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Research Article

Pattern and Radiographic Outcome of Subaxial Extension Injuries of The Cervical Spine: Case Series and Literature Review of The Current Treatment Approach

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Abstract

Motor vehicle accidents are a common cause of spine trauma. They are specifically associated with cervical spine fractures. Sub-axial facet fractures can present following the hyperextension mechanism and can also be associated with intervertebral disc injuries.

Post-injury loss of lordosis is a feared complication following these injuries. The treatment algorithm available in the literature is unclear as to whether to treat these cases surgically.

A retrospective case series was done on patients who presented to our institute with sub-axial extension Injuries of the cervical spine. The main reported outcome is post-operative sagittal alignment following the treatment modality used in our cases.

Hyperextension mechanism fractures were found in 40.47% (n = 22) of all patients, 19 of whom were hyperextension compression injuries, and 3 were hyperextension distraction injuries. Anterior cervical discectomy and instrumented fusion were shown to maintain post-operative sagittal alignment in all cases with extension injuries. External orthosis showed a 50% prevalence of progressive junctional kyphosis on follow-up.

Anterior cervical discectomy and instrumented fusion have been shown to provide excellent sagittal alignment restoration and maintenance on follow-up, while external orthosis showed a high rate of short-term post-operative junctional kyphosis.

Keywords: Radiographic; Subaxial; Injuries; Cervical Spine

Introduction

Road traffic accidents are considered one of the main causes of death in Saudi Arabia and around the World [1]. A retrospective study done in Saudi Arabia in 2020 showed that RTAs were the most common cause of traumatic spinal injuries accounting for 66.8% [2]. The same study also found a high association between RTAs and cervical spine injuries compared to other regions of the spine. While there are multiple classification systems in the literature used for the classification of sub-axial cervical spinal injuries and each has its advantages and disadvantages, extension-type injuries are a recognized entity in most classification systems [3,4]. They can present as extension compression injuries that affect the posterior element of the spine or extension distractive injuries that could lead to associated global instability of the spine due to the effect on the stabilising ligaments [5,6]. Hyperextension distraction injuries which are also referred to as hyperextension dislocations are known to cause rupture of the anterior longitudinal ligament and the intervertebral disc leading to translational or rotational forces that can further lead to compression of the spinal cord [6,7]. Hyperextension compression injuries range from isolated unilater-

al articular process fractures to the involvement of both articular processes or even lateral masses [6,7]. Facet fractures represent around 6.7% of all types of cervical spine fractures [8]. The mechanism that appears to be responsible for facet fractures is hyperextension combined with lateral bending and/or rotation, which may lead to disc disruption under tension and a fracture of the facet under compression with resultant rotational instability [9]. Management of extension injuries is controversial, especially in cases with unilateral non-displaced or minimally displaced fractures since most agree that cases with associated distractive injuries are surgical. It remains controversial whether any local kyphosis of the cervical spine is acceptable after cervical spine trauma [10]. In this study, we reviewed all cases of extension sub-axial cervical spine fractures assessed post-treatment sagittal alignment on follow-up of at least 6 months and reviewed the literature regarding the treatments available and outcomes reported.

Methods

A retrospective medical review of patients who presented to King Saud Medical City, which is a community-level I Trauma centre in the Riyadh region of the Kingdom of Saudi Arabia.

Patients included in this study are those who presented with facet joint and/or articular process injuries in the sub-axial cervical spine region from January 1st, 2017, to December 30th 2021. Cases were classified according to the mechanism of injury as follows; flexion compression, extension distraction, hyperextension compression, burst, and flexion distraction injuries (unilateral facet dislocation, and bilateral facet dislocations). The diagnosis was based on radiographic, computed tomography (CT), and magnetic resonance studies (MRI) reviewed by 2 spine surgeons and 2 board-certified orthopaedic surgeons.

Data that was collected included; age, gender, associated injuries, injury cause and mechanism, and surgical or non-surgical management. The subgroups of interest were studied as case series were hyperextension compression, and hyperextension distraction injuries with radiographic follow-up of at least 6 months as they are similarly presenting injuries due to the common extension mechanism and little strong evidence regarding the best treatment discussed in the literature. Further data included; fracture level and site, treatment type, Junctional sagittal Cobb angle after treatment, and at final follow-up. The junctional sagittal Cobb angle was measured above and below the injured articular process by the senior assessors (Illustration 1). The case series was illustrated in a separate table. A literature review was done using; PUBMED, EMBASE and Google Scholar databases with the following search keywords: Extension distraction injury to the cervical spine, articular process injury to the cervical spine, hyperextension injury to the cervical spine, and post-traumatic junctional kyphosis of the cervical spine, extension compression cervical spine injuries. Articles of interest are those that have included traumatic cases and elaborated on treatment modality options success based on radiographic outcome and are not associated with pre-existing degenerative pathologies that can be seen in central cord syndrome. The main aim of this study is to assess the pattern and radiographic outcomes of extension-type sub-axial cervical injuries and review the current literature to conclude the best current treatment approach and rationale for the less commonly discussed injuries and whether conservative or minimally invasive options are optimal at maintaining sagittal Cobb angle on follow-up.

Results

There were 54 patients with sub-axial cervical spine injuries included in the study, 11.11% (n = 6) were female and 88.89% (n = 48) were male patients. The average age at presentation of all cases was found to be 37.3 years (SD = 14.45). There were 47 (87.04%) cases which presented with an isolated cervical spine fracture and all extension distraction injuries were presented in isolation. (Table 1).

Injury Type	Male: Female	Age (years) Mean (SD)	Isolated: polytrauma
Flexion compression	7: 0	29.8 (6.70)	5: 2
Extension distraction	2: 1	49.07 (25.73)	3: 0
Hyperextension compression	17: 2	32.20 (10.87)	18 :1
Burst	2: 0	30.70 (4.89)	1: 1
Unilateral dislocation	8: 2	40.1 (17.54)	9: 1
Bilateral Dislocation	12: 1	44.55 (13.46)	11:2

Table 1: Demographic data of all subaxial cervical spine injuries reviewed with their injury mechanism.

Hyperextension mechanism fractures were found in 40.47% (n = 22) of all patients, 19 of whom were hyperextension compression injuries, and 3 were hyperextension distraction injuries. Non-surgical management was used in 17 patients, and all were in the hyperextension compression group. Overall mortality was found to be 14.81% (N = 8) in this study population, 5 of which were in the bilateral facet dislocation group. Road traffic accidents were the cause of injury in 49 patients (90.74%) while ground-level fall was the cause of injury in two patients and fall from a height of more than 1 meter caused 3 fractures. (Table 2)

Cause of Facet Injury (Total = 54)		Surgical N (%)	Non-surgicalal N (%)	Mortality N (%)	Injury Cause N (%)		
					RTA	Ground fall	Fall fromheight
Flexion compression7 (12.96%)	N = 7 (100%)		-	2 (28.57%)	7 (100%)	-	-
Extension distraction3 (5.56%)	N = 3 (100%)		-	-	3 (100%)	-	-
Hyperextension compression 19 (35.19%)	N = 2 (10.53%)		17(89.47%)		17 (89.47%)	-	2 (10.53%)
Burst (3.70%)	N = 2 (100%)		-	1 (50%)	2 (100%)	-	-
Flexion Distraction Injuries 23 (42.59%)	Unilateral dislocation N = 10 (18.52%)	10 (100%)	-	-	8 (80%)	1 (10%)	1 (10%)
	Bilateral Facet Dislocation N=13 (24.07%)	13 (100%)	-	5 (38.46%)	12(92.31%)	1 (7.69%)	-

Table 2: Summary of patient groups with treatment used, mortality, and injury cause.

22 patients were found to have extension injury mechanisms, 19 of which were followed for at least 6 months duration after treatment. Patients 1 through 16 had hyperextension compression injuries that caused articular process fractures. Patients 17 through 19 presented with extension distraction injuries that led to intervertebral disc injury with associated articular process fracture. Of all cases treated, there were 2 (12.5%), 4 (25%), and 10 (62.5%) managed with anterior cervical discectomy and interbody fusion, Halo immobilisation, and semirigid orthosis (Philadelphia C-collar), respectively. All patients who presented with extension distraction injuries were managed with anterior cervical discectomy and interbody fusion. Of all cases that underwent anterior cervical discectomy and interbody fusion (total = 5 patients) only 1 (20%) of which had a kyphotic segment immediately following treatment and at the final follow-up (patient 17). Of patients who were managed with Halo vest immobilization, only one patient's articular process fracture was the only indication for this treatment and was the only patient among this treatment group who had kyphotic segment alignment at the final follow-up (patient 5). Of patients who were managed with C-collar, 50% (n = 5) presented with a kyphotic segment at the final follow-up (cases 7, 9, 13, 14, and 16). Cases 13 and 16 had concomitant lamina fractures.

Case	Gender	Side	Injured Level	Associated injury	Treatment	Cobb Angle at Treatment	Cobb Angle at Final follow-up
1	Male	Left	C2,3,4 inferior articularprocess	-	ACDF	16 Lordosis	15 Lordosis (12 months)
2	Male	Right	C3 superior articularprocess	-	Collar	9 Lordosis	10 Lordosis (9 months)
3	Male	Left	C6 Superior articularprocess	Odontoid Base	Halo	1 Kyphosis	3.2 Kyphosis(6 months)
4	Male	Left	C7 superior articularprocess	C2 Vertebral body	Halo	5.70 Lordosis	8.80 Lordosis(9 months)
5	Male	Right	C3 superior articularprocess		Halo	9.9 lordosis	12.9 Kyphosis(9 months)
6	Male	Right	C3 Inferior articular process	Right C3 Pedicle andLamina	Halo	7.8 Kyphosis	15 Lordosis (6 months)
7	Male	Right	C5 Superior articular process C4 Inferior articularprocess	-	Collar	3 lordosis	0.7 Kyphosis(6 months)
8	Male	Right	C4 inferior articular process	Right C4 Pedicle andlamina	ACDF	3 Lordosis	8 Lordosis (9 months)
9	Male	Right	C5 Superior Articularprocess	-	Collar	11.5 Kyphosis	15.86 Kyphosis (6 months)
10	Female	Right	C5 inferior articular process	-	Collar	7 Lordosis	5.5 Lordosis (6 months)
11	Female	Right	C6 inferior articular process	-	Collar	4.5 Kyphosis	5.6 Lordosis(6 months)
12	Male	Right	C6 Superior Articularprocess	-	Collar	15.90 Lordosis	15.6 Lordosis(9 months)
13	Male	Right	C6 Inferior articular process	C6 bilateral lamina	Collar	10.30 kyphosis	11.5 Kyphosis(18 months)

14	Male	left	C7 superior articularprocess	-	Collar	5.90 kyphosis	10.83 Kyphosis (9 months)
15	Male	left	C7 superior articularprocess	-	Collar	12.80 Lordosis	7.2 Lordosis(6 months)
16	Male	Right	C6 inferior articular process	C6 Right Lamina	Collar	10.3 Kyphosis	11.5 Kyphosis(6 months)
18	Male	Left	C5 inferior articular process	C5-C6 Disc	ACDF	4.5 Lordosis	3.9 Lordosis(9 months)
19	Female	Right	C7 superior articularprocess	C6-7 Disc	ACDF	10.6 lordosis	5.6 Lordosis(9 months)

Table 3: Demonstrates the cases that presented with Extension mechanism injuries with their corresponding demographics, fracture characteristics, and segmental sagittal Cobb's angle.

Discussion

Hyperextension fractures of the sub-axial cervical spine are uncommon presenting injuries compared to others but more likely to cause nerve root involvement compared to anterior column fractures [8]. While severe injuries are known to be surgical, isolated articular process fractures are controversial about the best treatment options [11]. It has been reported that non-surgically treated cases with associated facet joint injury are prone to progressive junctional kyphosis [9,12]. Range of motion especially, flexion is increased following articular process injury with the profound global increase in range of motion following a concomitant disc transaction in cadaveric spine specimens [13,14]. This leads us to investigate the possible correlation between junctional kyphosis following extension-caused sub-axial spine fractures especially, in conservatively treated cases.

Dvorak et al. found that non-surgically treated fractures involving articular process injuries showed a worse clinical outcome compared to surgically treated cases despite the majority being isolated articular process fractures [11]. Totera., *et al*. found a high rate of treatment failure in cases which had an associated intervertebral disc involvement in their series. Also, they found that conservative management was successful in isolated non-displaced articular process fractures and proposed that MRI should be requested in patients with articular process fractures to rule out associated distractive injury to the intervertebral disc [15]. MRI is usually requested in our institute to rule out any associated distractive injury and to delineate soft tissue injury.

All cases which had associated disc injuries were managed surgically, as well as a case which had multiple contagious articular process fractures and a case that was associated with pedicle and lamina fractures. Progressive junctional kyphosis was found in 50% of non-surgically treated isolated non-displaced articular process fractures. We believe that the injury caused facet joint capsule disruption which led to junctional angulation in the patients who had junctional kyphosis on follow-up.

Anterior cervical procedures possess less risk of complications compared to posterior-based procedures in the cervical spine [16]. Moreover, they are known to better restore existing kyphosis intraoperatively by way of intervertebral space distraction, however, maintaining postoperative sagittal alignment on follow-up is in favour of posterior instrumented procedures [17]. In our centre, whenever facet joints are reduced, an anterior-based procedure is typically utilized since it carries less risk of wound complications compared to posterior-based procedures and from the data we reviewed, it has shown sustainable maintenance of sagittal alignment post-operatively.

Limitations

Our study was a short-term follow-up of Subaxial Extension Injuries of The Cervical so we are unsure if this finding is going to be a risk factor for cervical myelopathy in the long-term follow-up. Future studies could focus more on the long-term outcomes following treatment of extension cervical injuries as there is still no consensus to solidify one treatment over the other when it comes to functional outcomes.

Conclusion

Anterior cervical discectomy and instrumented fusion have been shown to provide excellent sagittal alignment restoration and maintenance on follow-up, while external orthosis showed a high rate of short-term post-operative junctional kyphosis.

What is already known on this topic

Anterior cervical discectomy and instrumented fusion have been shown to provide excellent sagittal alignment restoration and maintenance on follow-up, while external orthosis showed a high rate of short-term post-operative junctional kyphosis.

What this study adds

Anterior cervical discectomy and instrumented fusion have been shown to provide excellent sagittal alignment restoration and

maintenance on follow-up, while external orthosis showed a high rate of short-term post-operative junctional kyphosis.

Competing Interest

There are no conflicts of interest.

Authors Contributions

- **Ibrahim Fahad AlShugair:** Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work.
- **Bander S Alrashedan:** Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work.
- **Hussain AlKaff:** Final approval of the version to be published.
- **Elham AlGhamdi:** Final approval of the version to be published.
- **Mohammad O. Alawad:** Drafting the work or reviewing it critically for important intellectual content.
- **Nasser Alenazi:** Drafting the work or reviewing it critically for important intellectual content.
- **Abdelelah A Alenazi:** Drafting the work or reviewing it critically for important intellectual content.
- **Hamed Aljohani:** Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.
- **Saad AlSurur:** Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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