

Original Article

Upper cervical injuries: Clinical results using a new treatment algorithm

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Abstract

Introduction: Upper cervical injuries (UCI) have a wide range of radiological and clinical presentation due to the unique complex bony, ligamentous and vascular anatomy. We recently proposed a rational approach in an attempt to unify prior classification system and guide treatment. In this paper, we evaluate the clinical results of our algorithm for UCI treatment. **Materials and Methods:** A prospective cohort series of patients with UCI was performed. The primary outcome was the AIS. Surgical treatment was proposed based on our protocol: Ligamentous injuries (abnormal misalignment, facet perched or locked, increase atlanto-dens interval) were treated surgically. Bone fractures without ligamentous injuries were treated with a rigid cervical orthosis, with exception of fractures in the dens base with risk factors for non-union. **Results:** Twenty-three patients treated initially conservatively had some follow-up (mean of 171 days, range from 60 to 436 days). All of them were neurologically intact. None of the patients developed a new neurological deficit. Fifteen patients were initially surgically treated (mean of 140 days of follow-up, ranging from 60 to 270 days). In the surgical group, preoperatively, 11 (73.3%) patients were AIS E, 2 (13.3%) AIS C and 2 (13.3%) AIS D. At the final follow-up, the American Spine Injury Association (ASIA) score was: 13 (86.6%) AIS E and 2 (13.3%) AIS D. None of the patients had neurological worsening during the follow-up. **Conclusions:** This prospective cohort suggested that our UCI treatment algorithm can be safely used. Further prospective studies with longer follow-up are necessary to further establish its clinical validity and safety.

Key words: Fractures, ligamentous injury, spinal cord injury, upper cervical injuries, treatment

INTRODUCTION

Injuries of the occipital condyles, atlas and axis are complex and have a wide range of radiological and clinical

presentation.^[1,2] This great variability is due to the uniquely complex bony, ligamentous and vascular anatomy of the upper cervical spine region and the cranial base.^[1-3] Upper cervical spine stability depends on strong ligamentous structures that still allow significant flexion, extension, and axial rotation.^[1]

Many different classification systems have been developed to help surgeons with surgical treatment decisions for upper cervical spine injuries (UCI).^[4-8] Recently, we proposed a rational approach for these injuries based on ligamentous integrity and bone fractures characteristics, in an attempt to unify prior classifications system and guide surgical decision-making based on clinically relevant injury characteristics.^[9]

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In this paper, we present the clinical results of a consecutive series of patients prospectively treated according to the previously proposed treatment algorithm for UCI.^[9]

MATERIALS AND METHODS

This is a prospective cohort study of the clinical and radiological outcomes of 38 consecutive patients with upper cervical spine traumatic injuries, including injuries of the occipital condyle, atlas, axis or combined injuries, treated by one of the authors from 2009 to 2013. The patients were separated into 2 cohorts: Operative and non-operative treatment for purposes of assessing results.

Our treatment protocol for UCI since 2009 includes, as described previously.^[9]

Patients with ligamentous injuries underwent segmental instrumentation and fusion

Ligamentous injuries were defined as

Abnormal spinal misalignment, outside of the normative ranges of alignment involving the following articulations: Occipital condyle-C1, C1-2 or C2-3 facet joints, seen with distraction or rotational injuries. Perched or locked cervical facet joints and an increase in the atlanto-dens interval of more than 3.5 mm are examples of ligamentous instabilities that may be detected with CT imaging, MRI or dynamic plain radiography. Patients with injuries in the posterior elements of the axis with perched or locked facet joints of C2-3 were referred for early surgery.

In the surgical group, clinical and radiological assessment was performed at two weeks, one month, three months and six months after hospital discharge, then annually. External orthosis was not prescribed after surgery. All the patients had an early CT scan to check proper instrumentation placement after surgery.

Patients with bone fractures were treated conservatively with a hard cervical collar and were mobilized immediately after application of the orthosis

All the patients with fractures without dislocations, without abnormal subluxation or perched facet joints, without instability detected on dynamic radiological evaluation (not usually obtained in the immediate post-injury setting) were included in this group. Patients with subtle MRI abnormalities without clear CT scan abnormalities were included here as well.

Exception for initial surgery in this group were patients with odontoid fracture at the dens base and risk factors for non-healing – age >50, smoking, severe comminution of the base, or severe dens displacement from the body ≥ 5 mm in static radiological exams.^[9-12] The cervical collar was prescribed for 8 to 12 weeks and discontinued gradually after a normal flexion and extension lateral X-rays. Patients were assessed clinically and with plain lateral and antero-posterior X-rays or CT scan after two weeks, one month, three months and six months of

follow-up, then annually. Surgery was also performed in patients without healing or late misalignments/deformity.

In addition to the application of the aforementioned classification and treatment protocol, we also classified the UCI as follows:

Occipital dislocations

Classified according to Traynelis *et al.*, in type 1 (anterior cranial dislocation), 2 (vertical dislocation) and 3 (posterior cranial dislocation).^[7]

Occipital condyle fracture

Classified according to Anderson and Montesano in type 1 (axial compression), 2 (linear condyle fracture) and 3 (total avulsion of the alar ligament).^[13]

Atlas injuries

Fractures were classified according to its location (in the anterior/posterior arch or in the lateral mass); transverse ligamentous injuries were classified according to Dickman *et al.*, in type 1 (lesion of the transverse ligament injury in its substance) and 2 (avulsion of the insertion of the ligament).^[14]

Axis injuries

Classified as odontoid fractures according to Anderson and D'Alonzo in type 1 (fracture in the upper portion of the dens), 2 (fracture at the base of the dens) and 3 (fracture extends into the body of the atlas);^[4] posterior elements fractures were classified according to Levine and Edwards in: Type 1 (fractures with displacement of less than 3 mm and no angulation), 2 (severe angulation and displacement), 2A (angulation without displacement between the bone fragments) and 3 (unilateral or bilateral C2-3 facet dislocation).^[15]

Patients could cross over from one treatment arm to the other based on the failure of initial treatment, such as severe pain, deformity or neurological deficits or based on their own decision. The primary outcome measurement was neurological status. Neurological status was assessed based on the American Spine Injury Association (ASIA) Impairment Scale (AIS).^[16]

The surgical approach and complications were noted and described in detail. Institutional ethical committee approval was obtained for the study (CAAE: 17337313.7.0000.5404).

RESULTS

Non-surgical group-23 patients

There were 25 patients treated conservatively in the study period, with a rigid cervical collar. Two patients were excluded: One patient with an atlas fracture without dislocation died on the same hospital admission day due to severe traumatic brain injury. The other patient was excluded because of limited follow-up (15 days). Total of 23 patients were treated and followed. Mean follow-up was 171 days (ranging from 60 to 436 days, median of 132 days). Seventeen patients (73.9%) were male and six (26%) were female. With regards to trauma

etiology, eight patients were involved in car accident (34.7%), eight patients had a motorcycle accident (34.7%), five patients had fallen from some height (21.7%), one patient (4%) dived into shallow water and one (4%) was struck by a burst tire. All the patients were neurologically intact (AIS E). Injury characteristics in this group are presented in Table 1.

With regards to the primary outcome measure, none of the patients in the conservative group developed new neurological deficits. One patient, a 93-year-old female with a Levine type II Hangman's fracture treated with a rigid collar died four months after treatment of non-related causes.

Five patients failed conservative treatment and ultimately underwent surgical management. All five patients had type II odontoid fractures without healing after 8 to 12 weeks of rigid cervical collar use. None had risk factors for non-union such as older age (>50 years-old), dens base comminution, or severe dens-body displacement. All patients were treated with a C1-2 posterior instrumented arthrodesis. No other injury patterns failed conservative treatment.

Surgical group-15 cases

Fifteen patients were treated with early surgery. Mean follow-up was 140 days (ranging from 60 to 270 days, median of 120 days). Twelve patients (80%) were male and three (20%) were female. With regards to trauma etiology, eight patients were involved in car accident (53.3%), four patients had fallen from a height (26.7%), two patients had a motorcycle accident (13.3%), and one patient had a bicycle accident (6.6%). Injury characteristics in this group are presented in Table 2.

Preoperatively, 11 patients (73.3%) were AIS E, 2 (13.3%) AIS D and 2 (13.3%) AIS C. No patients had neurological worsening during follow-up. At the final follow up, the AIS score was: 13 (86.6%) AIS E and 2 (13.3%) were AIS D. All four patients with some motor impairment had clinical improvement after surgical treatment.

Posterior fixation with C1 lateral mass screw fixation and C2 laminar, pars or pedicle screws was performed in 10 patients. An occipital-C2-3 instrumented fusion was performed in 2 patients, and 3 patients underwent a C2-3 anterior discectomy and fusion with cervical traction for re-establishment of the facet joints congruence.

Surgical complications included: An intraoperative non intentional durotomy in a patient who underwent C1-2 fixation which was treated with local fat graft and primary suture; one patient with C1 lateral mass screw fixation had greater occipital nerve neuralgia for some weeks post-op; one patient had a local infection in the iliac crest harvest graft site requiring antibiotics; one patient with an occipital cervical dislocation had an anterior dural defect detected during surgery which was managed with local fat graft, fibrin glue and an external lumbar drain for three days after surgery; two patients had decubitus ulceration in the occipital region prior to surgery, requiring debridement. Neither of these patients had wound complications after surgery. One patient with C2 posterior element fracture did not have a good reduction after anterior

Table 1: Distribution of 23 patients with upper cervical spine injuries treated non-surgically according to injury characteristics

Local	Injury characteristic	N	%
Condyle	Compression of the Condyle	3	13
	Linear Condyle fracture	3	13
Atlas	Arch fracture (anterior or posterior)	2	8.6
	Arch and Lateral Mass	1	4.3
Axis	Posterior elements without bony displacement (Levine-Edwards Type 1)	4	17.3
	Posterior elements with mild bony displacement (Levine-Edwards Type 2)	1	4.3
	Odontoid fracture in the dens base	6	26
	Fracture in the Axis Vertebral Body	2	8.6
Combined injuries	Atlas Arch Fracture + Axis body	1	4.3
		23	100

Table 2: Distribution of 15 patients with upper cervical spine injuries treated surgically according to injury characteristics

Local	Injury characteristic	N	%
Occipito-C1 ligamentous injury*		2	13.3
C1-2 ligamentous injury		2	13.3
Odontoid fractures involving the dens base*	Negative risk factors for non-union	8	53.3
Axis posterior elements fractures with ligamentous injuries		3	20
		15	100

*One patient with occipital-C1 ligamentous injury (occipito-cervical dislocation) and two patients with odontoid fracture, although received early surgical indication, were operated after two weeks of the trauma because they have severe traumatic brain injury that precludes early surgery

cervical fusion but he was asymptomatic and without pain, and was managed conservatively. One patient had a C1 screw that appeared to penetrate the C0-C1 joint and was not revised because patient had just mild pain that resolved during clinical follow-up. Lastly, one patient with an odontoid fracture and severe neurological impairment for a concomitant TBI died three months after the trauma for pneumonia and sepsis. We presented two illustrative cases in Figures 1 and 2.

DISCUSSION

Surgical treatment of spinal injuries has three main goals: 1) avoidance of further neurological injury, 2) reduce and stabilize injured segments and 3) provide long-term stability for

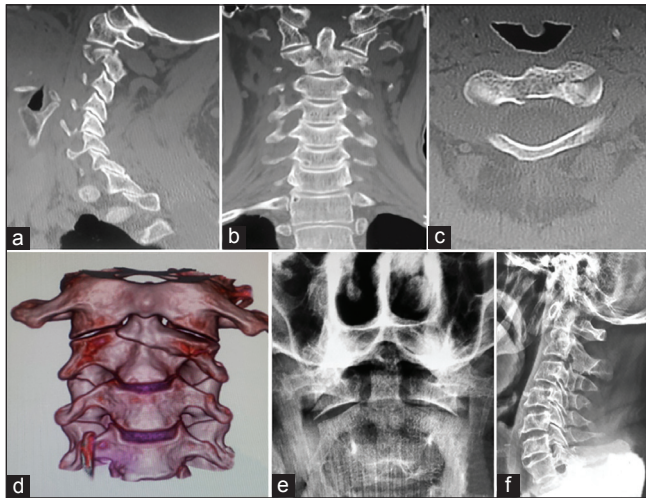


Figure 1: This 60-year-old man fell from the roof. He was neurologically intact. In a, b and c, respectively, sagittal, coronal and axial CT scan showing a linear fracture thorough the body of the axis, without misalignment, without facet injuries, such as perched or locked. In d, 3D CT scan reconstructions of the C2 fracture. This patient was treated with a rigid cervical collar for twelve weeks. After four months, he was without cervical pain and had a good bone healing (open mouth radiograph showed in e and maintained a reasonable cervical alignment (lateral cervical radiograph showed in f)

healing.^[17] To define the best indications for surgical treatment, many classification systems for UCI have been described.^[4,5,7,10,14] Of note, most of these systems proposed surgical treatment as an option for patients with ligamentous injury, based on the premise that healing would not occur with conservative treatment. In contrast, upper cervical spine bone injuries (with a few notable exceptions) heal well with conservative treatment, suggesting that an algorithm for UCI management will successfully guide treatment decisions. Our algorithm was based on the system proposed for subaxial cervical spine injuries, the SLIC, and for thoracolumbar spinal trauma, the TLICS.^[8,18] Although we had previously published a systematic review with our algorithm proposal, a clinical trial is necessary to confirm appropriateness prior utilization in routine practice.

In our series of 38 consecutive patients with upper cervical injuries, 23 patients were managed conservatively initially, and 15 patients received early surgery. Using the criteria previously reported to diagnose ligamentous injury, all unstable injuries were successfully identified, with no acute crossover between treatment groups and no early instability or neurological deterioration during follow-up. The four patients who had motor weakness (AIS C and D) were included in the surgical group. In contrast to the subaxial cervical spine and the thoracolumbar spine, neurological deficit is uncommon in upper cervical spine injuries and surgery is more commonly indicated for ligamentous disruption. The presence of a neurologic injury, when present, does however portend a highly unstable injury, requiring surgical stabilization.

Ligamentous injuries at the craniocervical junction are associated with a high mortality rate in literature.^[19] Most of these injuries

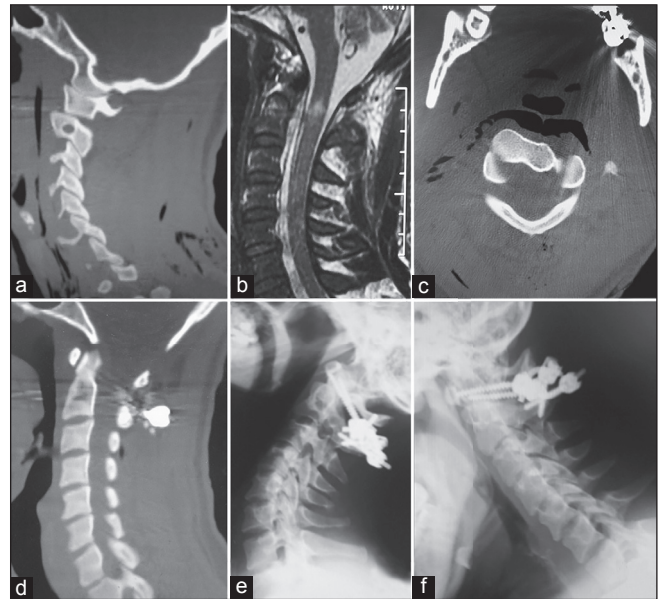


Figure 2: This man fall from a height with a C1-2 ligamentous injury (rotatory) with AIS of c and severe cervical pain. In a, a sagittal CT scan showing a subluxation between the right C1-2 joint. In b, sagittal T2 sequence MRI showing hyper signal in the upper cervical cord and c, axial CT scan showing atlanto-axial rotation. The patient underwent a C1 lateral mass – C2 laminar instrumentation and fusion. Alignment was restored (as shown in d, a sagittal CT scan reconstruction and in the flexion (e) and extension (f) cervical spine lateral radiograph. He was AIS d after seven months of follow-up without any cervical pain

are associated with concomitant traumatic brain injury and other systemic injuries.^[20] In our series, three patients with severe traumatic brain injury underwent late surgery, after clinical stabilization and normalization of brain CT scan. One of these died two months after surgery from sepsis and pneumonia secondary to poor neurological status. Another patient died of a traumatic brain injury during initial hospitalization, prior to treatment of the cervical injury and was therefore excluded from our analysis.

A high rate of successful conservative treatment was observed with the exception of type II odontoid fractures. While none had early instability, 5 of 6 patients without reported risk factors for non-union underwent late surgical treatment for radiographic nonunion. This has been noted in other studies as well.^[11] Patients with dens displacement, fracture comminution and/or inability to maintain fracture alignment may well benefit from surgical stabilization.^[12] Initial conservative management of type II odontoid fractures in patients less than 50 years of age without other known risk factors for nonunion may be reasonable. However, our series suggests that close clinical and radiological follow-up are necessary to confirm radiographic union.

While this study details the outcomes of a consecutive series of patients with upper cervical spine injuries where the upper cervical injury algorithm was used to inform treatment decisions, there are clear weaknesses. As with all non-randomized studies, not all confounding variables have been accounted for and this could lead to some bias in the results. In addition, follow-up is relatively short to identify long-term failures. That said, the early

benefits of the upper cervical injury algorithm are identified and a large multicenter prospective study may further support its use.

CONCLUSIONS

Prospective application of the UCI treatment algorithm was successfully utilized to identify all stable injuries, allowing early non-operative treatment. None of the patients deteriorated in neurological status or deformity/instability. Neurological outcomes were, in fact, excellent in both patient cohorts. Further prospective studies with longer follow-up and standardized patient reported outcomes are necessary to further establish the clinical validity and safety of the algorithm proposed for treatment of UCI.

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