European Spine Journal (2023) 32:84–92
https://doi.org/10.1007/s00586-022-07305-9

ORIGINAL ARTICLE

Do all Isler's type sacral fractures necessarily require surgical fixation?

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Received: 16 January 2022 / Revised: 10 May 2022 / Accepted: 24 June 2022 / Published online: 12 July 2022

Abstract

Introduction A unilateral vertical sacral fracture that exits medial or through the L5-S1 facet joint is considered to affect the lumbo-sacral integrity, and it is denoted as an indication for surgical fixation. However, no studies have analysed the outcomes after non-operative treatment of such injuries.

Methods A retrospective review of all sacral fractures treated over a five-year period was performed to identify patients with Isler's fractures. Demographic and surgical data, all pre-operative and follow-up images (AP radiographs, CT images), functional outcomes based on VAS, SF-12 and return to work were documented for all patients.

Results The incidence of Isler's fractures was 18% (34/181). The mean age was 42.12 ± 16.3 years. As per Isler's subtypes, fractures passed through L5-S1 joint in 13 (Type 2a) and medial to it in 15 (Type 2b), fractures of L5 or S1 facets in 3 (Type 1), Type 3 injuries were not detected. All patients had concomitant pelvic ring injuries. Sixteen fractures (neurologically intact, < 1 cm displacement, anterior ring stable, no facetal dislocation) were treated non-operatively while 18 patients underwent surgery. At a mean of 15.2 months, the fractures had united in all patients radiographically. The mean VAS score for low back pain (1.4 ± 1.01 vs 1.5 ± 0.79), ability to squat and sit cross-legged (56.3% vs 55.6%) and return to work (68.8% vs 66.7%), and Majeed score (77.2 ± 3.9 vs 79.6 ± 4.1) were similar in non-surgical and surgical groups, respectively, at the final follow-up.

Conclusion Our study indicates that 47% of Isler's fractures were mechanically stable and could be effectively treated non-operatively with good radiological and functional outcomes.

Keywords Sacral fractures · Isler's classification · Conservative · Surgery · Lumbosacral joint

Introduction

Sacral bone is an important keystone element by virtue of its position in the spino-pelvic junction. Its bio-mechanical importance can be viewed from three different perspectives. Firstly, it connects the whole spinal column with the iliac bones (spino-pelvic continuity). Secondly, it completes the posterior part of the circular pelvic ring (pelvic integrity). Finally, in the major stress bearing disc of the spinal column, the L5-S1 joint articulation is formed between the sacrum and L5 vertebra (Lumbo-sacral joint integrity). Fractures of the sacrum can affect any of these three aspects of the functions of the sacrum, independently or in combination. Initial classifications and management of sacral injuries were focussed on the integrity of pelvic ring [1, 2]. With the routine use of CT scan, the complexity of sacral fracture patterns that affected the alignment of the spino-pelvis was recognised [3, 4].

Isler in 1990 identified a subset of unilateral vertical fractures (Fig. 1) in which he noted that the proximal fracture line exited through or medial to the L5-S1 facet joint [5]. He believed that such a fracture pattern has the potential to affect the lumbo-sacral joint integrity later. Further to his description, few other authors have reported such fracture patterns and these injuries were termed as lumbo-sacral joint instabilities [6, 7]. The recognition of a fracture line passing medial to the L5-S1 facet joint has become a standard

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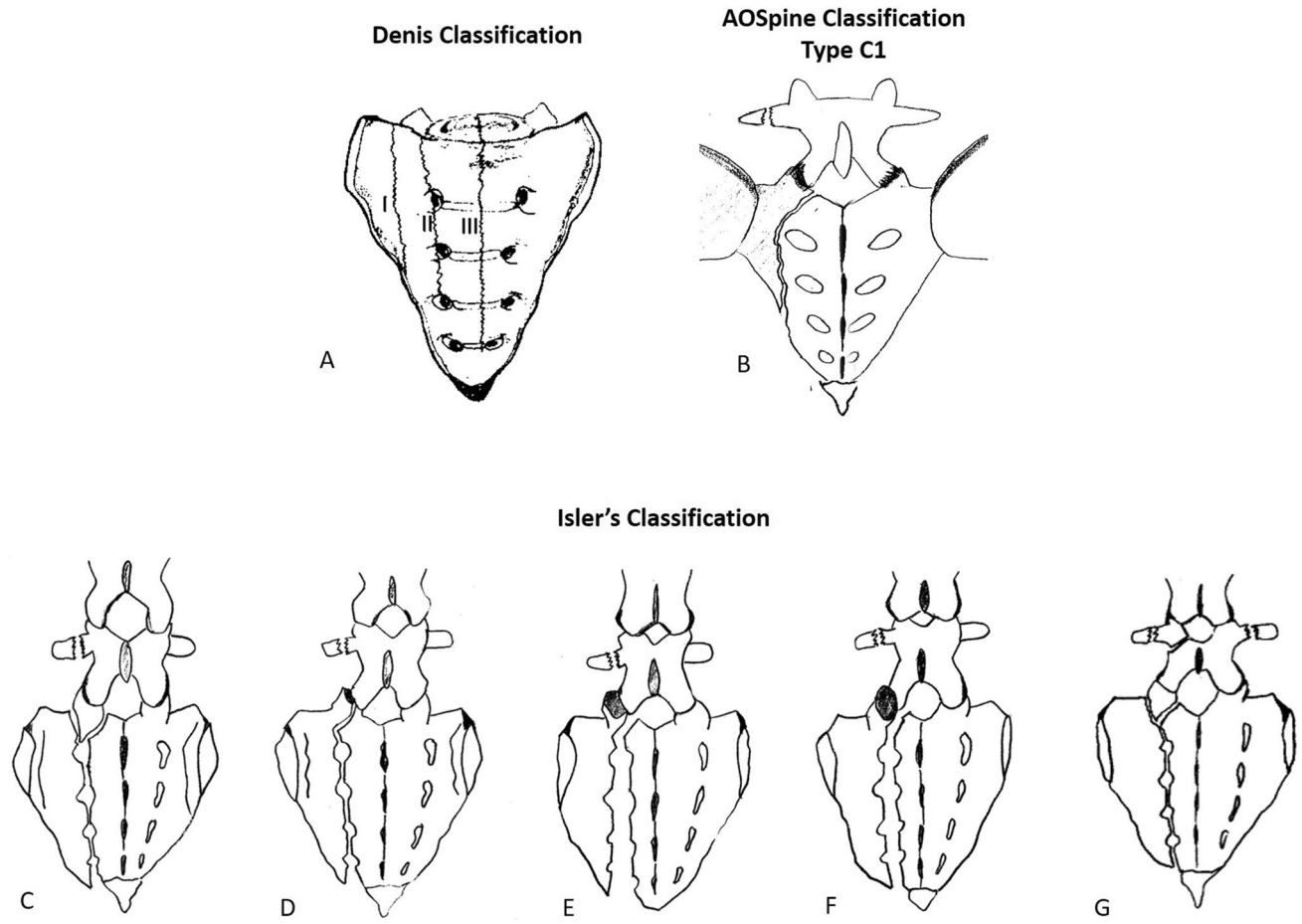

Fig. 1 Comparison between Denis, AO Spine and Isler's classification. Denis sacral fracture classification (Fig **A**) has three types which includes vertical fracture lines passing through sacral ala (I) or sacral foramina (II) or central sacral canal (III). AOSpine sacral fracture classification includes all types of sacral fractures and one of its subtypes illustrated here—type C1 (Fig **B**) reflects the Isler's vertical fracture line passing medial to the L5-S1 facet joint. The Isler's sacral fracture classification specifically indicates vertical fracture lines exiting medial to the L5-S1 facet joint (**C**–**G**). Type 1 (Fig **C**)—the vertical sacral fracture is accompanied by a fracture of one of the facets of L5-S1 facet joint. Type 2a (Fig **D**)—The fracture line passes through the S1 facet. Type 2b (Fig **E**)—fracture line passes medial to the facet but associated with L5-S1 facet joint subluxation. Type 2c (Fig **F**): The fracture line passes medial to the facet and associated with anterior dislocation of the L5 facet over the S1 facet. Type 3 (Fig **G**) are complex injuries, where the fracture line coursing medial to the facet is accompanied by multiple fractures of articular process, pars interarticularis of L5, lamina and the pedicles

surgical indication since then [8, 9]. In a recent comprehensive review on sacral fractures, the authors concluded that lumbo-sacral injuries, which should be sought for in the presence of transforaminal sacral fractures and should be treated surgically as failure to recognise and treat these injuries, may lead to lumbo-sacral incongruence and pain [10]. In a survey conducted by the AO Spine trauma knowledge forum, more than 80% of surgeons accepted that Isler's fractures can affect the integrity of the L5–S1 facet [9]. Further, Isler's fractures are considered to affect spino-pelvic integrity, and the use of spino-pelvic fixation has been advised [11, 12].

Despite its common usage and practice for more than thirty years, there are no studies in the literature to document whether the outcomes of patients with Isler's fractures are treated surgically or non-surgically. We performed a retrospective review of all sacral fractures treated over a 5-year period and selected patients with Isler's fractures to document their functional and radiological outcomes.

Materials and methods

The study was approved by the institutional review board of the hospital. All consecutive patients with sacral fractures were reviewed based on electronic database records. Those with CT images of the pelvis were included for further analysis. Patients with bilateral fractures, U/H-shaped fractures and low transverse fractures were excluded from the analysis.

Between 2016 and 2020, 181 sacral fractures had been treated in our institute. Thirty-four patients who had unilateral vertical fracture of the sacrum that exited medial or through the L5-S1 facet joint were selected for further analysis. The fractures were classified and subtyped as per Isler's original description. The decision to operate on Isler's fractures was based on the presence of hemi-pelvis displacement > 1 cm, neurological deficit and extent of anterior pelvic ring injury. Patients who underwent surgical treatment had either one or two percutaneous ilio-sacral screws and or lumbo-pelvic fixation. Patients with minimal fracture comminution were treated by percutaneous fully threaded ilio-sacral cancellous screws. Fractures with gross displacement, severe comminution and those which needed open reduction were treated by lumbo-pelvic fixation. Non-operatively treated patients were advised a period of bed rest for two weeks followed by non-weight bearing walking for another two weeks and gradual return to normal walking in the next two weeks. In the presence of contralateral limb injuries and upper limb injuries, non-weight bearing walking could not be initiated at two weeks and such patients were mobilised full weight bearing from the 3rd week based on their comfort levels. If the anterior pelvic ring was unstable, it was surgically stabilised by internal fixation.

All demographic, surgical data, pre-operative images (pelvis X-ray, CT scan) and post-operative follow-up X-rays of the pelvis were documented. Patients' return to work and low back pain scores based on VAS were noted at the final follow-up.

Results

Thirty-four patients with Isler's fractures formed the study group (incidence 18.7%) (Table 1). The mean age was 42.12 ± 16.3 years. There were 23 males and 11 females. The mechanism of injury was as follows: fall from height ($n = 21$) and road traffic accidents ($n = 13$). As per Isler's subtypes, three patients had fractures of L5 or S1 (type 1), fifteen patients had fractures that exited medial to the L5-S1 facet (Type 2b) and thirteen patients had fractures through the facet (Type 2a) (Table 2). Locked facets were observed in three patients (Type 2c). Type 3 injuries were not observed. Associated injuries included chest injury in seven patients, abdomen injury in nine patients, spine injuries in twenty-one patients and injuries of the extremities in eighteen patients. All the patients had injuries to the pelvic ring (100%). Of 18, 16 (88.9%) of unstable, operatively treated Isler's fractures had an ipsilateral fracture of L5 transverse process while only 18.7% (3/16) of non-operative group had L5 transverse process fracture. Six had pubic diastases, 21 patients had unilateral rami fractures and twelve had bilateral rami fractures.

Table 1 Demographic details of patients

	Conservative group	Surgical group
Total	16	18
Mean age (Years)	46.89 ± 16.72	36.27 ± 13.87
Gender		
Male	13	10
Female	3	8
Mechanism of injury		
Fall from height	8	13
Road accident	8	5
Other pelvic injuries		
Pubic diastasis	3	3
Rami fracture		
Unilateral	10	11
Bilateral	5	7
Associated injuries		
Head injury	1	2
Chest injury	3	4
Abdominal injury	4	5
Limb injury	9	9
Spine injury	11	10
Functional outcomes		
VAS (mean)	1.67 ± 0.92	0.82 ± 0.76
SF-12 (mean)	36.2	38.2
Able to sit cross-legged	56.3% ($n = 9$)	55.6% ($n = 10$)
Back to previous work	68.8% ($n = 11$)	66.7% ($n = 12$)

Sixteen patients were treated non-operatively (Group 1—un-displaced and minimally displaced fractures) (Fig. 2) while 18 patients with displaced fractures underwent surgical fixation (Figs. 3 and 4). The different surgical constructs included ilio-sacral screws in 10, lumbo-pelvic fixation in 5 patients and triangular osteosynthesis in 2 patient, and additional pelvic infix was done in 2 patients (Group 2) (Table 2). Four patients in surgical group and two in non-operative group had undergone pubic rami plating. At a mean follow-up of 15.2 months (range 6–48 months), the sacral fractures had united in both the groups. The mean VAS score for low back pain was statistically similar in both the groups at the final follow-up. Ability to squat and sit cross-legged (56.3% vs 55.6%) and return to work (68.8% vs 66.7%) were similar in non-operative and surgical groups, respectively, at the final follow-up.

Discussion

This is the first study to compare the outcomes between non-operative care and surgical fixation in Isler's fractures. Isler's fractures hitherto have been considered as injuries indicating lumbo-sacral instability [7] and surgical fixation has been necessarily advised [10]. But in this study, we have

Table 2 Master chart of patients

S.no.	Age	Gender	Mode of injury	Associated injuries	Isler's types	Pubic diastasis	Types of surgical fixation	SF 12	Majeed score	Follow-Up (months)	Complications
Non-operatively treated Patients Group (n = 16)											
1	60	M	RTA	Chest	2b			30	73	6	
2	60	F	RTA	Abdomen, Limb, Spine	2b			36	68	10	DVT
3	56	M	RTA	Chest, Spine	2b			44	84	12	Pneumonia
4	45	M	RTA	Limb, Spine	2a	Yes		32	79	12	
5	30	M	FFH	Limb	2b			36	89	14	
6	46	M	FFH	Limb	2b			30	71	14	
7	75	M	RTA	Spine	2a	Yes		42	72	12	
8	35	M	RTA	Limb, Spine	2a			32	83	12	
9	75	M	FFH	Limb, Spine	2a			34	60	10	UTI
10	30	M	RTA	Chest	2a			42	85	10	
11	22	F	FFH	Limb	2a			44	89	12	
12	43	M	FFH	Abdomen, Limb, Spine	2a			42	86	36	
13	30	M	RTA	Abdomen	2b			38	74	12	
14	55	F	FFH	Spine	2b			34	73	18	
15	70	M	FFH	Abdomen	2a	Yes		32	76	12	UTI
16	47	M	FFH	Limb, Spine	2a			30	74	36	
Operated Patients Group (n = 18)											
17	35	M	FFH	Chest	2c		Percutaneous Sacro-Iliac Screw Fixation	45	76	6	
18	50	F	RTA	Chest	2a		Percutaneous Sacro-Iliac Screw Fixation	32	68	8	
19	26	F	FFH	Chest, Limb	2b		Spinopelvic Fixation	33	77	14	Pleural effusion
20	31	M	FFH	Limb, Spine	2b		Spinopelvic Fixation	42	82	14	
21	17	M	FFH	Abdomen, Limb, Spine	2b	Yes	Spinopelvic + Percutaneous Screw	32	80	14	
22	24	F	FFH	Spine	2a		Spinopelvic Fixation	45	85	24	
23	52	F	RTA	Spine	2c		Percutaneous Sacro-Iliac Screw Fixation	40	79	12	
24	43	M	FFH	Abdomen, Spine	1	Yes	Spinopelvic Fixation	38	79	36	
25	53	F	FFH	Abdomen, Limb, Spine	2b		Percutaneous Sacro-Iliac Screw Fixation	44	82	12	UTI
26	32	M	FFH	Spine	2b		Percutaneous Screw + Infix	38	81	12	
27	35	M	FFH	Limb	2b		Percutaneous Sacro-Iliac Screw Fixation	38	76	20	
28	73	M	FFH	Spine	1		Percutaneous Sacro-Iliac Screw Fixation	36	79	48	UTI
29	35	M	FFH	Abdomen, Spine	2a		Percutaneous Sacro-Iliac Screw Fixation	44	86	12	
30	41	M	RTA	Abdomen, Spine	2b	Yes	Percutaneous Sacro-Iliac Screw Fixation	36	84	10	
31	19	F	FFH	Limb	1		Spinopelvic Fixation	40	81	10	
32	28	F	RTA	Limb	2c		Spinopelvic + Percutaneous + Infix	34	80	12	
33	30	M	FFH	Limb, Spine	2a		Percutaneous Sacro-Iliac Screw Fixation	38	75	12	

Table 2 (continued)

S.no.	Age	Gender	Mode of injury	Associated injuries	Isler's types	Pubic diastasis	Types of surgical fixation	SF 12	Majeed score	Follow-Up (months)	Complications
34	29	F	RTA	Limb, Chest	2b		Percutaneous Sacro-Iliac Screw Fixation	32	83	12	

FFH Fall from height; *RTA* Road traffic accident; *UTI* Urinary tract infection; *DVT* Deep vein thrombosis; *SF*-12—Short Form 12)

documented similar functional and radiological outcomes in appropriately chosen non-operative and surgically treated patients.

Isler published his original article in 1990 based on radiographic evaluation of 193 pelvic fractures (CT scan was available in only 52 cases). He noted that lumbo-sacral lesions (Isler's injury) were documented in 12 cases (incidence 3.5%). In our study, based on CT analysis, the incidence is 18.7%. This observation has been echoed by other authors as well [5–7]. The more commonly CT imaging is used for diagnosis, and more such fracture patterns are detected [6].

Isler had classified the LSJI into three subtypes based on the patterns of fracture line:

(1) Type 1: Extra-articular fractures—associated with fracture of S1 or L5 facet. Here the fracture line was accompanied by a fracture of one of the facets of L5-S1 facet joint.
(2) Type 2: Articular fractures: The fracture line passed through the L5-S1 joint.

    (a) Fracture dislocation—fracture through S1 facet
    (b) Subluxation—fracture line medial to the facet associated with joint subluxation,
    (c) Locked dislocation—fracture line medial to the facet associated with anterior dislocation of the S1 facet over the L5 facet.

(3) Type 3: Complex injuries, where the fracture line coursing medial to the facet was accompanied by multiple fractures of articular process, pars interarticularis of L5, lamina and the pedicles.

In our series, we noted that Isler's fractures could be classified specifically into the different subtypes only with thin slice CT viewed in all three planes—axial, sagittal and coronal. The injuries were complex and most commonly were, either through (Type 2a) or medial to the L5-S1 facet joint (Type 2b). Isolated fractures of L5 or S1 facets (Type 1) were rare ($n=3$). Locked facet was noted in three patients (Type 2c). Type 3 injuries were not observed in unilateral fracture patterns and were present in patients with U-shaped sacral fractures.

The Isler's classification postulated for the first time that a vertical fracture line affecting the facet integrity through a fracture or subluxation can result in LSJI. He stressed that recognising L5-SI locked dislocation would necessitate an open reduction for proper reduction of the sacral fracture. In his article, only 24% of the fractures could be evaluated by a CT scan and he reckoned that the incidence of LSJI could be higher if all fractures were evaluated with CT. Hence, he pointed out the value of performing CT scan in all posterior

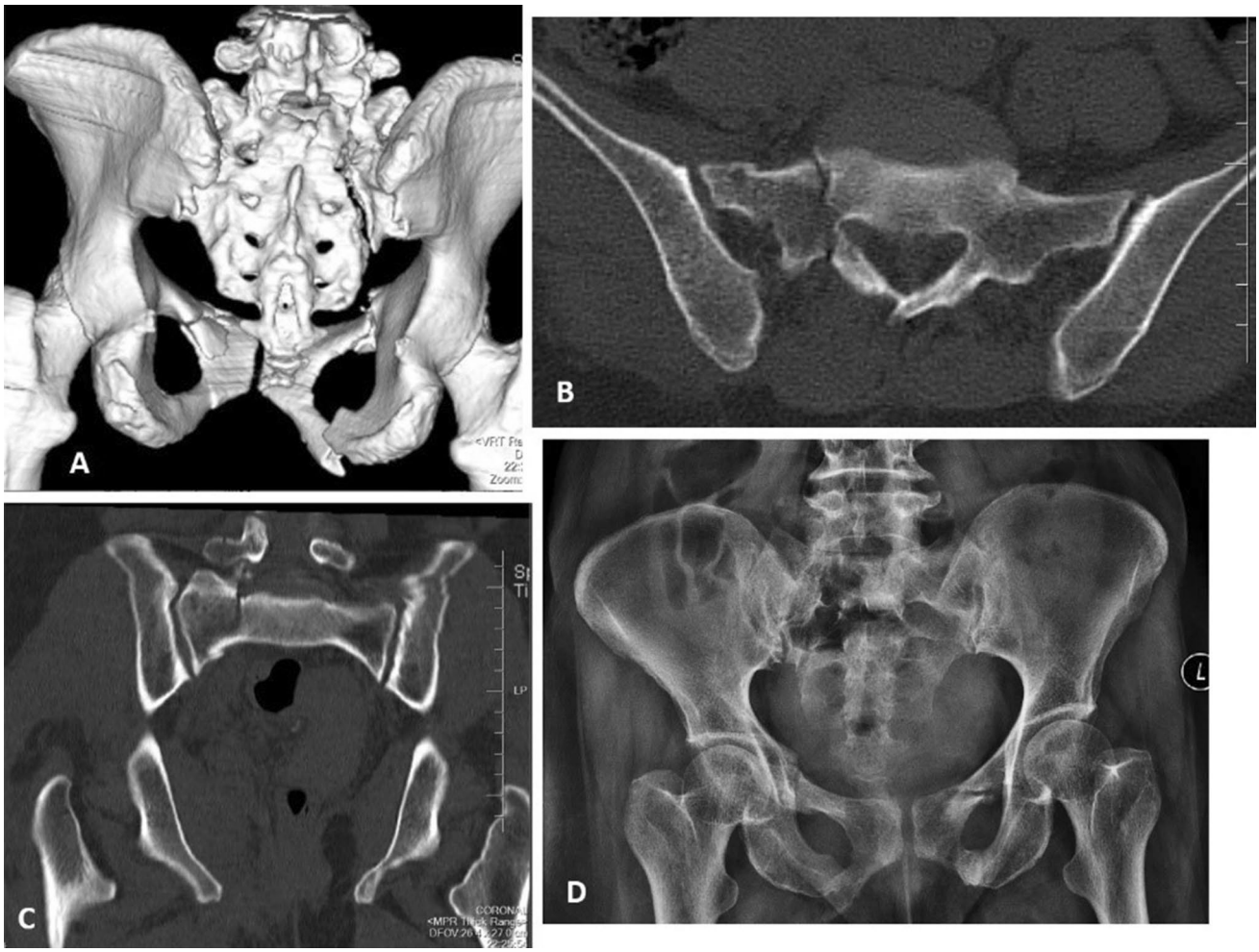

Fig. 2 3D reconstructed CT image (**A**), axial CT (**B**) and coronal CT (**C**) sections show a vertical fracture line passing through the S1 facet (Isler's type 2a). Fractures through both pubic rami are visualised. **D** Follow-up pelvis AP X-ray at the end of 8 months shows a healed fracture

ring injuries. Finally, he concluded that traumatic degeneration of the lumbo-sacral facet joints may be an important cause of lumbo-sacral pain after pelvic ring injuries.

Despite its popularity and ubiquity in acceptance throughout the world, there are only a few articles that have studied the occurrence of Isler's injuries in their population. Oransky and Gasparini studied 71 pelvic fractures with rotatory instability and vertical shear instability and noted that 13 patients had LSJI [7]. They observed the three different types of Isler's LSJI and also noted a fourth type of injury in three patients. In 1997, Leone et al. studied 73 unstable pelvic fractures with CT and radiographs and noted a sacral fracture in 42 patients [6]. LSJI described by Isler was noted in 14 patients, including all the three subtypes. The authors reiterated the observations of Isler, but noted a slightly higher incidence of LSJI (6% versus 19%), which they attributed to the performance of CT in all patients.

Despite the limited follow-up studies performed on this topic, there is a widespread acceptance among the spinal and trauma surgeons that fractures that exit medial to the L5-S1 joint are potentially unstable injuries. In a survey conducted by the AO Spine trauma knowledge forum, among 474 surgeons, 4 out of 5 respondents observed that such injuries need to be treated differently than lateral vertical fractures [9]. This was independent of the treating surgeon's years of practice and experience in treating sacral fractures.

There is a popular belief among spine surgeons that Isler's fracture affects spino-pelvic continuity. Our study indicated that it may not be the situation in some cases. When a fracture line that passes lateral to the L5-S1 facet joint (Denis Type 1 fracture), it courses through the sacral ala and there is discontinuity between the lateral part of sacrum with its attached hemi-pelvis and the medial part of the sacrum with its attached spinal column (Fig. 5A). A coexistent injury to the anterior pelvic ring can cause instability here. However, when a fracture line passes medial to the L5-S1 joint, it also courses through the lateral part of the S1 body at its articular surface (Fig. 5B). Here, the lateral part of the sacrum is in

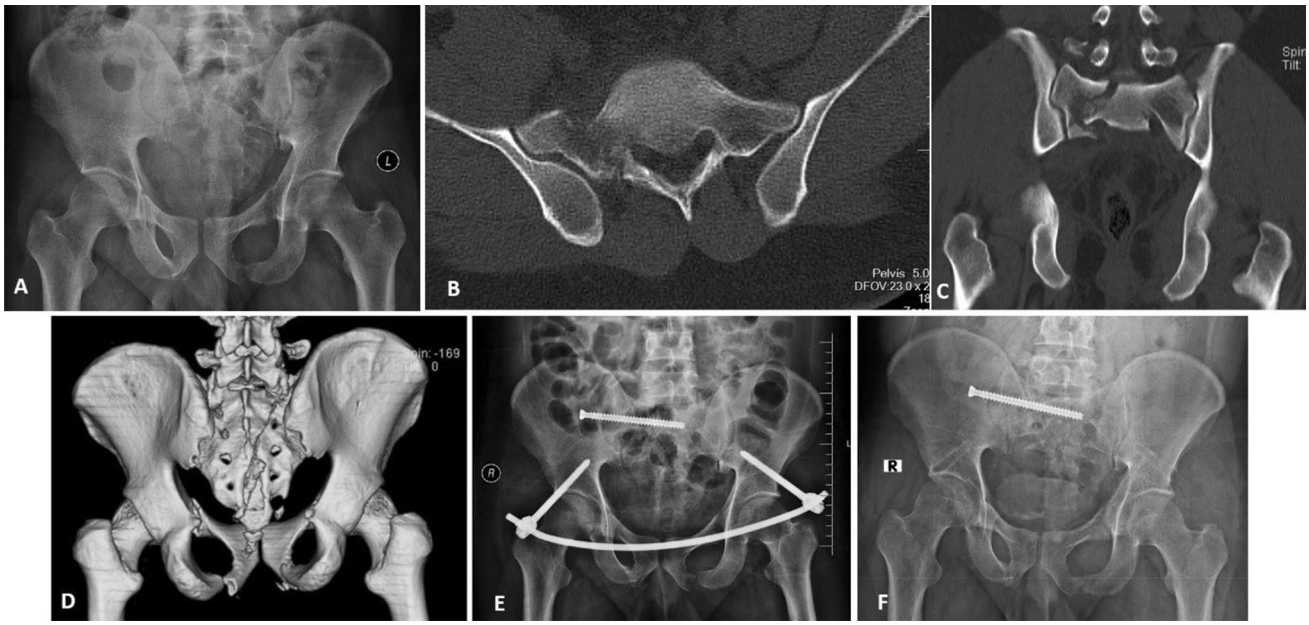

Fig. 3 Antero-posterior radiograph (**A**), axial CT (**B**), coronal CT (**C**) and 3D reconstructed images (**D**) of Isler's type 2b fracture with fracture displacement. In the 3D image, the fracture line exits medial to the L5-S1 facet joint and associated with subluxation. The fracture has been reduced and fixed with ilio-sacral screws and temporary pelvic infix (**E**). The final follow-up AP X-ray after removal of the infix (**F**)

continuity with the L5-S1 facet joint, and hence, the fracture should be theoretically more stable than a pure Denis Type 1 fracture. In the absence of a facetal dislocation and fracture displacement either vertical or antero-posterior, Isler's injuries need not be considered as absolute indications of surgical fixation.

We also noticed a higher incidence of displaced L5 transverse process fracture in unstable Isler injuries. This could also be a surrogate indicator for instability as reported in other pelvic injuries [13, 14]. In our patients, the indications for surgery were based on the extent of fracture displacement and severity of coexistent injury to the anterior pelvic ring. Un-displaced and minimally displaced fractures even with the presence of fracture medial to the L5-S1 facet joint were treated non-operatively with good outcomes. This indicates that in terms of fracture stability, Isler's fracture does not cause additional instability. However, their impact in terms of future degeneration of the L5-S1 joint should be studied through long-term (> 10 year) follow-up studies. This is particularly important in fractures with displaced facet fracture and facetal subluxation since this would predispose to L5-S1 facetal arthropathy. In the light of the current evidence, it appears that there is no increased incidence of back pain in these patients.

The limitations of the study are its retrospective nature, small study number and short-term follow-up. The outcomes included radiographs and clinical assessment, while a 3D CT scan to assess facet congruity and fracture healing would have been ideal in all the patients. Other radiological observations including MRI to evaluate the status of L5-S1 disc and coronal balance of the spine and spinopelvic alignment were also not evaluated in the study. Surgical fixation was also not standard and included percutaneous screws, lumbo-pelvic fixation, triangular osteosynthesis and supplementary anterior fixation in some patients. Biomechanically the strength of these fixations is quite variable, and hence, standardisation would be preferred [15].

In conclusion, the incidence of Isler's fractures is about one in five sacral fractures. The injury could be displaced or un-displaced. The presence of the Isler's fracture per se is not an indication for surgical fixation and a decision can be made based on fracture displacement and integrity of the pelvic ring. If patients are neurologically intact, the fracture is minimally displaced or un-displaced, anterior pelvic ring is intact and the facets are not dislocated, these injuries can be treated by non-operative measures.

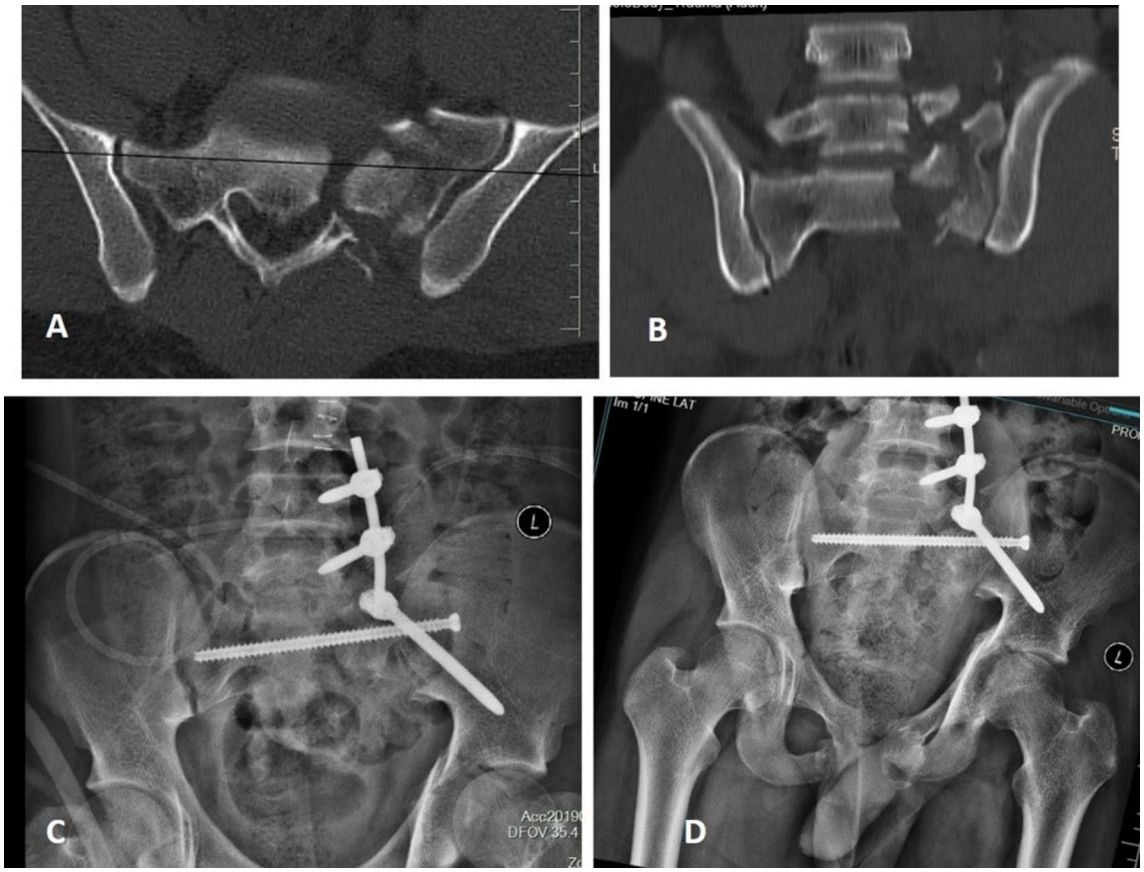

Fig. 4 Axial **A** and Coronal CT images **B** show a displaced Isler type 2a fracture. The fracture lines are complex and can be seen traversing the S1 facet associated with subluxation. The fracture has been treated with unilateral spino-pelvic fixation and percutaneous sacral fixation **C**. Follow-up images show good fracture healing **D**

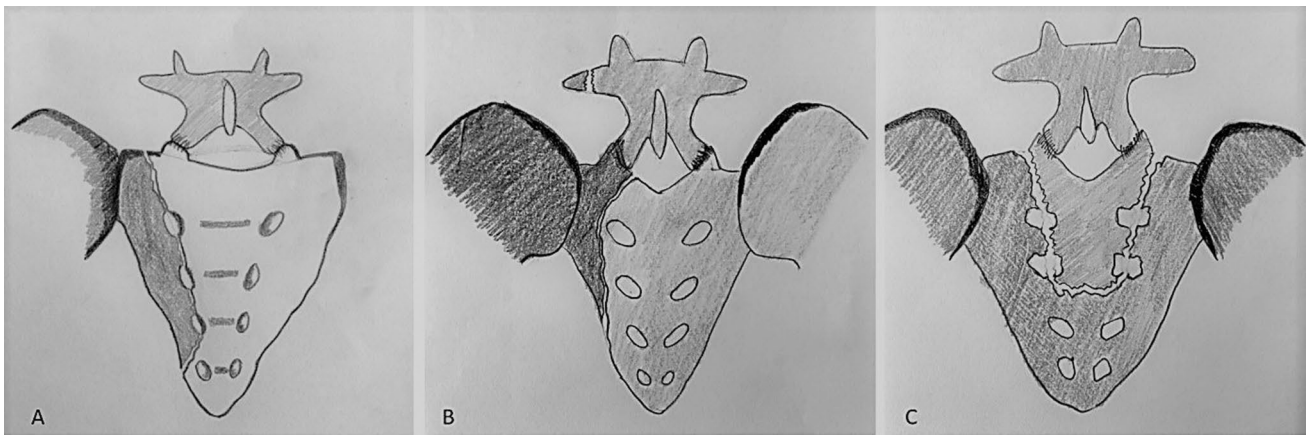

Fig. 5 **A** In fractures that pass lateral to the L5-S1 facet joint (Denis type 1/2 fractures, the potential for instability is high since there is no continuity between the lateral sacrum and pelvis, with any part of the spinal column, **B** Whereas in Isler's fractures, the lateral part of the fractured sacrum is connected to the facet joint and hence the spino-pelvic continuity is not disrupted. **C** In spino-pelvic dissociation, the median broken part of sacrum along with spinal column is separated from pelvis. These are highly unstable injuries

Funding The study was funded by the Ganga Orthopaedic Research and Education Foundation (GOREF).

Declarations

Conflict of interest None.

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