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An Analysis of Patient and Fracture Characteristics and Clinical Outcomes in Patients With Hyperostotic Spine Fractures

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Abstract

Study Design: Retrospective study.

Objective: To evaluate outcomes and complications following operative and nonoperative management of hyperostotic spine fractures.

Methods: Patients presenting between 2008 and 2017 to a single level 1 trauma center with hyperostotic spine fractures had their information and fracture characteristics reviewed. Bivariate analyses were conducted to compare patients across a number of characteristics and outcomes. Multivariate logistic regression models for complication and mortality were done in a stepwise fashion.

Results: Sixty-five ankylosing spondylitis (AS) or diffuse idiopathic skeletal hyperostosis (DISH) patients with a spine fracture met our inclusion criteria. DISH was slightly more prevalent (55% vs 45%). Overall delayed diagnosis, reoperation, mortality (at 1 year), and complication rates were high at 32%, 13%, 23%, and 57%, respectively. In multivariate logistic regression models, patients undergoing operative management had significantly increased odds of having a complication (odds ratio [OR] = 23.03, 95% confidence interval [CI] = 2.24-236.45, P = .008), while increasing age was associated with increased odds of death (OR = 1.18, 95% CI = 1.06-1.31, P = .003).

Conclusions: Patients with AS or DISH who fracture their spine are at high risk of complication and death. However, neither operative nor nonoperative treatment increases the odds of mortality. This study helps add to a growing, but still limited, body of literature on the characteristics of patients with spine fractures in the setting of AS or DISH.

Keywords

fracture, hyperostotic spine, ankylosing spondylitis, diffuse idiopathic skeletal hyperostosis, outcomes

Introduction

Two disorders cause hyperostotic spines ("stiff spines"): ankylosing spondylitis (AS) and diffuse idiopathic skeletal hyperostosis (DISH). A rheumatologic disease, AS falls within the diagnostic entity of axial spondyloarthritis,[1] which has an estimated prevalence of 0.9% to 1.4% in the US population.[2] AS is also commonly associated with the HLA-B27 antigen.[3] In contrast, while the etiology of DISH remains unknown, the clinical presentation is well known, including back pain and spinal stiffness associated with radiographic evidence of ossification along the anterolateral margins of 4 contiguous vertebrae.[4]

Awareness of DISH has recently increased as related comorbidities are being reported.[5] While the causes of AS and DISH differ, both conditions are associated with a substantial spinal

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fracture risk.[6,7] Indeed, fractures occurring in the setting of these disorders are associated with significantly greater morbidity and mortality than patients without these conditions.[7,8]

Over recent years, that has been a growing interest in better understanding the natural history of "stiff spine fractures," as well as outcomes following operative and nonoperative treatment, when indicated. However, likely due to the relative rarity of the conditions, there is limited research on the topic. In one retrospective study, Caron et al found that patients with spine fractures in the setting of AS or DISH had a high risk for complications and death.[8] In another study, Teunissen et al found that the incidence of spinal cord injury (SCI) was high in patients with spine fractures in the setting of AS or DISH.[9] Because of the limited research on this topic, especially when it comes to comparing fractures at different spine levels (eg, cervical vs thoracic vs lumbar), additional research is warranted to try to further understand risk factors for complications, reoperation, and mortality.

The primary purpose of this study was to evaluate both patient and spine fracture characteristics in patients with AS or DISH. Our secondary analyses were the following: (1) to compare outcomes (delayed diagnosis, reoperation, mortality [at 1 year], complications) between patients with AS and those with DISH, between patients with a neurologic injury and those without, between patients undergoing operative management and those undergoing nonoperative management, and among patients based on spine fracture location; (2) to compare patient and spine fracture characteristics between those with a complication and those without a complication, as well as those that expired within 1 year of fracture and those who did not; and (3) to determine patient and spine fracture characteristics that are associated with increased odds of complication or mortality.

Methods

Patient Sample

This study was reviewed and approved by the appropriate institutional review board.

Between 2008 and 2017, patients presenting to a single level 1 trauma center with spine fractures were considered for inclusion in this study. We narrowed our patient sample by including only patients with spine fractures who also had a diagnosis of AS or DISH. The diagnosis of AS or DISH was determined using each patient's medical record and was confirmed by reviewing patient imaging with 1 of 3 attending spine surgeons. Continuous characteristics recorded included age (in years) and body mass index (BMI). Categorical variables recorded included sex (male or female), race (white, black, or other), comorbidities listed in the patient's electronic medical record (0, 1, or ≥2), cause of spine fracture (ground-level fall, fall from height, motor vehicle collision, other), spine level(s) fractured (cervical, thoracic, lumbar, cervical-thoracic, thoracic-lumbar), SCI (yes or no), and if SCI present, ASIA (American Spinal Injury Association) grade.

Statistical Analysis

Descriptive characteristics were reported. Bivariate analyses were conducted at initial presentation to compare the following: (1) patients with AS versus patients with DISH; (2) patients with a neurologic injury versus those without a neurologic injury; (3) patients undergoing operative management versus those undergoing nonoperative management; (4) the rate of delayed diagnosis, reoperation, mortality (at 1 year), and complications in patients with AS versus those with DISH; (5) the rate of delayed diagnosis, reoperation, mortality (at 1 year), and complications based on spine fracture location; (6) the rate of delayed diagnosis, reoperation, mortality (at 1 year), and complications based on the presence of neurologic injury; (7) patient and spine fracture characteristics between those who had a complication and those who did not; and (8) patient and spine fracture characteristics between those who expired and those who did not. Chi-square tests were used to compare categorical variables across groups unless a cell had a frequency of less than 5; in such cases, Fisher's exact tests were used.[10] For continuous variables, *t* tests were used. In the multivariate logistic regression models for complication and mortality, only variables significant at the $P < .10$ level were included. This stepwise approach has been used previously in the literature.[11] Significance for final results was set at $P < .05$ a priori.

Results

A total of 65 patients with a spine fracture in the setting of confirmed AS or DISH met our inclusion criteria (Table 1). A large majority were white (91%), male (82%), and had 2 or more comorbidities (69%; Table 1). The average age was 70 years (range = 39-96 years), and average BMI was 31 (range = 19-53; Table 1). Slightly more patients had DISH compared to AS (55% vs 45%; Table 1). Nearly half of the patients (48%) fractured their spine from a ground-level fall, and over half of patients had fractures in the thoracic region (54%; Table 1). A total of 19 patients (29%) had an SCI (Table 1). There was no significant difference in any patient or fracture characteristic between those with AS compared with those with DISH (Table 2). There was a significant difference in spine fracture location when comparing patients with and without an SCI, with a larger percentage of patients with SCI having a cervical spine fracture (47% vs 15%, $P = .02$; Table 3). In addition, all patients with an SCI underwent operative management. A significantly greater percentage of patients undergoing nonoperative management did not have an SCI (100% vs 63%, $P = .006$; Table 4).

Over half of all patients experienced at least one complication, with an overall complication rate of 57% (Table 5). In the intraoperative and perioperative timeframes, pulmonary complications were the most common (intraoperative: 43% of all intraoperative complications; perioperative: 26% of all perioperative complications; Table 6). In the postoperative timeframe, the most common complication was "other," which most commonly encompassed persistent pain (33% of all

Table 1. Patient and Spine Fracture Characteristics (n = 65).

Characteristic	
Age, years; mean (range)	70 (39-96)
Sex, n (%)	
Male	53 (82)
Female	12 (18)
Race, n (%)	
White	59 (91)
Black	4 (6.2)
Other	2 (3.1)
Body mass index; mean (range)	31 (19-53)
Comorbidities, n (%)	
0	2 (3.1)
1	18 (28)
≥2	45 (69)
Spine disorder, n (%)	
Ankylosing spondylitis	29 (45)
DISH	36 (55)
Cause of spine fracture, n (%)	
Ground-level fall	31 (48)
Fall from height	11 (17)
Motor vehicle collision	16 (25)
Other	7 (11)
Spine level(s) fractured, n (%)	
Cervical	16 (25)
Thoracic	35 (54)
Lumbar	5 (7.7)
Cervical-thoracic	7 (11)
Thoracic-lumbar	2 (3.1)
Presenting ASIA grade, n (%)	
A	8 (12)
B	3 (4.6)
C	2 (3.1)
D	6 (9.2)
E	46 (71)
Spinal cord injury, n (%)	
Yes	19 (29)
No	46 (71)

Abbreviations: DISH, diffuse idiopathic skeletal hyperostosis; ASIA, American Spinal Injury Association.

Table 2. A Comparison of Patient and Spine Fracture Characteristics by Diagnosis.

Characteristic	AS (n = 29)	DISH (n = 36)	P
Age, years; mean (range)	67 (39-96)	72 (47-92)	.12
Sex, n (%)			.20
Male	26 (90)	27 (75)	
Female	3 (10)	9 (25)	
Race, n (%)			.44
White	28 (97)	31 (86)	
Black	1 (3.5)	3 (8.3)	
Other	—	2 (5.6)	
Body mass index; mean (range)	31 (19-41)	31 (20-53)	.99
Comorbidities, n (%)			.89
0	1 (3.5)	1 (2.9)	
1	7 (24)	11 (31)	
≥2	21 (72)	24 (67)	
Treatment			.65
Operative	22 (76)	29 (81)	
Nonoperative	7 (24)	7 (19)	
Cause of spine fracture, n (%)			.43
Ground-level fall	16 (55)	15 (42)	
Fall from height	6 (21)	5 (14)	
Motor vehicle collision	5 (17)	11 (31)	
Other	2 (6.9)	5 (14)	
Spine level(s) fractured, n (%)			.34
Cervical	10 (34)	6 (17)	
Thoracic	12 (41)	23 (64)	
Lumbar	3 (10)	2 (5.6)	
Cervical-thoracic	3 (10)	4 (11)	
Thoracic-lumbar	1 (3.5)	1 (2.8)	
Presenting ASIA grade, n (%)			.69
A	4 (14)	4 (11)	
B	—	3 (8.3)	
C	1 (3.5)	1 (2.8)	
D	3 (10)	3 (8.3)	
E	21 (72)	25 (69)	
Spinal cord injury, n (%)			.79
Yes	8 (28)	11 (31)	
No	21 (72)	25 (69)	

Abbreviations: AS, ankylosing spondylitis; DISH, diffuse idiopathic skeletal hyperostosis; ASIA, American Spinal Injury Association.

postoperative complications; Table 6). During the perioperative and postoperative timeframes, the same number of patients expired (n = 7 in each timeframe; Table 6). Nearly one quarter (23%) of all patients with AS or DISH presenting with a spine fracture expired within 1 year (Table 5). A total of 7 patients (13%) required reoperation (Table 5). There was a delayed diagnosis in 32% of patients (Table 5). Of note, there was no significant difference in the rate of delayed diagnosis by spine level (cervical, no delay vs delay: 27% vs 19%; thoracic, no delay vs delay: 50% vs 62%; lumbar, no delay vs delay: 4.5% vs 14%; multiple spine levels, no delay vs delay: 18% vs 4.8%; $P = .24$), nor was there a significant difference in the rate of delayed diagnosis based on whether or not a patient had a SCI (no SCI, no delay vs delay: 68% vs 76%; SCI, no delay vs delay: 32% vs 24%; $P = .51$). There was no significant difference in delayed diagnosis, reoperation, mortality (at 1 year), and overall complications between patients with AS compared with those with DISH (Table 5). Additionally, there was no significant difference in delayed diagnosis ($P = .24$) or reoperation rate ($P = .26$) based on spine fracture location (Table 7). However, a significantly higher percentage of patients with a cervical spine fracture expired at 1 year compared with the percentage of patients with fractures at other spine levels ($P = .005$; Table 7). Furthermore, a significantly higher percentage of patients with a cervical or thoracic spine fracture had a complication compared with patients with fractures at other spine levels ($P = .004$; Table 7).

In bivariate analysis, the distribution of spine fracture location differed significantly between those with a complication and those without a complication, with a greater percentage of patients with cervical (38% vs 7.1%) or multiple level (19% vs 7.1%) fractures having a complication ($P < .01$; Table 8). In addition, a significantly larger percentage of patients with SCI

Table 3. A Comparison of Patient and Spine Fracture Characteristics by Presence of Spinal Cord Injury (SCI).

Characteristic	SCI (n = 19)	No SCI (n = 46)	P
Age (years), n (%)	66 (39-84)	72 (44-96)	.11
Sex, n (%)			.08
Male	13 (68)	40 (90)	
Female	6 (32)	6 (13)	
Race, n (%)			.79
White	17 (89)	42 (91)	
Black	1 (5.3)	3 (6.5)	
Other	1 (5.3)	1 (2.2)	
Body mass index; mean (range)	33 (20-53)	31 (19-51)	.25
Comorbidities, n (%)			.42
0	—	2 (4.4)	
1	7 (37)	11 (24)	
≥2	12 (63)	33 (72)	
Treatment			.006
Operative	19 (100)	32 (70)	
Nonoperative	—	14 (30)	
Cause of spine fracture, n (%)			.49
Ground-level fall	12 (63)	19 (41)	
Fall from height	2 (11)	9 (20)	
Motor vehicle collision	4 (21)	12 (26)	
Other	1 (5.3)	6 (13)	
Spine level(s) fractured, n (%)			.02
Cervical	9 (47)	7 (15)	
Thoracic	10 (53)	25 (54)	
Lumbar	—	5 (11)	
Cervical-thoracic	—	7 (15)	
Thoracic-lumbar	—	2 (4.4)	

Table 4. A Comparison of Patient and Spine Fracture Characteristics by Treatment Type.

Characteristic	Operative (n = 51)	Nonoperative (n = 14)	P
Age, years; mean (range)	70 (39-96)	74 (51-92)	.19
Sex, n (%)			.99
Male	41 (80)	12 (86)	
Female	10 (20)	2 (14)	
Race, n (%)			.74
White	45 (88)	14 (100)	
Black	4 (7.8)	—	
Other	2 (3.9)	—	
Body mass index; mean (range)	31 (19-53)	31 (21-40)	.82
Comorbidities, n (%)			.70
0	2 (3.9)	—	
1	13 (25)	5 (36)	
≥2	36 (71)	9 (64)	
Spine disorder, n (%)			.65
Ankylosing spondylitis	22 (43)	7 (50)	
DISH	29 (57)	7 (50)	
Cause of spine fracture, n (%)			.43
Ground-level fall	24 (47)	7 (50)	
Fall from height	9 (18)	2 (14)	
Motor vehicle collision	14 (27)	2 (14)	
Other	4 (7.8)	3 (21)	
Spine level(s) fractured, n (%)			.09
Cervical	13 (25)	3 (21)	
Thoracic	29 (57)	6 (43)	
Lumbar	3 (5.9)	2 (14)	
Cervical-thoracic	6 (12)	1 (7.1)	
Thoracic-lumbar	—	2 (14)	
Presenting ASIA grade, n (%)			.17
A	8 (16)	—	
B	3 (5.9)	—	
C	2 (3.9)	—	
D	6 (12)	—	
E	32 (63)	14 (100)[a]	
Spinal cord injury, n (%)			.006
Yes	19 (37)	—	
No	32 (63)	14 (100)	

Abbreviations: DISH, diffuse idiopathic skeletal hyperostosis; ASIA, American Spinal Injury Association; SCI, spinal cord injury.
[a]Two of these patients presented without an SCI; however, they then exhibited a worsening exam and ultimately required surgery.

had a complication than did not (41% vs 14%, P = .03; Table 8). Furthermore, a significantly larger percentage of patients undergoing operative management had a complication compared with those undergoing operative management and not having a complication (92% vs 61%, P = .005; Table 8).

In bivariate analysis, patients who were older (79 years vs 67 years, P = .002) and had a lower BMI (28 vs 32, P = .02) were more likely to die (Table 9). The distribution of spine fracture location differed significantly between those who expired and those who did not expire, with a greater percentage of patients with a cervical spine fracture expiring (53% vs 16%, P = .01; Table 9).

In the complications multivariable logistic regression model, patients undergoing operative management had significantly increased odds of having a complication (odds ratio [OR] = 23.03, 95% confidence interval [CI] = 2.24-236.45, P = .008), while patients with spine fractures in the thoracic region had decreased odds of having a complication (OR = 0.03, 95% CI = 0.0028-0.41, P = .008; Table 10). In the mortality multivariable logistic regression model, increasing age was associated with increased odds of death (OR = 1.18, 95% CI = 1.06-1.31, P = .003), while patients with spine fracture in the thoracic region had decreased odds of death (OR = 0.02, 95% CI = 0.001-0.23, P = .002; Table 10).

Table 5. A Comparison of Patient Complications by Diagnosis.

Outcome, n (%)	All (n = 65)	AS (n = 29)	DISH (n = 36)	P
Delayed diagnosis	21 (32)	13 (45)	7 (22)	.05
Reoperation	7 (13)	4 (57)	3 (43)	.34
Mortality (at 1 year)	15 (23)	8 (53)	7 (47)	.44
Complications	37 (57)	17 (46)	20 (54)	.80

Abbreviations: AS, ankylosing spondylitis; DISH, diffuse idiopathic skeletal hyperostosis.

Example of Surgical Management

An example of a patient surgically managed is seen in Figure 1. In our study, cervical hyperextension fractures were

Table 6. An Illustration of the Complications by Timeframe.[a]

Complication Type	Intraoperative, n (%)	Perioperative (0-90 Days), n (%)	Postoperative (>90 Days to Latest Office Follow-up), n (%)
Pulmonary	3 (43)	18 (26)	3 (11)
Cardiac/ cardiovascular	1 (14)	12 (17)	1 (3.7)
Neurological	1 (14)	9 (13)	3 (11)
Instrumentation failure	1 (14)		
Surgical site infection		6 (8.6)	2 (7.4)
Urinary tract infection		9 (13)	
Dysphagia		2 (2.9)	1 (3.7)
Sepsis		3 (4.3)	
Altered mental status		4 (5.7)	
Small bowel obstruction			1 (3.7)
Other (eg, persistent pain)			9 (33)
Mortality	1 (14)	7 (10)	7 (26)
Total	7 (100)	70 (100)	27 (100)

[a]Note the total number of complications portrayed in this table is greater than denoted in Table 3; this is because we report all complications here, while Table 3 reports patients with at least one complication.

Table 7. A Comparison of Patient Complications by Spine Fracture Location.

Outcome, n (%)	All (n = 65)	Cervical (n = 16)	Thoracic (n = 35)	Lumbar (n = 5)	Multiple (n = 9)	P
Delayed diagnosis	21 (32)	4 (19)	13 (62)	3 (14)	1 (4.8)	.24
Reoperation	7 (13)	3 (43)	2 (29)	—	2 (29)	.26
Mortality (at 1 year)	15 (23)	8 (53)	3 (20)	1 (6.7)	3 (20)	.005
Complications	37 (57)	14 (38)	14 (38)	2 (5.4)	7 (19)	.004

predominantly managed with a posterior spinal fusion typically spanning 3 levels above and below the fracture level. Thoracic and lumbar fractures were managed via posterior spinal fusion with instrumentation spanning 3 levels above and below the fracture. Over the study period the senior author has transitioned to using percutaneous instrumentation for the management of thoracic and lumbar hyperostotic fractures.

Example of Nonoperative Management

In our sample, 14 patients (22%) were treated nonoperatively at the discretion of the attending spine surgeon. All of them presented without neurological deficits (ie, ASIA E). The decision not offer surgery was at the discretion of the attending spine surgeon and predominantly based on significant patient comorbidities that made the patient at high risk of not being extubated or not tolerating general anesthesia. Of the 14 patients treated

Table 8. A Comparison of Patient and Spine Fracture Characteristics, Complication Versus No Complication.

Characteristic	Complication (n = 37)	No Complication (n = 28)	P
Age, years; mean (range)	69 (39-96)	71 (44-92)	.63
Sex, n (%)			.91
Male	30 (81)	23 (82)	
Female	7 (19)	5 (18)	
Race, n (%)			.82
White	33 (89)	26 (93)	
Black	3 (8.1)	1 (3.6)	
Other	1 (2.7)	1 (3.6)	
Body mass index; mean (range)	30 (19-53)	32 (21-40)	.28
Comorbidities, n (%)			.79
0	1 (2.7)	1 (3.6)	
1	9 (24)	9 (32)	
≥2	27 (73)	18 (64)	
Spine disorder, n (%)			.80
Ankylosing spondylitis	17 (46)	12 (43)	
DISH	20 (54)	16 (57)	
Cause of spine fracture, n (%)			.43
Ground-level fall	20 (54)	11 (39)	
Fall from height	6 (16)	5 (18)	
Motor vehicle collision	9 (24)	7 (25)	
Other	2 (5.4)	5 (18)	
Spine level(s) fractured, n (%)			<.01
Cervical	14 (38)	2 (7.1)	
Thoracic	14 (38)	21 (75)	
Lumbar	2 (5.4)	3 (11)	
Multiple	7 (19)	2 (7.1)	
Spinal cord injury			.03
Yes	15 (41)	4 (14)	
No	22 (59)	24 (86)	
Management			.005
Operative	34 (92)	17 (61)	
Nonoperative	3 (8.1)	11 (39)	

Abbreviations: DISH, diffuse idiopathic skeletal hyperostosis.

nonoperatively, 2 patients (14%) expired within 1 year and 3 patients (21%) treated nonoperatively had complications. An example of a patient nonoperatively managed is seen in Figure 2.

Discussion

While there is increasing interest in better understanding clinical outcomes of patients with hyperostotic spine fractures due to AS or DISH, there remains limited research in the area. In our study of 65 patients, we found that there was no difference in any patient or spine fracture characteristic between patients with AS compared with those with DISH. The overall complication rate was 57%, while mortality at 1 year was 23%. A delayed diagnosis occurred in 32% of patient cases. Patients undergoing operative management had increased odds of having a complication, while older patients had increased odds of death at 1 year. Patients with a thoracic spine fracture had decreased odds of complication and mortality.

Table 9. A Comparison of Patient and Spine Fracture Characteristics, Deceased Versus Alive at 1 Year.

Characteristic	Deceased (n = 15)	Alive (n = 50)	P
Age, years; mean (range)	79 (64-96)	67 (39-92)	.002
Sex, n (%)			.99
Male	12 (80)	41 (82)	
Female	3 (20)	9 (18)	
Race, n (%)			.40
White	14 (93)	45 (90)	
Black	—	4 (8.0)	
Other	1 (6.7)	1 (2.0)	
Body mass index; mean (range)	28 (19-37)	32 (21-53)	.02
Comorbidities, n (%)			.28
0	—	2 (4.0)	
1	2 (13)	16 (32)	
≥2	13 (87)	32 (64)	
Spine disorder, n (%)			.56
Ankylosing spondylitis	8 (53)	21 (42)	
DISH	7 (47)	29 (58)	
Cause of spine fracture, n (%)			.92
Ground-level fall	8 (53)	23 (46)	
Fall from height	2 (13)	9 (18)	
Motor vehicle collision	3 (20)	13 (26)	
Other	2 (13)	5 (10)	
Spine level(s) fractured, n (%)			.01
Cervical	8 (53)	8 (16)	
Thoracic	3 (20)	32 (64)	
Lumbar	1 (6.7)	3 (8.0)	
Multiple	3 (20)	6 (12)	
Spinal cord injury			.99
Yes	4 (27)	15 (30)	
No	11 (73)	35 (70)	
Management			.49
Operative	13 (87)	38 (76)	
Nonoperative	2 (13)	12 (24)	

Abbreviations: DISH, diffuse idiopathic skeletal hyperostosis.

Table 10. Factors Independently Associated With Outcomes of Interest (Complications, Mortality).

Model 1: Characteristics With $P < .10$ in Bivariate Analysis With Complications		
Pseudo R^2	0.33	
Characteristic	OR (95% CI)	P
Operative management	23.03 (2.24-236.45)	.008
Spinal cord injury	2.41 (0.53-10.92)	.25
Spine level fractured		
Cervical	Ref	
Thoracic	0.03 (0.0028-0.41)	.008
Lumbar	0.084 (0.0037-1.89)	.12
Multiple	0.92 (0.062-13.46)	.95

Model 2: Characteristics With $P < .10$ in Bivariate Analysis With Mortality		
Pseudo R^2	0.42	
Characteristic	OR (95% CI)	P
Age	1.18 (1.06-1.31)	.003
Body mass index	0.87 (0.74-1.03)	.11
Spine level fractured		
Cervical	Ref	
Thoracic	0.02 (0.001-0.23)	.002
Lumbar	0.07 (0.002-1.81)	.11
Multiple	0.16 (0.02-1.40)	.10

Our findings must be evaluated with the study limitations in mind. First, all patients are from a single institution. Our institution is an urban, level 1 trauma, academic medical center; thus, our findings may not be generalizable to dissimilar centers. A multicenter, prospective trial would offer more robust insight. Second, there may be selection bias as we are reporting the results of treatment chosen by the attending surgeon at the time of admission, and different treatment choices may have influenced the outcome. Third, our patient sample is relatively small (n = 65). However, a number of previous studies evaluating AS and DISH patient outcomes have reported fewer patients.[12-16] Nonetheless, a larger sample size would be preferred, as it would have allowed us to better determine the impact of specific comorbidities or other patient factors on outcomes. Ultimately, we believe our work captures information previously underreported in the literature. Fourth, our dataset does not include specific insight into reasons behind delayed diagnosis, an important and persistent problem encountered in such clinic scenarios. A prospective study is warranted to better determine exactly what factors may lead to delayed diagnosis. Last, we did not measure patient-reported outcome measures for all patients due to the length of the study period, as well as the lack of preoperative patient-reported outcome measures for most patients.

In our study, we found no difference in any patient or fracture characteristic between patients with AS compared with those with DISH. Similarly, previous work by Teunissen et al found no difference in baseline patient and fracture characteristics based on whether patients had a spine fracture in the setting of AS or DISH.[9] In addition, Schoenfeld et al also report that baseline patient and fracture characteristics did not significantly differ based on whether a patient had a spine fracture in the setting of AS or DISH.[17] Furthermore, Teunissen et al similarly found that there is no difference in complication rate based on whether patients have a spine fracture in the setting of AS or DISH.[9] When we analyzed patient mortality at 1 year, we did not find a significant difference based on AS or DISH diagnosis. This is consistent with the work done by Teunissen et al[9] but in contrast to Schoenfeld et al, who found that the mortality rate was significantly higher at the 1-year timeframe in patients with AS.[17] We believe the difference seen in the Schoenfeld et al study may be do the smaller sample size of that study (n = 43).[17] A prospective, multicenter study may help confirm whether there truly is or is not a difference in complication or mortality rates based on AS or DISH diagnosis.

Determining factors associated with complications and death can help surgeons in their discussions with patients and
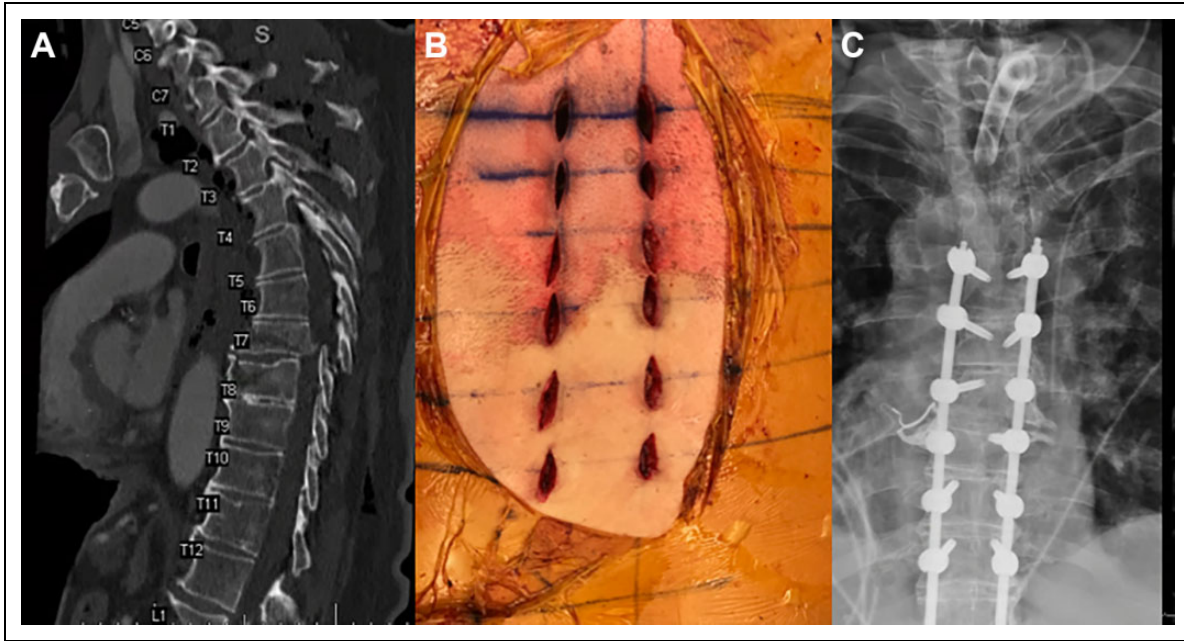
Figure 1. A 73-year-old male struck by a vehicle while riding his bicycle and sustaining a T7-T8 hyperextension fracture. The patient was ASIA B on presentation. He had significant skin abrasions and pulmonary injury requiring a chest tube. (A) Sagittal CT of the thoracic spine demonstrates the hyperextension fracture. (B) The patient was managed with percutaneous instrumentation from T5 to T10. At latest follow-up, AP (C) radiograph of the thoracic spine demonstrates intact instrumentation and alignment. Courtesy of Dr. Mesfin.
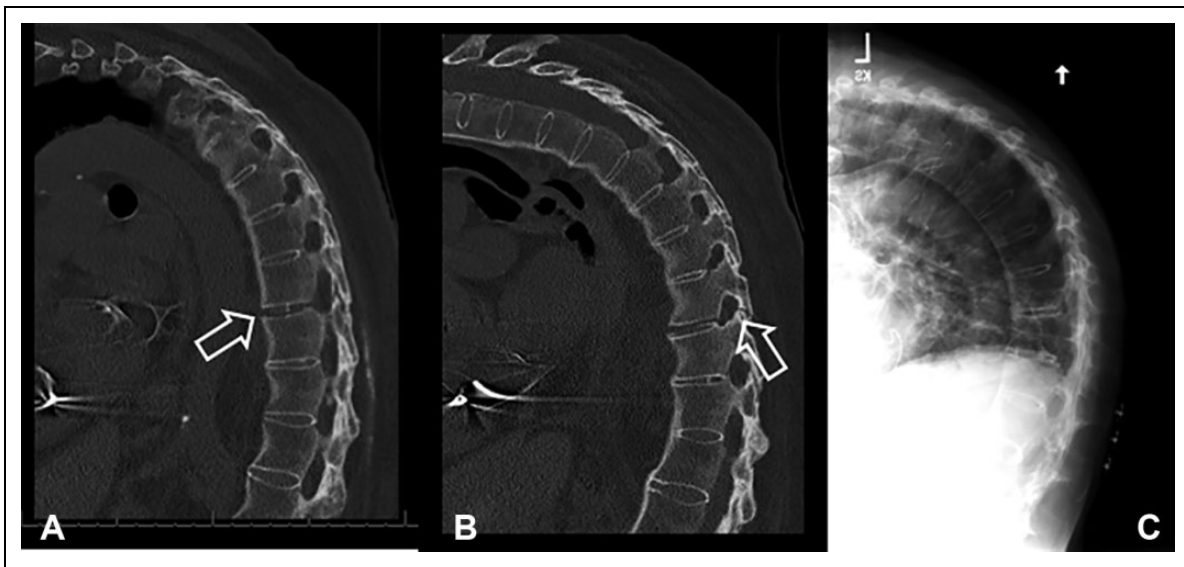
Figure 2. A 82-year-old female sustained a ground-level fall. She sustained a right pneumothorax, as well as a hemothorax. She is on Xarelto for atrial fibrillation and has a history of cardiomyopathy with an ejection fraction of 25%. (A, B) Sagittal CT demonstrating a 3-column T11 hyperextension fracture (open arrows). The patient was neurologically intact. Due to her comorbidities and concerns regarding her ability to withstand general anesthesia, she was treated with a Rotorest bed for 3 weeks then transitioned to a TLSO for 3 months. (C) Lateral radiograph of the thoracic spine at 7 months following nonoperative treatment demonstrating intact alignment and fracture healing. Courtesy of Dr. Mesfin.

family members about outcome expectations. In the current study, we found a significantly higher percentage of cervical spine fractures in the setting of AS or DISH associated with both clinical outcomes. Similarly, previous work using the Nationwide Inpatient Sample by Wysham et al found that patients with cervical spine fractures in the setting of AS had

a significantly higher mortality rate.[18] In another study utilizing Nationwide Inpatient Sample, Kurucan et al found a significant association between cervical spine fractures managed operatively in patients with AS and pulmonary complications.[19] However, in the multivariable logistic regression analysis, we found that patients with a thoracic spine fracture in the setting

of AS or DISH had decreased odds of having a complication or dying from the event within 1 year; the other spine regions did not show such an association. While the location of the spine fracture is not a modifiable risk factor, we believe that, in general, surgeons should keep in mind that certain fracture locations may be more prone to worse outcomes and counsel patients and family members accordingly. The same issue occurs in age; as the patient's age increases, the odds of death increase as well by 18% for each year. Similar to fracture location, this is an unmodifiable risk factor but should be taken into account by surgeons when counseling patients and families.

In addition to fracture location, we also found that a significantly higher percentage of patients undergoing operative management sustained a complication. This was confirmed in our multivariable logistic regression as an independent risk factor for increased odds of a complication. However, it is important to note that while we did not see a significantly higher rate of SCI in patients who expired; of those that did expire, 27% had an SCI.

One of the challenging elements of managing spine fractures in patients with AS or DISH is determining whether operative or nonoperative management is warranted. In our study sample, all of our patients treated nonoperatively (n = 14) had no neurological deficit. Hyperostotic spine fractures are inherently unstable and often require operative stabilization. However, in instances where the patient is too ill to tolerate general anesthesia, the senior author's practice is to manage the patients with immobilization with a brace and bed rest. This is well tolerated in thoracic-level injuries as opposed to cervical-level injuries. Most of the patients with thoracic and/or lumbar hyperostotic fractures were treated with a brace and healed uneventfully. In some instances, the fracture did not propagate to the posterior elements. Initially, patients were managed in a continuous rotation bed (RotoRest) for 1 to 2 weeks and then transitioned to a thoracic lumbar sacral orthosis (TLSO) brace. However, the RotoRest bed can be poorly tolerated in patients with thoracic hyperkyphosis; thus, in these situations, the patient is in bed rest for 2 weeks before starting to ambulate with a TLSO. We believe there is a role for select patients with thoracic and/or lumbar hyperostotic fractures without neurological deficits to be managed nonoperatively. The patient's comorbidities, risk of surgery, and patient compliance with immobilization must be taken into account.

Conclusion

This study helps add to a growing, but still limited, body of literature on the characteristics of patients with spine fractures in the setting of AS or DISH. However, future research is needed to better understand differences in outcomes that may be seen based on spine fracture location, as our sample size—while large on the whole compared with previous literature on this topic—remained too small by spine fracture location to conduct robust subanalyses. Overall, we quantified clinical outcomes, showing that the overall delayed diagnosis, reoperation, mortality (at 1 year), and complication rates are high at 32%, 13%, 23%, and 57%, respectively. Last, we found that the risk factors most associated with increased or decreased odds of complications and mortality were unmodifiable prior to having a fracture; thus, our findings are most valuable in assisting surgeons in having open and honest discussions with patients and their families about expected clinical outcomes.

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