw technique.[20,21]

Our case example underscores a number of important points regarding the best treatment of unstable Jefferson fractures. First, the "rules of Spence" may not correlate directly to C1-C2 stability. Historical treatment algorithms have relied on the radiographic distinction to establish stability at the atlantoaxial joint and to guide treatment. However, rupture of the transverse ligament does not definitively imply that C1-C2 instability exists. As Dickman has previously discussed, the most reliable way of assessing C1-C2 stability in unstable

Jefferson fractures is by measuring of extent of anterior subluxation on lateral flexion and extension views.[22] The patient in our case example has significant lateral mass widening (14mm) with clear evidence of an avulsion of the transverse ligament. However, on serial flexion –extension x-rays, he demonstrated only 3mm of atlantoaxial separation (Figures 1-2). In this patient, it is likely that the residual stability is provided by intact alar ligaments and/or portions of facet capsules, as well as scarring of the avulsed transverse ligament. Protective immobilization with a rigid cervical collar produced adequate long-term stability to enable bony fusion of the atlas fracture.

This case study also supports prior studies that emphasized the importance of examining the type of transverse ligament fracture when making the decision to pursue early surgical intervention. Dickman and colleagues classified transverse ligament injuries into two main types.[23-24] Type I injuries are intra-substance ruptures of the transverse ligament whereas Type II injuries are avulsions involving the tubercle at the insertion of the transverse ligament on the C1 lateral mass. Dickman showed that the two injuries have two distinctly different treatment outcomes. Type I injuries are incapable of healing and require surgery and Type II injuries can heal if the fracture is immobilized and the avulsion fragment osteointegrates. Although the study was limited to isolated injuries of the transverse ligament, its principles can be applied to management of Jefferson fractures with transverse ligament disruption. Our case example shows that avulsion fractures of the transverse ligament can be sufficiently stabilized by a rigid cervical collar to allow both union of the atlas fracture as well as healing of the avulsion (Figures 3 and 4).

CONCLUSION

The favorable outcome of the patient described in the case example highlights that a rigid collar is a possible treatment for a specific subset of patients with unstable Jefferson fractures. Patients who present subacutely without neurologic deficit and who are strongly against surgical stabilization may benefit from treatment in a rigid cervical collar. In such patients, it is important to demonstrate clinical and radiographic stability and to conduct very close follow-up. We advocate monthly clinical examinations with flexion and extension films at the three-month time period. Based on the results of case example, we recommend immobilization with a rigid cervical collar for a total of 12 weeks, with weaning of the collar until the patient is pain free.

KEY POINTS

- Treatment algorithms which rely of the "Rules of Spence" to determine stability at the atlantoaxial joint and to guide treatment of unstable Jefferson fractures may not be clinically relevant.
- The most reliable way of assessing C1-C2 stability in unstable Jefferson fractures is by measuring of extent of anterior subluxation on lateral flexion and extension views.
- Patients who present subacutely without neurologic deficit who demonstrate radiographic evidence of atlantoaxial stability, may benefit from treatment in a rigid cervical collar.
- Avulsion fractures of the transverse ligament are sufficiently stabilized by a rigid cervical collar to allow both union of the atlas fracture as well as healing of the avulsion.
- Patients with unstable Jefferson fractures who are treated in rigid cervical collars need close follow-up and frequent flexion-extension radiographs.

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