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The role of ultrasonography in examination of the stability of Tile-B2 pelvic fractures

7 case reports and a literature review

Bin-Fei Zhang, MD[a], Hong Zhang, MD[b], Peng-Fei Wang, MD[a], Hu Wang, MD[a], Jin-Lai Lei, MD[a], Ya-Hui Fu, MD[a], Yu-Xuan Cong, MD[a], Hai Huang, MD[a], Xiao-Ming Huo, MD[b], Yan Zhuang, MD, PhD[a,*], Kun Zhang, MD[a]

Abstract

Background: Determining whether a Tile-B2 pelvic fracture is stable is very challenging. We sought to identify the role of ultrasonography in determining the stability of Tile-B2 pelvic fractures.

Methods: We collected the clinical data of patients with Tile-B2 pelvic fractures who presented at Xi'an Hong-Hui Hospital between June 1, 2016, and August 5, 2016. The treatment strategy of each patient was determined by a team of senior surgeons in the department. A single sinologist observed the movement of the fracture sites in patients during rest, under compression, and during separation to determine fracture stability. According to the pelvic fracture stability assessment, an appropriate treatment strategy was redetermined. Overall, 7 patients, including 5 women and 2 men, with Tile-B2 pelvic fractures were included in this case series.

Results: During the initial examination, senior surgeons recommended that 2 patients should undergo internal fixation and 4 patients, conservative treatment; treatment was undecided for 1 patient. After ultrasonography examination, 4 patients underwent surgery via the Stoppa (n = 2) or ilioinguinal approach (n = 1) or cannulated screw fixation (n = 1). The rest of the patients (n = 3) received conventional treatment. Follow-up ranged from 6 to 10 months. Most of the patients showed excellent functions based on their last Majeed grading scores. There were no complications during the follow-up. Using ultrasonography examination, the preoperative treatment plan in 1 patient was changed, and the uncertain preoperative plan in 1 patient was identified.

Conclusion: Preoperative assessment of stability using ultrasonography may assist surgeons in making appropriate treatment choices for patients with Tile-B2 pelvic fractures.

Abbreviations: CT = computed tomography, LC = lateral compression, OTA = Orthopaedic Trauma Association.

Keywords: case report, examination, stability, Tile-B2 pelvic fractures, ultrasonography

1. Introduction

Accidents are the primary cause of pelvic fractures, predominantly high-energy blunt trauma accidents. The classification of pelvic ring injuries helps surgeons understand the anatomy of the injury, make better preoperative plans, and predict patient prognosis.

Traditionally, Tile-B type fractures are classified as unstable pelvic fractures,[1] and operative treatment is advocated.[2,3] Recently, researchers have reported that part of Tile-B2 pelvic ring fractures could be treated nonoperatively and that patients can achieve acceptable functional outcomes after nonsurgical management of LC-1 pelvic injuries.[4] Furthermore, to our knowledge, no evidence exists suggesting that surgical stabilization of LC-1 and LC-2 pelvic fractures improves patient pain, decreases narcotic use, or improves the time to mobilization.[5] Tile-B2 or LC-1 type patterns actually represent a spectrum of heterogeneous injuries, ranging from stable to unstable patterns.[6] Therefore, there is no accepted strategy for assessing and identifying fractures better suited for invasive or conservative treatment. Additionally, in 2014, survey completed by the Orthopaedic Trauma Association (OTA), members highlighted that there are vast differences in the decision-making practices among surgeons currently treating LC-1 (Tile-B2) injuries, and studies are warranted to establish strict guidelines for surgical treatment.[6]

Thus, estimating the stability of pelvic fractures is of utmost importance. Determining whether a Tile-B2 fracture is stable is very challenging. Sagi et al recommended examination under anesthesia for pelvic fractures that are not clearly stable or not based on pelvic morphology.[7] However, anesthesia provides many inconveniences for patients.

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[a] Department of Orthopedic Trauma, [b] Department of Ultrasound Medicine, Hong-Hui Hospital, Xi'an Jiao Tong University College of Medicine, Xi'an, Shaanxi Province, China.

[*] Correspondence: Yan Zhuang, Department of Orthopedic Trauma, Hong-Hui Hospital, Xi'an Jiao Tong University College of Medicine, No. 555 Youyi East Road, Xi'an 710054, Shaanxi Province, China (e-mail: zhuangyan2512@126.com).

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We investigated whether ultrasonography, which is flexible and convenient, could determine pelvic fracture stability. Hence, we collected data from a case series to evaluate the role of ultrasonography in the diagnosis of patients with unstable Tile-B2 pelvic fractures.

2. Patients and methods

2.1. Ethical statement

This study was approved by the Ethics Committee of Hong-Hui Hospital, the Xi'an Jiao Tong University (No. 2016053). In addition, this study was performed in line with the international ethical guidelines for studies involving human subjects according to the Declaration of Helsinki.[8]

2.2. Patient information

Patients were included in the study if they met the diagnostic criteria for Tile-B2 pelvic fractures.[9] Patients should have a history of trauma, falling, or traffic accident. Patients should suffer from pelvic pain, tenderness, dysfunction, and local swelling. Diagnosis and fracture type was confirmed using x-rays (anterior-posterior, inlet, and outlet) and computed tomography (CT) examination. X-rays and CT showed partially stable (incomplete disruption of posterior arch) fracture with a lateral-compression injury (internal rotation) in the pelvis, including ipsilateral anterior and posterior injuries or contralateral (bucket-handle) injuries. Clinical data were collected from the Xi'an Hong-Hui Hospital between June 1, 2016, and August 5, 2016.

2.3. Methods and example

A 53-year-old man fell from a height of 3 m. After 11 hours, the patient was admitted into emergency department and Tile-B2 pelvic fracture was identified (x-rays and CT). We first made sure the patient's hemodynamics was stable and the patient was safe. The ECG findings showed that the patient was stable. His heart rate was 102 bpm, blood pressure 110/65 mm Hg, SpO_2 98%, and respiratory rate 21 bpm. Arterial blood gas (PaO_2 and lactic acid) and urinary output were monitored to prevent hemorrhagic shock. His PaO_2 was 75 mm Hg, and lactic acid was 1.6 mmol/L. A urethral catheter was used to monitor the renal perfusion; urinary output of this patient was 800 mL in 10 hours. Even though blood routine test showed HGB of 115 g/L and hematocrit of 30.3%, 2.0 U of red blood cells and 1500 mL sodium lactate Ringer injection were transfused to maintain stable hemodynamics.

Before the ultrasonography test, 5 senior surgeons suggested the conservative treatment course for this patient, based on their experience.

On the third day after the admission, the patient's vital signs were stable and he was prepared to undergo the ultrasonography test. One hour before the start of the test, the patient was asked to take an oral painkiller (oxycodone and acetaminophen, 5 mg; China National Pharmaceutical Group Corporation, Chengdu, China). The patient was placed in the supine position. The Philips IU-22 (Philips Medical Systems, Best, the Netherlands) was used for ultrasound examination. The patient was tested by a senior sinologist (HZ) and orthopedist (B-FZ). We inferenced that when the fracture site was in motion, the ultrasonic probe could capture the moving track.

First, the position of the anterior pelvic ring fracture was marked on the body surface with the ultrasonic probe, with the help of x-rays and CT information. The long axis of the ultrasound probe was adjusted to visualize the fracture sites. Two possible strong echo points were identified at sites, and the distance between the 2 sites was identified with the ultrasonic probe. Second, the sinologist observed the movement of the fracture sites carefully when patient was in a resting state. Third, the sinologist observed the movement of the fracture sites when the orthopedist performed the pelvic compression and separation test on the anterior superior iliac spine with greatest effort. The sinologist (HZ) measured the maximum displacement in the horizontal line between the 2 sites. We used the compression and separation test when the sites were identified, to avoid performing the test multiple times. Although 1 time was sufficient in most patients, we performed the test 2 or 3 times in complex fractures, but never more than 3 times.

Figure 1 demonstrates the ultrasonography test in the example patient. Displacement in the horizontal line during rest is in

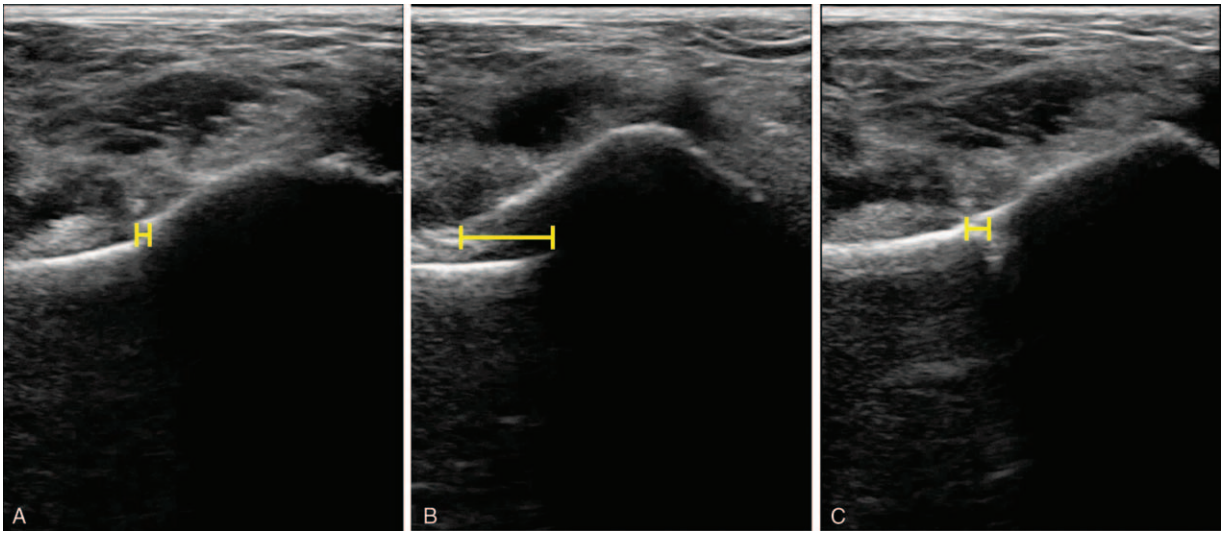

Figure 1. This detailed method measures the displacement under the ultrasonic probe while the orthopedist performs the pelvic compression and separation tests. (A) Displacement in the horizontal line during rest (yellow lines). (B) Displacement in the horizontal line during the compression test (yellow lines). (C) Displacement in the horizontal line during the separation test (yellow lines).

Figure 1A (yellow lines): we could see the displacement is less between 2 sites of fracture in the pubic branch; when the orthopedist (B-FZ) compressed the pelvis, displacement became larger and larger than at rest (Fig. 1B), and the displacement was also larger than at rest when the pelvis was separated (Fig. 1C). The formula for mobility is as follow: Mobility $= |D_{\text{Fig 1b}} - D_{\text{Fig 1a}}| + |D_{\text{Fig 1c}} - D_{\text{Fig 1a}}|$. In this example, mobility is 0.72 cm.

After ultrasonography imaging, the previous surgeons discussed the treatment again based on their combined experience and stability result under the pelvic compression and the separation test. At last, the example patient was operated by Stoppa approach.

Among the patients who required surgery, either the standard 3-window ilioinguinal approach or the Stoppa approach was chosen,[10,11] taking into account the individual differences and type of injuries. During surgery, the camera captured images of the relative movement of fractures during rest, compression, and separation test. In the follow-up, patient's function was evaluated using the Majeed grading system.[12]

3. Results

3.1. Initial patient assessment

Seven patients (5 women and 2 men) with a mean age of 50.28 ± 19.02 years met the criteria for inclusion. The study population included 3 high falls, 2 accidents, and 2 stumbles. Patient 2 and 6 had a history of hypertension and diabetes, whereas patient 2 and 3 had combination injuries. All the patients reported moderate-to-severe pain at the pubic branch or sacroiliac joint during the physical examination. Detailed patient information is shown in Table 1. ECG monitoring was performed when the patients were admitted to the hospital, and we ensured that their blood pressure and heart rate were stable. In patient 4 and 7, 2.0 U of red blood cells were transfused.

3.2. Initial therapeutic interventions

Five senior surgeons decided the treatment strategies for every patient before the ultrasonography test. They suggested that 2 patients undergo internal fixation and 4 patients, conservative treatment; treatment was undecided in 1 patient (Table 1).

3.3. Follow-up assessment of outcomes and interventions

Fracture site mobility was measured in each patient after the ultrasonography examination. The mobility of patients 1 to 7 were 0.51, 0, 0.42, 0.63, 0.29, 0, and 0 cm, respectively. Patients 1, 3, 4, and 5 were diagnosed as unstable Tile-B2 pelvic fractures (Table 1).

With the additional information provided by ultrasonography, 4 patients underwent surgery, including 2 using a Stoppa approach, 1 using an ilioinguinal approach, and 1 with cannulated screw fixation. Three patients underwent conventional treatment. The follow-up was from 6 to 10 months, and the last Majeed grading was evaluated. Most of the patient outcomes were excellent, but patient 1 had a 7-month-old fracture and patient 2, a right intertrochanteric fracture (Table 1). There were no complications in the follow-up. Images of patients 2, 4, and 5 are shown in Figures 2–4, respectively.

With the help of ultrasonography examination, preoperative treatment plan in 1 patient was changed, and uncertain preoperative plan in 1 patient was identified. These 2 patients showed an excellent function in the follow-up.

4. Discussion

The study expands on the growing sentiment that static radiographs and CT scans do not adequately delineate the degree of instability of incomplete traumatic pelvic ring disruptions. We simply wish to highlight and introduce the incidence of instability patterns for various incomplete pelvic ring injuries under the ultrasonography test, in hopes that further study will be undertaken to better define and treat these difficult injuries.

Among the 7 patients included in our retrospective case series, 4 were diagnosed with unstable fractures and only 2 (patient 1 and 3) were deemed to require surgery as an initial option. In 1 case (patient 4), stability was uncertain, and 1 patient (patient 5) was deemed to require a conservative treatment. Due to the ultrasonography assessments, we were more confident to recommend surgery for patients 1 and 3, and we also determined that surgery would be the optimal treatment for patient 4, whom we did not know how to treat initially. In addition, ultrasonography results changed the treatment plan for patient 5, resulting in a recommendation of conservative treatment. Pelvic stability was diagnosed in 3 patients (patients 2, 6, and 7), which had nonoperative treatment.

Sagi et al examined pelvic stability in 31 patients with Tile-B2 pelvic fractures during anesthesia. Sixteen patients required anterior or posterior surgical stabilization after examination.[7] Unfortunately, this method requires patients to undergo anesthesia, and physicians are exposed to radiation. However, ultrasonography allows patients to be examined in an outpatient

Table 1

The detailed information of 7 patients.

Patients	F/M	Age, y	Cause of injury	Combined injury	Length from injury to our outpatient/ inpatient	Discussed treatment (only pelvis)	Ultrasonography test (maximum displacement)	Definitive treatment	Surgical approach	Follow-up, mo	Majeed grading system
1	F	42	High fall	/	7 mo	Operative	Unstable (0.51 cm)	Operative	Ilioinguinal approach	9	Fair
2	F	76	Stumble	Right intertrochanteric fracture	5 d	Conservative	Stable (0 cm)	Nonoperative	/	10	Good
3	F	43	Accident	Right clavicle fracture	4 d	Operative	Unstable (0.42 cm)	Operative	Stoppa approach	9	Excellent
4	M	32	High fall	/	2 d	Uncertain	Unstable (0.63 cm)	Operative	Stoppa approach	7	Excellent
5	M	63	Accident	/	3 d	Conservative	Unstable (0.29 cm)	Operative	Cannulated screws	6	Excellent
6	F	69	Stumble	/	1 mo	Conservative	Stable (0 cm)	Nonoperative	/	6	Excellent
7	F	27	high fall	/	1 h	Conservative	Stable (0 cm)	Nonoperative	/	6	Excellent

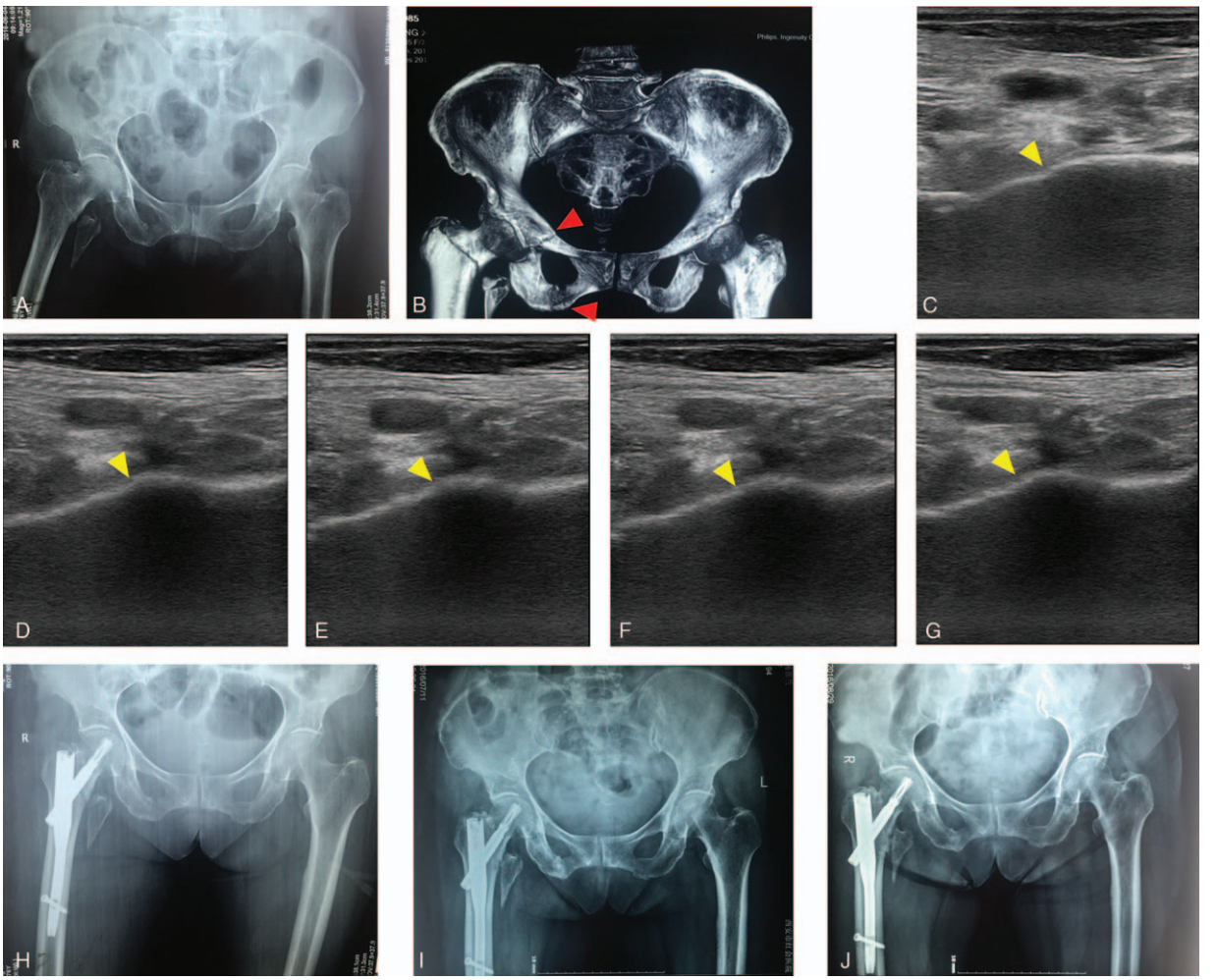

Figure 2. Patient 2, 76-y-old female, accidentally fell while walking in June 2016, conservative treatment. (A) Plain film x-ray and (B) CT at admission (fracture sites are marked with a red arrowhead). (C) Ultrasound shows that the fracture site is relatively stable during rest. (D–G) Ultrasound under compression and separation (fracture sites in the superior ramus are marked with yellow arrowheads) (see Video, Supplemental Video 1 and 2, http://links.lww.com/MD/B874, http://links.lww.com/MD/B875 which demonstrates the ultrasonography during resting stage and under compression and separation). (H) Plain film x-ray after surgery. (I) Plain film x-ray at 1 mo. (J) Plain film x-ray at 2 mo, showing that the fracture in the pelvis has healed. CT = computed tomography.

setting without anesthesia or physician's exposure to radiation. Most importantly, ultrasonography could record a dynamical video.

Based on our hypotheses and surgical conditions, ultrasonography provided vital information on pelvic stability and helped make important decisions. To the best of our knowledge, this is the first report on pelvic stability using ultrasonography.

Olson et al defined a stable pelvic ring as "one that could withstand the physiologic forces incurred with protected weight bearing, and/or bed to chair mobilization without abnormal deformation of the pelvis, until bony union or soft tissue healing could occur."[13] Since static radiographs and CT scans do not adequately delineate the degree of instability of incomplete traumatic pelvic ring disruptions, researchers have tried various methods to identify stability.[7] Unfortunately, there is no widely accepted tool or examination in the field. The stability of Tile-B2 pelvic fractures is particularly challenging to determine, along with complete or incomplete disruption of the posterior arch. Therefore, instability, as an etiologic factor in pelvic pain, has not been satisfactorily addressed in the literature. The senior surgeons in our hospital always determine treatment strategy using imaging and/or patients' subjective pain level. These methods can lead to subjective treatment strategies based on physicians' personal opinion or experience. Although the importance of classifying pelvic stability in the planning treatment process is well known, we have not found a professional tool for that purpose. Therefore, we combined the technology of ultrasonography and pelvic fracture stability examinations for this purpose.

We acknowledge that this study had several limitations. Although the benefits of ultrasonography cannot be underestimated, there are several drawbacks associated with it. The direction of ultrasonic probe is an important factor in the measurement of stability. The fragments of fractures are dimensional structures, but the information gained via ultrasonography is from a cross-sectional plane. Thus, it is difficult with an ultrasonic probe to reflect the 2 tips of a fracture and keep a constant cross section in any direction during the compression and separation tests due to movement of the soft tissue. In addition, we determined stability based on displacement distance; even though patients were compressed and separated by 1 physician, it is very hard to exert the same level of force on every person. Therefore, the definition of stability and instability may be relative. Lastly, these

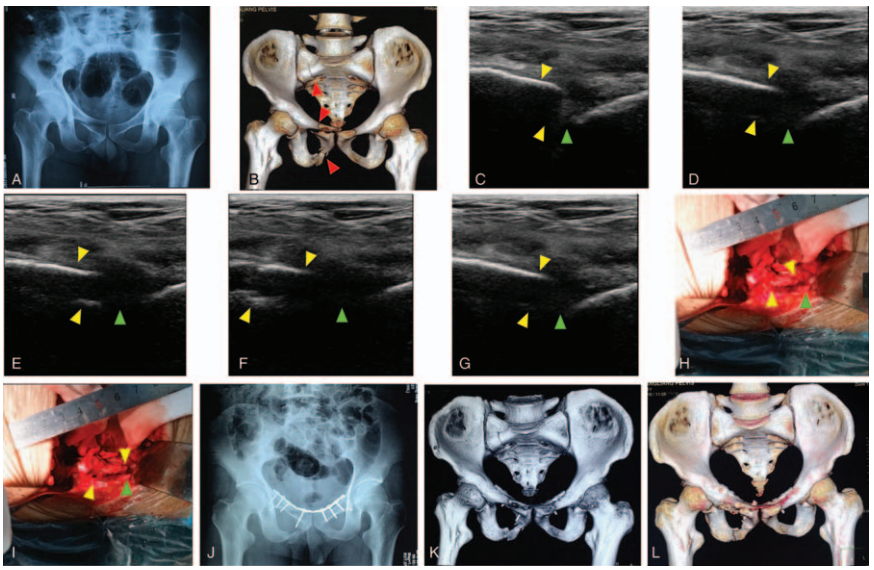

Figure 3. Patient 4, 32-y-old male, fell from a 4-m height in June 2016, treatment strategy undecided. (A) Plain film x-ray and (B) CT at admission (fracture sites are marked with a red arrowhead). (C) Ultrasound shows that the fracture site is relatively stable during rest. (D–G) Ultrasound under compression and separation (fracture sites in the superior ramus are marked with yellow arrowheads) (see Video, Supplemental Video 3, http://links.lww.com/MD/B876 which demonstrates the ultrasonography under the compression and separation test). (H) During surgery, movement is identified between the 2 fracture sites at rest, and (I) under compression (see Video, Supplemental Video 4, http://links.lww.com/MD/B877 which demonstrates the movement under the compression and separation test) (fracture sites in the superior ramus are marked with yellow arrowheads and pubic tuberosity is marked with green arrowheads). (J) Plain film x-ray and (K) CT after surgery. (L) At the final examination, the fracture in the pelvis is partly healed. CT = computed tomography.

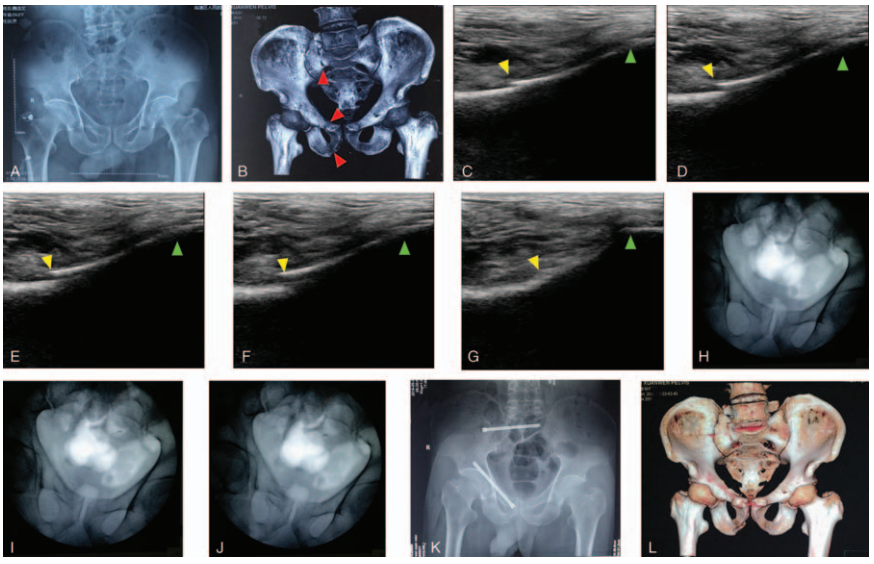

Figure 4. Patient 5, 63-y-old male, suffered an accident in June 2016, conservative treatment. (A) Plain film x-ray and (B) CT at admission (fracture sites are marked with red arrowheads). (C) Ultrasound shows relative movement at the fracture sites during rest. (D–G) Ultrasound under compression and separation (fracture site in the superior ramus is marked with a yellow arrowhead and pubic tuberosity is marked by a green arrowhead) (see Video, Supplemental Video 5, http://links.lww.com/MD/B878 which demonstrates the ultrasonography under compression and separation). During surgery, movement is identified between the 2 sites of the fracture at rest (H) and under compression (I, J). (K) Plain film x-ray and (L) CT after surgery. CT = computed tomography.

limitations may have introduced various biases in the diagnosis of patients with unstable Tile-B2 pelvic fractures.

In conclusion, preoperative assessment of stability using ultrasonography may assist surgeons in making more appropriate treatment choices for patients with Tile-B2 pelvic fractures.

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