Medical and Research Publications
International Open Access

Research Article **Journal of MAR Orthopedics (Volume 4 Issue 2)**

Lower Lumbar Spine Fractures; Functional and Radiological Prospective Review. An Experience of Academic Centre from Saudi Arabia.

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Received Date: September 26, 2022

Published Date: October 05, 2022

Abstract

Objectives To investigate both clinical and radiological outcomes of burst fractures in the lower lumbar spine. The secondary objective is to investigate the long-term effect on lumbar lordosis and pelvic parameters.

Design Prospective review.

Setting Level one trauma and academic center.

Participants 15 patients.

Interventions Conservative and surgical management.

Outcome measures Functional and radiological evaluation.

***Results**: Fifteen patients were included in the study with a minimal follow-up of five years, with a median age of 32 years. Ten patients were managed conservatively, and five patients were treated surgically. In the conservative group, the vertebral kyphotic angle at initial and follow up were 8□(0-13) and 5□(2-17) respectively, while the lateral Cobb angle was 11□(7-16) and 6.5□(2-14) at initial and follow up. In the surgically treated patients, the vertebral kyphotic angle was 15□(12-34) at initial and 6□(3-17) at follow-up. The initial anterior vertebral body height loss in conservative and surgical groups is 16% (10- 27) and 63% (43-80), respectively. At follow-up, no significant loss of correction in both treatment groups.*

***Conclusions**: There is no significant difference in the long-term functional and radiological outcomes between patients with lower lumbar fractures managed by conservative or surgical intervention. Neither group had significant long-term changes regarding lumbar lordosis and pelvic parameters.*

***Key Words:** Lumbar spine, spine fracture, Oswestry Disability Index, Short Form-36, outcome, Saudi Arabia.*

Introduction

Traumatic spinal injuries usually cause severe impacts on individuals and society and affect the healthcare system, quality of life, and economic burden on the healthcare system 1. The global incidence of spine fractures is 10.5 per 100,000 people worldwide2.

Burst fracture of the Lower lumbar spine is extremely rare, with an incidence of approximately 1% of all spine fractures 3,4. Unlike thoracolumbar spine fractures, the lower lumbar spine uncommonly presented with severe kyphotic deformity5. Indeed, many lower lumbar spine anatomic characteristics contribute to its low incidence. The vertebral body and intervertebral discs increase in size caudally to support the upper body axial loading. Wedging of vertebral bodies and intervertebral discs in the lower lumbar spine contributes significantly to lumbar lordosis6. Iliolumbar ligaments are strong and resist various movements, especially flexion and extension7.

There is no classification for the lower lumbar spine, no clear indications for surgical interventions, and no treatment guidelines; the consensus is kyphosis > 25 degrees, loss of anterior vertebral height > 50%, evidence of instability or neurological injury warranted surgical intervention3. All available information in the literature is not conclusive, and surgeons' clinical judgment usually determines management strategy. There were neither recent publications on fractures of the lower lumbar spine nor the local report of such injury.

The purpose of this study is to report both clinical and radiological outcomes of burst fractures in the lower lumbar spine with a long-term follow-up. Our secondary objective is to investigate the long-term effect of this injury over lumbar lordosis and pelvic parameters.

Methods

The study was conducted in a level one trauma and academic teaching hospital; The study was approved by the Institutional Review Board of Imam Abdulrahman Bin Faisal University (No. IRB-UGS-2020-01-411).

We retrospectively reviewed the hospital electronic Database (Quadramed) and Operative Theatre logbook of patients admitted with lumbar spine fractures between 2005 and 2016.

The inclusion criteria were patients with a burst fracture of the lower lumbar spine (L3-L5), all age groups, and minimal follow-up of five years. We excluded upper lumbar spine fractures (L1, L2),

multiple non-contiguous vertebral fractures, and isolated transverse fractures. Pathological fractures and spine deformities such as scoliosis or spondylolisthesis were also excluded.

A total of 306 patients with lumbar spine fractures were identified over the study period, 56 duplications, and 187 patients did not meet the inclusion criteria. Sixty-three patients with lower lumbar spine fractures (L3-L5) were identified, 40 patients were living in another province and could not attend final follow-up, seven patients declined to participate, and 15 patients agreed to participate in the study. Patient's demographic data such as sex and age at the time of injury, mechanism of injury, level of vertebral fracture, associated injuries, and mode of treatment; conservative and operative management were retrieved.

Fifteen patients were scheduled in the outpatient clinic for clinical and radiological evaluation by a spine surgeon. Upon arrival, the participants signed written consent, and were asked to answer two questionnaires; a validated Arabic version of the Oswestry Disability Index (ODI)8 questionnaire and Short-form 36 (SF-36)9.

Participants were evaluated by a spine surgeon and open-ended questions such as pre-injury working status, return to work, post-injury job modifications, or change of job. The radiological evaluation consists of standing lumbar spine posterio-anterior and lateral view; no CT scan was requested at follow-up. All patients had initial CT scans and were used to classify the vertebral fracture according to the AO classifications10 and to measure canal compromise at mid axial images of the fractured vertebra 11. The Initial, immediate post-treatment and final follow-up radiographs were evaluated. The following radiological parameters were measured, the Vertebral Kyphotic angle(VKA), Lateral Cobbe Angle (LCA), and the percentage loss of anterior vertebral Body Height (AVBH) and the lumbar lordosis11. Pelvic parameters such as Pelvic Incidence (PI), Sacral Slope (SS), Pelvic Tilt (PT) 12 were all measured on standing radiographs at post-treatment and final follow-up. Data were extracted, coded, and exported to Prism 9 (GraphPad Software, San Diego, California, USA).

Patients and public involvement.

Patients and the public were not involved in the design or conduct of this study.

Statistical analysis

We used the Shapiro-Wilk test to determine the normality of the continuous data. The mean and the standard deviation are used for the normally distributed data. In contrast, the median and the interquartile range (IQR) are used in non-normally distributed data. Categorical data are presented as absolute values with frequencies or percentages. The Mann-Whitney test is used to detect any significance between conservative and operative groups in terms of functional outcome and return to work. Wilcoxon rank-sum test was used to evaluate the overall change in the radiological outcomes regardless of the mode of treatment. A P-value < 0.05 was considered statistically significant.

Results

All patients were males, and the median age was 32 years. The motor vehicle accident was the most common cause in 12 patients (80%), two patients (13.3%) had spine fractures after falling from a height, and one patient (6.7%) sustained fractures due to sport-related injury (Table 1).

A total of 20 burst fractures [10 (20%) A3.1, 1 (5%) A3.2, 9 (45%) A3.3] identified . Single vertebral fracture in ten patients (66.6%) and five patients (33.4%) had multiple lumbar vertebral fractures, 8 (40%) in L3, 10(50%) involved L4, and 2 (10%) involved L5 (Table1). All multiple vertebral fractures were at L3 and L4.

Ten patients (66.6%) had conservative treatment by custom molded Thoraco-lumbar brace with thigh extension with immediate mobilization, and bracing was for 10-12 weeks. Five (33.4%) patients underwent surgical management, and the indications were either severe cancel compromise combined with neurological deficit or loss of AVBH more than 40%. Four patients (80%) have posterior fixation by short-segment pedicle screws and fusion. One patient (20%) underwent anterior corpectomy, anterior cage, and plate fixation due to neurological injury with a canal compromise of 96%; no postoperative bracing was applied. Two patients (13.3%) had initial incomplete neurological injuries at initial presentation that required decompression, three patients (20%) have associated injuries (Table 1). There were no worsening of neurology or postoperative complications. All patients showed solid fusion at the final follow-up, and none underwent hardware removal.

Patient Characteristics	
Total number of patients	15
Sex	M: F = 1:0
Age; years (median, IQR)	32(17-47)
Single vertebral fracture	10 (66.6%)
Multiple vertebral fractures	5 (33.4%)
Lumbar Spine Fracture	Total 20
L3	8 (40%)
L4	10 (50%)
L5	2 (10%)
Mechanism of Injury	
Motor vehicle accident (MVA)	12 (80%)
Fall from Height	2(13.3%)
Sport	1(6.7%)
Associated Injury	
None	12(80%)
Pelvic fracture	1 (10%)
CNS involvement	1 (10%)
Upper limb fracture	1 (10%)
Treatment	
Conservative	10 (70%)
Surgery	5 (30%)

Table 1: Patient's Characteristics, Mechanisms of injury, Associated injuries, and Treatment.

Radiological outcomes

In the conservative group, the median VKA at initial presentation and follow-up was 8□ (0-13) and 5□ (2-17), respectively. VKA at Post-treatment and Final follow-up radiographs showed no significant changes with a P-Value of 0.76 (Figure 1). In the surgically treated patients, the median VKA was 15□ (12-34) at initial presentation and was 6□ (3-17) final follow up; however, this change was not statistically significant with a P-value of 0.18. VKA in surgically treated patients at Post-treatment and Final follow-up radiographs showed no significant differences with a P-Value of 0.43 (Figure 2). The median AVBH loss at initial presentation in the conservative group was 16% (10- 27), while for the surgical group was 63% (43-80), which is statistically significant.The median percentage of canal compromise in both conservative and operative groups were 0% (0-10) and 43% (39-96), respectively, which was also statistically significant (Table 2).

No consequential loss of AVBH was observed (Figure 3). In the surgical group, the AVBH improved from 63% (43-80) to 16% (10-20) and was 19% (13-23%) at final follow up; changes between initial and post-treatment and between post-treatment and last follow up were not statistically significant (Figure 4). The LCA in the conservative group was 11□ (7-16) and 6.5□ (2-14) at initial and follow-up, respectively, which was statistically significant with a P-value of 0.01. In the surgical group, the LCA at initial presentation was 16□ (10-25) and was 5º (0-12) at follow-up, which is not statistically significant; P-value of 0.1. There was no significant change in all pelvic parameters in conservative and operative groups at follow-up. (Table 3).

Radiological Parameters (Median, IQR)	Conservative	Surgery	P-Value
% AVBH loss	16% (10-27)	63% (43-80)	0.0007
% CC	0% (0-10)	43% (39-96)	0.0003

Table 2: Initial Percentage of Anterior Vertebral Body Height (AVBH) loss and Canal Compromise (CC); Conservative and Surgical group; Mann-Whitney Test.

	Conservative			Operative		
Radiological Parameters (median, IQR)	Initial	Follow up	P-value	Initial	Follow up	P-value
Lumbar Lordosis	47° (29-65)	41° (21-57)	0.2322	43° (32-52)	47° (35-53)	>0.9999
Pelvic Incidence	50° (35-77)	52° (37-65)	0.8223	61° (35-67)	50° (38-60)	0.3125
Sacral Slope	31° (9-55)	31° (12-51)	0.5781	31° (8-41)	31° (10-44)	0.7500
Pelvic Title	14° (7-27)	13° (5-25)	0.7168	11° (8-21)	13° (4-18)	>0.9999

Table 3: Radiological Parameters of Conservative and Operative Group at Initial Presentation, and Final Follow-Up; Wilcoxon Test.

Functional outcomes

At follow-up, the overall median ODI and SF-36 were 20 and 50, respectively; the median ODI for the conservative group was 17.5 while it was 20.0 in the operative group. SF 36 is conservative, and operative groups were 53 and 44, respectively. There was no significant difference between conservative and operative groups regarding functional outcome at follow-up (Table 4).

Functional Scale (Median, IQR)	Conservative	Surgery	P-Value
ODI %	18 (0-46)	20 (13-36)	0.7445
SF-36	53 (32-95)	44 (29-81)	0.5135

Table 4: Functional Outcome at Final Follow-up both Conservative and Surgical group; Mann-Whitney Test.

Return to work and Job Modification

Out of 15 patients interviewed, nine patients (60%) were employed at the injury time. One patient (11.1%) changed their job, three patients (33.4%) modified their duties, five patients (55.5%) had no job changes. The median return-to-work time is three months (2–4 months), with no statistical significance between conservative and operative groups with a P-value of > 0.99. The remaining six patients (40%) at the time of follow-up, four patients (66.7%) were still unemployed because they are persuading higher studies, two patients (33.3%) had to change their carrier choice due to their spine injury.

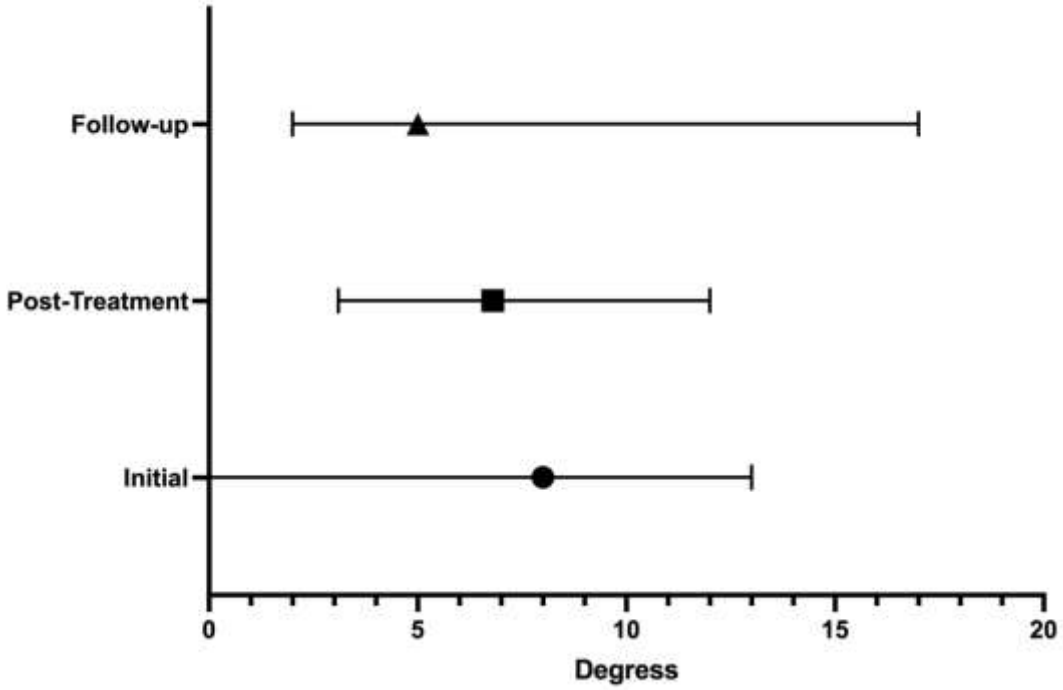

Figure 1: Vertebral Kyphotic Angle, Conservative group at Initial, Post-Treatment, and Follow-up; Median / Interquartile Range.

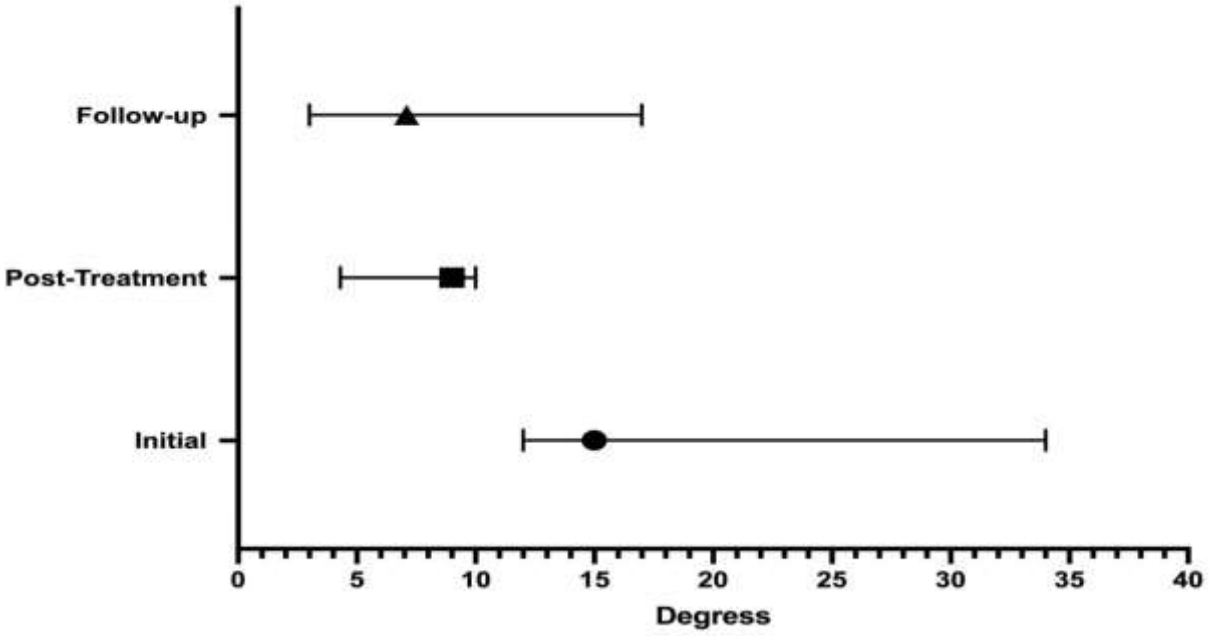

Figure 2: Vertebral Kyphotic Angle, Surgical Group at Initial, Post-Treatment, and Follow-up; Median / Interquartile Range.

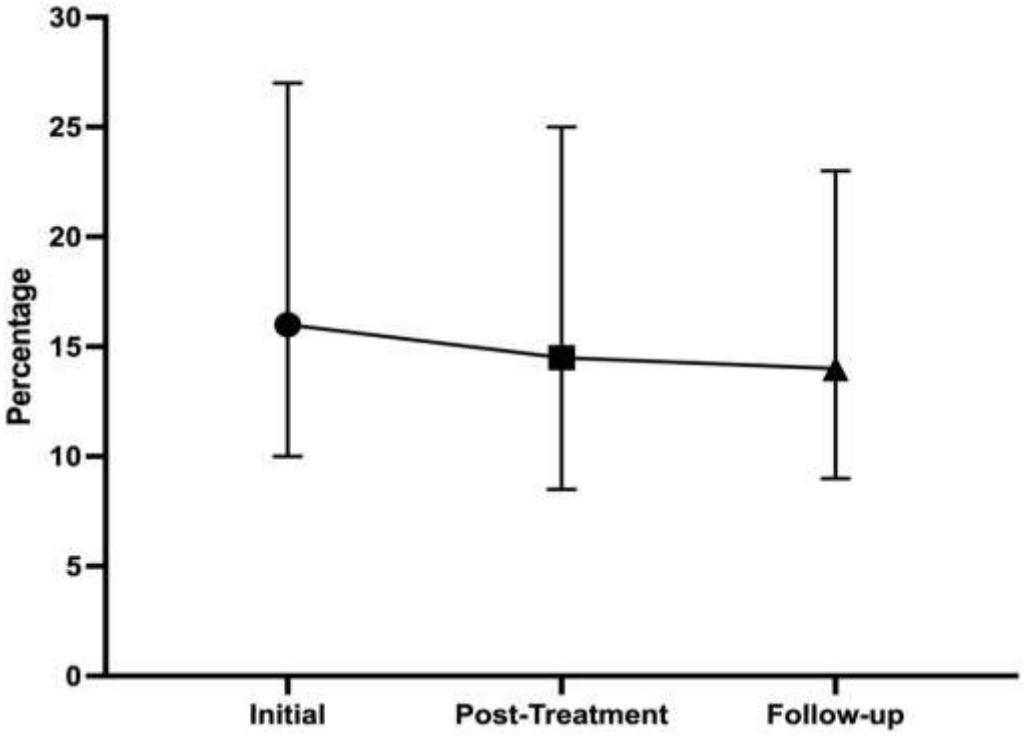

Figure 3: Anterior Vertebral Height loss, Conservative group at Initial, Post-Treatment, and Follow-up; Median / Interquartile Range.

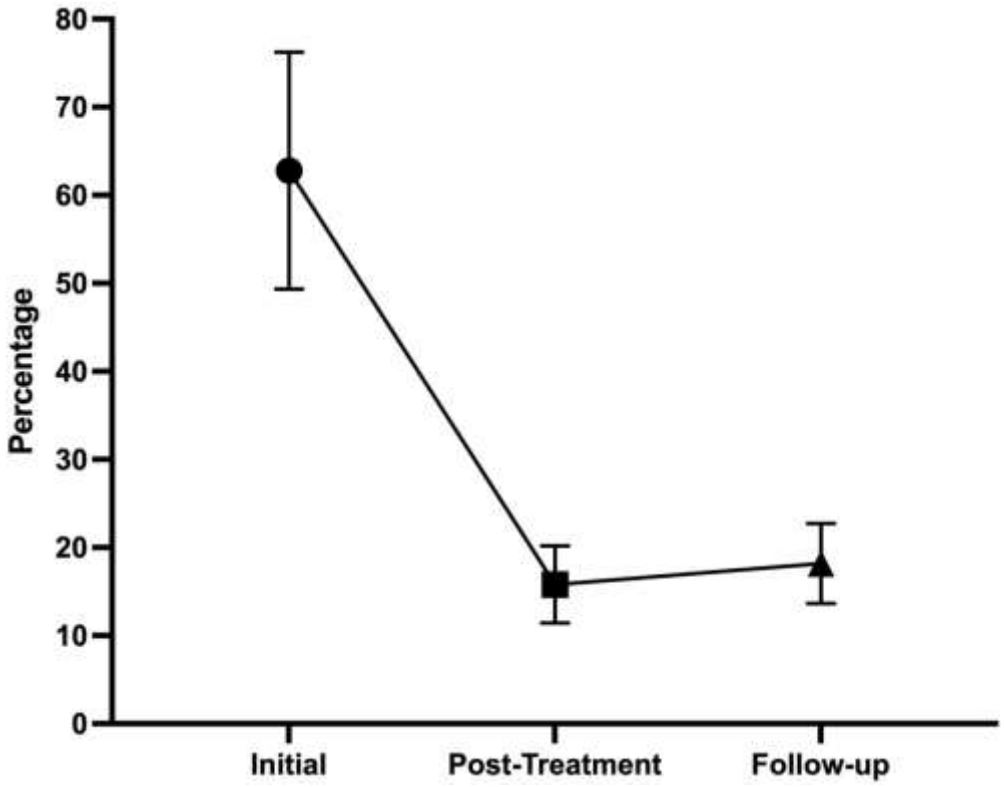

Figure 4: Anterior Vertebral Height loss, Surgical Group at Initial, Post-Treatment, and Follow-up; Median / Interquartile Range.

Discussion

Burst fractures in the Lower lumbar spine are rare injuries, accounting for 1% of spine fractures3,4. Major trauma such as motor vehicle accidents and falls from height are the most common causes 3,4,13,14, combat-related injuries of the lower lumbar spine have been reported 15.

Burst fracture usually results from axial loading and flexion, affecting anterior and middle columns. Contrary to the thoracolumbar region, the center of gravity falls through or posterior to the vertebral body. A flexion movement distributes the axial compression evenly across the vertebral body15, making severe kyphotic deformity uncommon5.

The lower lumbar spine has unique anatomic and biomechanical characteristics. The vertebral body increases in size progressively in the caudal direction, in which L5 has the largest vertebral body that allows a more remarkable ability to absorb axial forces and support upper body weight. Anterior vertebral height progressively increases in a caudal direction leading to a trapezoid shape of the L5

vertebral body. The Intervertebral disc contributes significantly to the overall biomechanical role of the lumbar spine; the anterior disc height is twice higher than the posterior height, which contributes considerably to overall lordosis6. Iliolumbar ligaments play an essential role in the stability of the lumbosacral junction; it connects the fourth and fifth lumbar vertebras to the posterior part of the ilium and has been shown in an experimental study that it restricts flexion, extension, and lateral bending 7. Anatomical location plays a significant role; L5 is situated below the pelvic brim, which adds more stability 13.

The spinal canal in the lower lumbar spine is larger than the thoracolumbar region and increased in size in a caudal direction, and L5 had the widest spine canal in the vertebral column 16. Although no direct relationship exists between the degree of neurological deficit and the percentage of canal compromise at the time of injury 13, 90% canal compromise has been written without neurological injuries17. Neurological damage commonly presented as a nerve root lesion which had a favorable prognosis16, furthermore, a 40-50% post-traumatic spine canal remodeling has been reported at one year18.

There is no classification system for lower lumbar spine fractures, although most surgeons use the classification proposed by Denise 19. The Thoracolumbar Injury Classification and Score(TLICS), developed for the thoracolumbar spine 20, has three components; fracture morphology, neurological status, and clinical modifiers in which, when combined, will formulate management strategy. The TLICS has been investigated in the lower lumbar spine fractures and showed fair reliability 21. A concomitant pelvic ring injury should not be underestimated. An isolated transverse process fracture in the lower lumbar spine, especially in L5, should draw attention to the possibility of pelvic spine dissociation22, which mandates a different treatment strategy23. We electively used AO spine classification, which is more descriptive, and the scoring within the category represents the severity.

There are no clear guidelines and indications of surgery in lower lumbar spine fractures; however, the consensus is kyphosis > 25 degrees, loss of vertebral height > 50%, evidence of instability or neurological injury warranted surgical intervention3.

Conservative treatment had been recommended in neurologically intact patients, especially in isolated fractures of L5 14,17,24. In a systemic review of publications over 30 years of lower lumbar spine fractures by Schouten et al. 25, 13 publications were included; all were retrospective case studies. Six studies compared conservative and surgically treated patients. According to the author, several points introduced bias, such as sample size, inequalities between treatment groups, unmatched injury lesions between the treatment groups in terms of severity of the fracture, radiological parameters, and

neurological injury. Less severe fracture with mild neurological affection has been included in the conservative groups, making it difficult to draw a solid conclusion regarding the indications and superiority of either treatment.

In our study, the median age was 32 years, which makes this injury of the young age group resulting from significant trauma. The incidence of neurological injures was 13.3%, all were in the surgical group, and all were nerve root injuries, which showed complete recovery at final follow up. In the literature, Seybold et al. reported a multicentre study of 42 patients, 20 patients treated conservatively, while 22 patients underwent surgical fixation, the incidence of neurological injury was 42.8%, more than half of these patients sustained cauda equina injury; two patients had a higher level of vertebral fracture; however, they reported occurrence of nerve root injury of 19%, 17%, and 25% at L3, L4, and L5 respectively5. Another multicentre study by Motten et al. reported a 35.3% incidence of neurological injury in 34 patients 26, 50% of these injuries involved the cauda equina. Both studies reported no or partial recovery of those with cauda equina injury. Isolated nerve root lesions in both reviews showed complete recovery. In our study, the surgical group sustained more severe burst fracture, significant canal compromise. Neurological injury and considerable loss of anterior vertebral height were the drives to operate; decompress the canal; restore the vertebral height and improve the local kyphotic deformity. At final radiographic measurements, the amount of correction of VKA and AVBH in operative groups was twice as a conservative group. Still, it was not significant statistically due to the sample size. A systemic review by Schouten et al. found that surgical intervention improves spine alignment; however, there was no correlation between radiological and functional outcomes 25.

Our study is the first study to show on a long-term follow-up that no statistically significant changes in pelvic parameters and lumbar lordosis are both treatment groups. However, whole spine sagittal profile analysis may be needed to investigate; compensatory thoracic or cervical spine radiological changes may exist and provide more insight into short- and long-term outcomes.

In functional outcome, in our study, ODI and SF36 showed no statistical difference between operative and conservative management at follow-up, which is similar to other reports 4,14. Other scores have been used to assess functional status in lower lumbar spine fractures, such as the Dallas questionnaire and Smiley-Webster scale, and Visual Analogue Scale that showed no superiority between the treatment groups10,19, 25. Despite the rarity, unique characteristics in terms of anatomy, biomechanics, and ongoing debate regarding treatments and controversies of treatment outcome, a research study group on lower lumbar spine injuries are needed. Vertebral and pelvic radiological

parameters should be investigated since the current may not reflect the unique local biomechanics of the lower lumbar spine.

A relationship with pelvic parameters needs to be investigated; possible interactions or relationships may reflect a secondary compensatory pelvic mechanism that might explain or impact the outcome. A task research force is required to explore and develop a classification for the lower lumbar spine that considers radiological parameters and modifiers such as adjacent sacral or pelvic fracture. Another research opportunity is to create a functional scoring system that includes a neurological assessment like nerve roots assessment; isolated or mix; sensory or motor deficit. Another essential aspect to consider is the sphincter lesions, type, severity since that not only carries a prognostic factor but also aid in evaluating both the improvement and the outcome.

Strengths and Limitations

Our report reflects 11 years review with a minimum of 5 years follow-up. It is the first report in the middle east region. To the best of our knowledge, it is the first report to present a long-term reflection of lower lumbar spine fracture over lumbar lordosis and various pelvic parameters. However, it has limitations. The number of patients is small, and both treatment groups do not have the same number of patients, which reflects on statistical analysis. Selecting patients with more severe fracture patterns for surgical management may introduce bias. Another limitation is the communication difficulty that existed, although we could identify many patients. A national health database would facilitate enrolling more patients and conducting a multicentre study if some patients moved out of the province.

Conclusion

In our study, conservative and surgically treated patients have similar radiological and functional outcomes. Moreover, no long-term effect was observed on lumbar lordosis or pelvic parameters in both groups. However, controversies exist in the literature due to sample heterogeneities and lack of management guidelines. A gap exists in the radiological assessment that should consider regional biomechanics and sagittal spine-pelvic relationship. A research task investigation is needed focusing on developing a classification and outcome measures that will facilitate the development of treatment guidelines.

Acknowledgment: Nil

Ethical Approval Statement: The study was approved by the Institutional Review Board of Imam Abdulrahman Bin Faisal University (No. IRB-UGS-2020-01-411).

Funding Statement: No grant or funding was received or raised to conduct this study.

Competing Interests Statement: All authors have no conflict of interest.

Contributor ship Statement: DD is the guarantor of this study. All authors have made substantial contributions to the conception or design of the work or the acquisition, analysis or interpretation of data. They were involved in drafting the work or revising it critically. All authors gave final approval of the version published and agree 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.

Data Availability Statement: Data are available upon reasonable request. Harvard Dataverse https://doi.org/10.7910/DVN/B7EMNI

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