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SPINE

Treatment of unilateral cervical facet fractures without evidence of dislocation or subluxation: a narrative review and proposed treatment algorithm

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- Isolated cervical spine facet fractures are often overlooked.
- The primary imaging modality for diagnosing these injuries is a computed tomography scan.
- Treatment of unilateral cervical facet fractures without evidence of dislocation or subluxation remains controversial. The available evidence regarding treatment options for these fractures is of low quality.
- Risk factors associated with the failure of nonoperative treatment are: comminution of the articular mass or facet joint, acute radiculopathy, high body mass index, listhesis exceeding 2 mm, fragmental diastasis, acute disc injury, and bilateral fractures or fractures that adversely affect 40% of the intact lateral mass height or have an absolute height of 1 cm.

Keywords: cervical facet fracture; isolated; non-displaced; trauma; Spine

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Introduction

Facet joints play a significant role in the sagittal and rotational stability of the subaxial cervical spine (1). It is estimated that facets get 23% of the axial load force to which cervical and upper thoracic spine are exposed to (1, 2). Historically, both isolated and unilateral facet fractures have been defined as biomechanically stables to support physiologic loads (3). However, there is still great uncertainty around defining stability for these types of injuries (4). The failure of the nonoperative treatment was reported in about 20% of the cases, probably due to missed mechanical instability. The torpid evolution of isolated cervical spine facet fractures can result in persistent cervical pain, subsequent displacement, deformity, and even neurological impairment (4).

The isolated facet joint injury, i.e. without associated injury of the vertebral body, disc, and/or tension bands (discoligamentous structures), is an infrequent condition, representing 6% of all traumatic cervical injuries (5). Its rare occurrence results in a limited availability of clinical studies, which are usually retrospective and analyze the results obtained from small samples. This entails the availability of low-quality evidence to support the diagnosis, classification, treatment, and understanding of the prognosis of these injuries (6).

High-energy injury represents the prominent kinetics involved in injury mechanisms of isolated cervical facet fractures, with motor vehicle accidents representing its main etiology (7). In this context, the clinical spectrum of cervical facet injuries is variable, and its principal symptomatology includes from fracture-dislocations with neurological impairment (from nerve roots or spinal cord) as a consequence of flexion–distraction mechanisms, to nondisplaced injuries of the lateral mass caused by axial load with neck pain (7). There is wide agreement on the need of surgical treatments for fractures with evident displacement and/or neurological impairment (8). Conversely, isolated facet fractures without displacement or an associated neurological damage are still a controversial issue.

We aim to perform a narrative review of the literature related to the diagnosis and treatment of isolated nondisplaced, or minimally displaced, cervical facet injuries without neurological impairment.

Methods

An extensive literature review was conducted among scientific databases (Medline, Embase, and LILACS), during the period from January 1, 1990, to January 2023, to gather a comprehensive understanding of the current options for diagnosing and treating isolated, nondisplaced, or minimally displaced cervical facet injuries without neurological impairment. We included experimental and observational studies that investigated diagnoses and treatment of these specific injuries while excluding case reports. The research strategy has been formulated by the project team using the following keywords and Medical Subject Headings (MESH): ‘spine’; ‘vertebral column’, ‘spinal column’, ‘vertebra’, ‘vertebrae’, ‘cervical’, ‘spinal fractures’, ‘spine injury’, ‘zygapophyseal joint’, ‘facet joint’.

Our approach involved conducting a narrative review to synthesize the findings. Subsequently, an algorithm was developed to provide spinal surgeons with a structured framework for effectively managing these types of injuries.

Results

In total, 564 titles were identified with our research strategy among data bases. After screening titles, only ten articles were shortlisted for further review according to our selection criteria. Additionally, 26 articles were included by manual citation search to address our narrative review (4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40).

Discussion

Diagnosis

The first diagnosis assessment method for patients with cervical trauma are plain radiographs, which is a low-cost test of easy access and fast availability (9). In complex fractures or dislocations, spondylolisthesis of the vertebral body and/or segmental kyphosis are usually evident. However, isolated nondisplaced facet joint injuries often go unnoticed. It is estimated that up to 67% of these injuries are not detected when assessed through plain radiographs only. In these cases, dynamic radiographs are one of the available resources to demonstrate unseen instability (10, 11, 12, 13).

The main complementary diagnostic tool is the computed tomography (CT) scan, including sagittal and coronal reconstruction, due to its ability to analyze bone anatomy in the three views of the lateral mass. The scan effectiveness has 99% sensitivity and 100% specificity, compared to 36% and 52%, respectively, of the cervical radiographs (13, 14, 15, 16). Additionally, the use of contrast (computed tomography angiography (CTA)) allows to assess the potential compromise of the cervical vessels (vertebral artery), specifically in higher cervical injuries, fracture-dislocations, injuries involving the foramen transversarium and/or in patients with spinal and basilar symptoms (17, 18, 19).

Magnetic resonance imaging (MRI) enables the assessment of soft tissues, especially the vertebral disc, the ligaments and the neural structures (9).

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However, its role in the diagnostic algorithm of cervical spine facet fractures without evident displacement has not been completely clarified yet (20). Halliday *et al.* estimated the value of the cervical magnetic resonance to predict mechanical instability through the assessment of the integrity of structures such as the joint capsule, the interspinous ligament, and the anterior and posterior longitudinal ligaments. They also captured the failure of the nonoperative treatment in 9 out of 24 patients who presented injuries in at least three of these four structures (10). In a retrospective study involving 27 cases, Ha *et al.* reported 11 cases of patients with associated disc injury; however, they could not determine their connection with the outcome of the treatment (21). In an investigation carried out by the author who supports the following narrative review, 32 patients were evaluated retrospectively, and 6 cases of failure of the nonoperative treatment were informed. All of the cases reported an associated acute disc injury, regardless the type of fracture (22). In spite of the poor quality of the evidence available, it seems to be a tendency suggesting the usefulness of MRI in the assessment of potentially unstable injuries through direct visualization of the integrity of the vertebral disc and/or the ligament structures (Fig. 1) (9, 10, 12, 20, 22).

Classifications

Classifications can only be considered as valid if they are clinically relevant, reliable, and accurate (23).

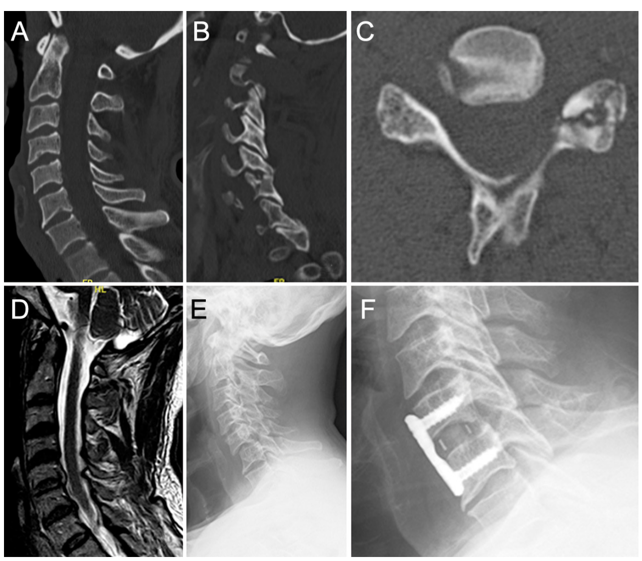

Figure 1

Case example (A–F): 55 years old man with a F2 C6 left facet fracture. (A) Cervical CT sagittal view without evidence of cervical listhesis. (B) Cervical CT sagittal view showing F2 fracture at C6. (C) Cervical CT axial view showing lateral mass fracture with comminution. (D) Evidence of C5–C6 acute disc injury on MRI (T2) sagittal view. (E) X-ray control at 3 weeks with evidence of C5–C6 progressive listhesis. (F) C5–C6 anterior cervical discectomy and fusion.

Although multiple classification systems of traumatic cervical fractures have been introduced in the literature, only a few of them have been evaluated to determine their effectiveness. While there is a predominant use of descriptive/anatomical classifications and/or classifications that analyze the injury mechanism, there is no benchmark as regards their treatment approach or prognosis. The development of classifications that categorize facet joint injuries has been even more infrequent.

It is estimated that the first classification of traumatic subaxial cervical spine injuries was published by Böhler in 1929 (24). In 1970, Holdsworth described an injury mechanism-based system following the observation of more than 2000 patients with traumatic vertebral injuries, without identifying their vertebral topography nor defining the injury stability (25). In 1982, Allen and Ferguson proposed a classification system that was also based on categorizing different fractures depending on their injury mechanism, which had scarce clinical relevance, substantial interobserver variability, no regard to facet joints and limited importance given to treatment approach (26).

It was not until 2005 that, in a retrospective study involving 31 patients who received surgical treatment due to fractures to the articular mass in the subaxial cervical spine, Kotani *et al.* proposed four subtypes of unstable fractures (separation of lateral mass, comminution fracture, split fracture, and traumatic spondylolisthesis) based on CT scans (27). However, this classification does not differentiate fractures according to their stability, does not set out any treatment criteria (nonoperative/surgical), and does not include all possible fracture patterns. In 2009, Lee *et al.* presented a new classification related to the previously proposed system, which was based on a retrospective study involving 31 cases of isolated fractures of the lateral mass in the subaxial cervical spine with rotational instability (29). The authors described six different fracture subtypes, adding two fracture subtypes to the ones already described: fractures in the articular processes with or without dislocation (28).

Meanwhile, in 2007, Vaccaro and the Spine Trauma Study Group published the Subaxial Cervical Spine Injury Classification System (SLIC) (29). This classification and scoring system measures injury severity on the basis of fracture morphology, neurologic status, and integrity of the discoligamentous complex and gives a final score that suggests the course of treatment. This system does not take into consideration the isolated fractures of the articular mass and its intrinsic severity.

During the last decade, Vaccaro *et al.* published the most currently disseminated system, the 'AO Spine Subaxial Cervical Spine Injury Classification System (SCICS)'. This system, just like its predecessor used for thoracolumbar fractures and proposed by the same group, includes the fracture morphology classification, the neurologic status, and the presence of clinical modifiers that may

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affect the treatment decision-making. However, the authors agree with the subaxial cervical topography, specifically with the classification of the facet joint fracture in four subtypes (F1–F4) (30). In order to classify facet joint injuries, they suggest that the following aspects should be considered: fracture displacement larger or smaller than 1 cm, percentage of compromise of the articular area of more or less than 40%, presence of a floating lateral mass, and evidence of displacement (subluxation/dislocation). It should be noted that the criteria that define the extent of the displacement and the percentage of facet joint involved in the fracture had been previously described by Spector *et al.* as predictive factors of nonoperative treatment failure in isolated cervical spine facet fractures (4).

While the latter system has demonstrated substantial inter- and intraobserver agreement, there is still inconsistency related to the terminology and interpretation of these injuries, which leads to a lack of standardization in the criteria related to the treatment of these injuries (8, 31).

Treatment

The common clinical context of cervical spine facet fractures usually involves care provided to patients with high-energy trauma. It is important to note that facet joint injuries might be overlooked and the associated severe nonvertebral injuries may have an impact in such inadvertence, especially in patients with multiple trauma (19, 32). In this context, the care provided at baseline should be multidisciplinary and follow the Advanced Trauma Life Support (ATLS) protocol. The clearance of the cervical spine injuries will be influenced by the initial responsiveness level of the patients (10, 33). The possibility to conduct a case history and a comprehensive physical exam might improve our level of clinical suspicion in the presence of midline cervical tenderness and/or neurological impairment. On the contrary, our course of action with unconscious patients will be guided exclusively by imaging, and CT is the test of choice to rule out cervical spine fractures and, in particular, those that involve the cervical facet joint.

The criteria of instability, whether evident or potential, of cervical traumatic injuries that have historically been described include compromised anterior and/or posterior tension bands, segmental kyphosis of more than 11°, vertebral displacement greater than 3.5 mm, and axial rotation of more than 11°. Many of these criteria were incorporated in scoring or classification systems over time (3, 29, 30, 34). For burst-type vertebral compression fractures, the magnitude of the collapse and its comminution are also relevant (29, 30). However, the above criteria are not sufficient to understand isolated and unilateral facet joint fractures without evident displacement. Retrospective studies that analyze the nonoperative treatment outcomes regarding this specific subtype of injury have shown mixed results. On one side, three series of unilateral

Table 1 Isolated cervical facet fracture literature.

Study	Country	SC/MC	Sample, *n*	Treatment, *n*	Failure rate, *n* (%)	Study design	Mean FU, months	Risk factors
Van Eck *et al.* (37)	USA	SC	74	CON	7 (9%)	RCS	9	Radiculopathy on admission; listhesis >2 mm (initial CT); high BMI; great fracture displacement
Vedantam *et al.* (35)	USA	SC	35	CON	6 (17%)	RCS	2.7	–
Halliday *et al.* (10)	USA	SC	24	CON: 12; SUR: 12	7 (58%)	RCS	NR	3 (25%) patients of nonsurgical group had posterior ligamentous injury.
Spector *et al.* (4)	USA	SC	24	CON	5 (20%)	RCS	88%: >3	Fracture involving >40% of the height of the lateral mass; >1 cm of the articular fragment fracture.
Lee and Sung (28)	Korea	SC	39	CON:15; SUR: 27	12 (80%)	RCS	18	NR
Pehler *et al.* (36)	USA	SC	88	CON: 67; SUR: 21	11 (16%)	RCS	14.1	Fracture involving >40% of the height of the lateral mass; >1 cm of the articular fragment fracture; weight >100 kg; comminution.
Awad *et al.* (39)	USA	SC	40	CON: 26; SUR: 14	–	RCS	6	Pedicular fracture with comminuted lateral mass.
Totera *et al.* (22)	Chile	SC	37	CON	6 (16%)	RCS	6	F2 or F3 with associated acute disc injury

CON, conservative; CT, computed tomography; FU, follow-up; MC, multicentric; NR, not reported; RCS, retrospective cohort study; SC, single center; SUR, surgery.

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nondisplaced or minimally displaced facet fractures reported a similar rate of nonoperative treatment failure, which ranged between 16.4% and 20% of the cases (35, 36, 37). On the other side, Aarabi *et al.* reported nonoperative treatment failures in 60% of the cases treated with orthosis or halo vest (in 9 out of 15 cases), which developed to progressive subluxation or kyphotic segmental deformity (38).

The risk factors related to the failure of the nonoperative treatment that have been described in the available literature include: comminution of the articular mass or facet joint, acute radiculopathy, high body mass index, spondylolisthesis of more than 2 mm, fragmental diastasis, acute injury of the disc, and bilateral fractures or fractures that adversely affect 40% of the height of the intact lateral mass or an absolute height of 1 cm (Table 1 and Fig. 2) (4, 29, 39).

A systematic review has been recently published, which analyzed the quality of the evidence available related to the treatment of isolated nondisplaced, or minimally displaced, facet joint fractures. Its main limitation is that it synthesizes data from only six retrospective studies based on small samples. The summary of this data suggests that patients who received surgical treatment had better results compared to those who received nonoperative treatment. However, two of these six studies included in the review involved patients with neurological deficit, ligamentous injury, or both, in almost all the cases. Therefore, they provide outliers which affect the synthesis of the data. When excluding the outliers from the analysis, the four remaining studies show consistent and equally successful results after the comparison of the nonoperative treatment and the surgical treatment, with success rates of >80% in both methods (6).

The authors' therapeutic algorithm

Based on the review of the available literature and the authors' experience, we propose a therapeutic algorithm for each type of injury, according to the AO Spine subaxial cervical spine injury classification system (Fig. 3) (30), to distinguish between the stable injuries and the potentially unstable ones to avoid complications (Fig. 4):

- F1: Stable injury, generally due to low-energy mechanisms and with predictable progression; the use of rigid collar for 4 weeks followed by a soft collar for 2 weeks is suggested, with radiographic follow-up after 2 and 6 weeks. The use of MRI in single injuries is not recommended, since in multiple studies these have demonstrated to be stable, even with associated soft tissue injuries. It is essential to differentiate this type of injury from the F2 injuries at baseline, putting emphasis on comminution and extension of the trace to the transverse process as key elements for diagnosis.
- F2: Injury with potential for instability, defined by its joint compromise and, in many cases, its associated comminution. It is recommended to dismiss a more

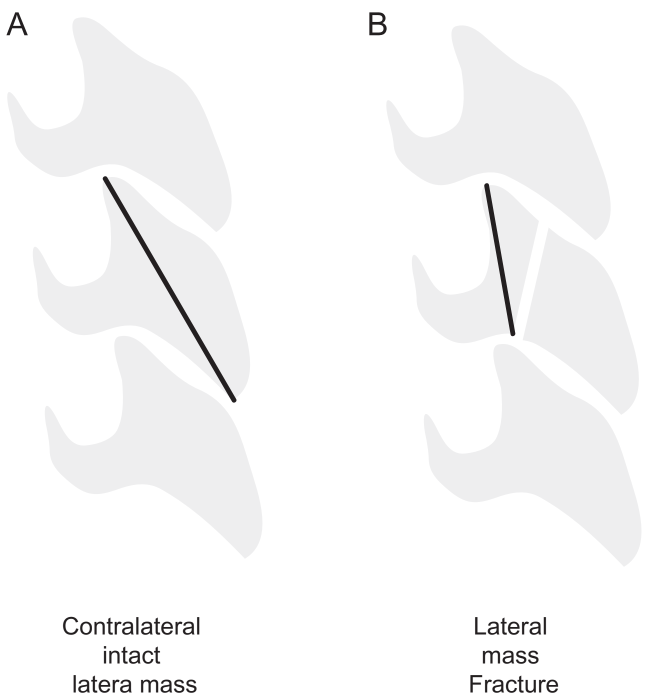

Figure 2

Measurement of the absolute height of the intact lateral mass and the fracture fragment according to Spector *et al.* (4) (A) The absolute height of the contralateral intact lateral mass was defined as the maximum cephalocaudal tip-to-tip height measured on sequential CT sagittal images; (B) The absolute height of the fracture fragment was defined as the maximum tip-to-tip cephalocaudal height measured on sequential sagittal CT images. The percentage of the absolute height of the fracture fragment related to the intact contralateral mass can be estimated: $(b/a) \times 100$.

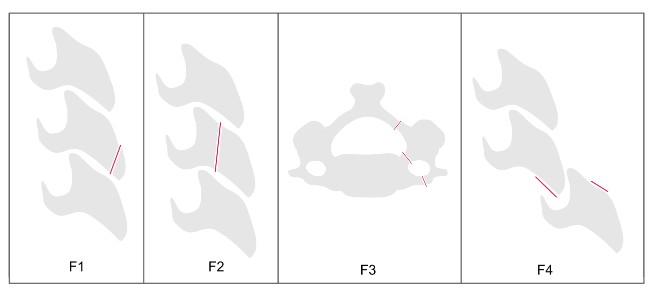

Figure 3

AO Spine cervical facet fracture classification. F1 is a nondisplaced facet fracture (either superior or inferior facets). Fracture fragments are smaller than 1 cm and comprise less than 40% of the lateral mass. F2 is a facet fracture with fragments either larger than 1 cm, comprise more than 40% of the lateral mass, or there are signs of displacement. F3 (floating lateral mass) is a disruption of the pedicle and lamina resulting in disconnection of superior and inferior articular processes at a given level or set of levels. F4 is a traumatic subluxation or perched/dislocated facet (30).

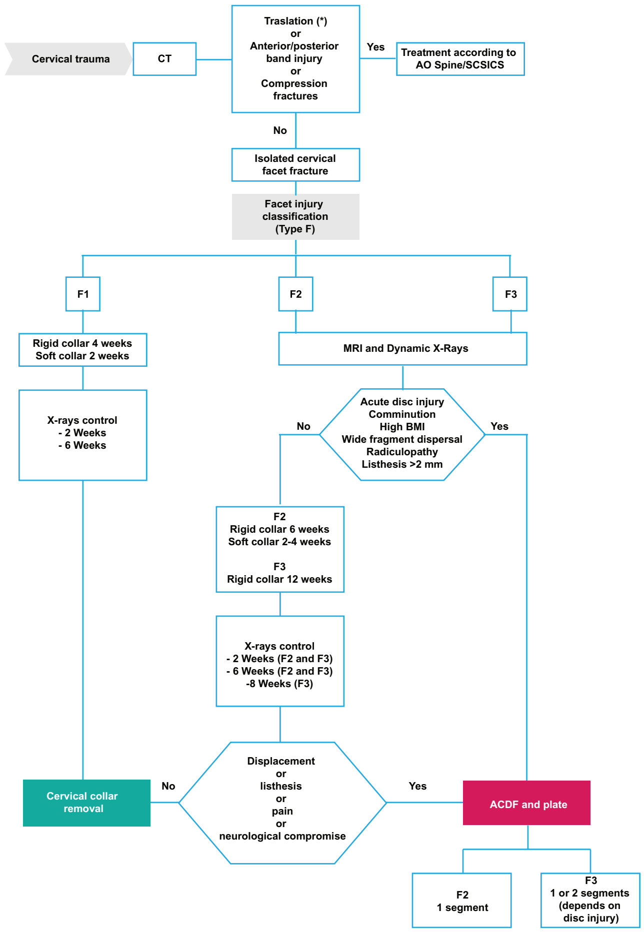

Figure 4

Treatment algorithm. SCSICS, Subaxial Cervical Spine Injury Classification System (30); ACDF, anterior cervical discectomy and fusion; CT, computed tomography; MRI, magnetic resonance imaging; BMI, body mass index. *Including F4 isolated facet fractures.

severe associated injury (fracture type B or C); therefore, its detection should never be minimized. Their treatment is mainly nonoperative, if no signs of instability exist, with the use of rigid collar for 6 weeks, followed by a soft collar for 2–4 weeks and radiographic follow-up after 2 and 6 weeks. If this treatment fails, anterior cervical arthrodesis in the compromised segment is recommended. The previously defined risk factors are key. The use of MRI from baseline and, when possible, manually guided extension and flexion x-ray, ideally performed by the surgeon itself, from the beginning may show the potential instability of the injury.

- F3: This is the most controversial and argued type of injury. The literature considers this type of fracture to be unstable and therefore of early surgical resolution; these fractures have reported up to 100% of nonoperative treatment failure. It is suggested to conduct an MRI to determine disc integrity as the primary stabilizer. When possible, controlled dynamic radiographs are also recommended. If the injury is stable and the disc is intact, nonoperative treatment is suggested with the use of rigid collar for 12 weeks and close monitoring. For unstable injuries and/or acute disc injuries, surgery and monosegmental or bisegmental arthrodesis is suggested, depending on the associated injuries.
- F4: In this type of injuries, subluxation or dislocation equal to a vertebral displacement and are categorized as type C fractures according to AO Spine classification; therefore, these should be treated as such, which is not in scope of this review's objective.

Conclusion

Articular mass or unilateral subaxial cervical spine facet fractures, whether these are nondisplaced or minimally displaced fractures, are a rare condition across the clinical spectrum of traumatic injuries of the cervical spine. In addition, the evidence available to set out a treatment is of low quality. Identifying injuries with potential of instability, and with the risk of nonoperative treatment failure, is still challenging, especially in relation to type F2 and F3 fractures according to the AO Spine classification. Considering the evidence available, it is suggested to carry out dynamic radiographs, ideally performed by the surgeon himself/herself, as well as CT with an MRI in order to determine a suitable diagnostic and treatment. The CT allows to recognize the diameter and the percentage of joint compromise, the displacement, the comminution, and possible vascular compromise (CTA). The MRI allows for the observation of associated injuries in the vertebral disc, the anterior/posterior tension bands, and the neural axis. Instability, whether evident or potential, is an indication for arthrodesis.

ICMJE Conflict of Interest Statement

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of this review.

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