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Original Article

Does the residual displacement of pelvic ring affect the functional outcome in pelvic ring injures?

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Abstract: Purpose: The effects of residual displacement on the functional outcome of the patient are not distinctly known and the acceptability criteria of residual displacement of the pelvic ring remain disputed. The purpose of this study is to evaluate the effect of residual displacement on functional outcome in pelvic ring injuries. Materials and Methods: A total of 49 patients with pelvic ring injuries (both operative and non-operative) were followed up for six months. Anteroposterior (AP), Vertical and rotational displacements were measured at admission, after surgery and at six months. Resultant displacement (vector addition of AP and vertical displacement) was taken for comparison. Displacement was graded as excellent, good, fair and poor according to Matta's criteria. Functional outcome assessment was done at six months using Majeed score. Work adjusted Majeed score was calculated for non-working patients by taking the percentage score. Results: We compared the means of residual displacement with functional outcome (Excellent/Good/Fair) and found that there was no significant difference between the groups in operative (P=0.33) or non-operative patients (P=0.09). This showed that patients with relatively higher residual displacement also had satisfactory functional outcomes. The functional outcomes were compared after dividing the residual displacement into 2 groups: <10 mm and >10 mm and no significant difference was found in outcomes for either operative or non-operative patients. Conclusion: Up to 10 mm of residual displacement is acceptable in pelvic ring injuries. More prospective studies with a longer follow up are needed for determination of correlation between reduction and functional outcome.

Keywords: Pelvic ring injuries, trauma, pelvic fractures, functional outcome, residual displacement

Introduction

Displaced pelvic fractures are a marker of high energy trauma. Pelvic injuries, according to major classification systems, are divided into either stable fractures which can withstand normal physiologic loading without significant displacement, or unstable fractures which tend to displace under physiologic loads. Pelvic stability is dependent on the integrity of osseo-ligamentous complex [1]. In general, displacements of more than 1 cm and posterior SI ligament injuries warrant close attention at initial evaluation [2]. Functional outcome of pelvic injury patients depends on various factors such as age, pre-injury status, fracture type and severity, amount of residual displacement and associated injuries. As discussed in multiple previous studies, age negatively affects functional outcome in pelvic fractures, with substantially lower level of functional outcome compared to age-matched general population [3]. This is probably due to poor bone stock and reduced regeneration capabilities [4]. Fracture severity and velocity of trauma can independently affect long term functional outcome. High energy trauma is frequently associated with bladder and rectum injuries as well as other orthopaedic injuries [5]. Previous studies have mentioned about functional outcome with respect to various factors, but only a few studies have evaluated the effect of residual displacement on functional outcome [6-9], The effects of the residual displacement of the pelvic ring on the functional outcome of the patient are not distinctly known and the acceptability criteria of residual displacement of the pelvic ring remain disputed.

The aim of this prospective observational case series is to evaluate the effect of residual displacement, as measured on NCCT (Non-

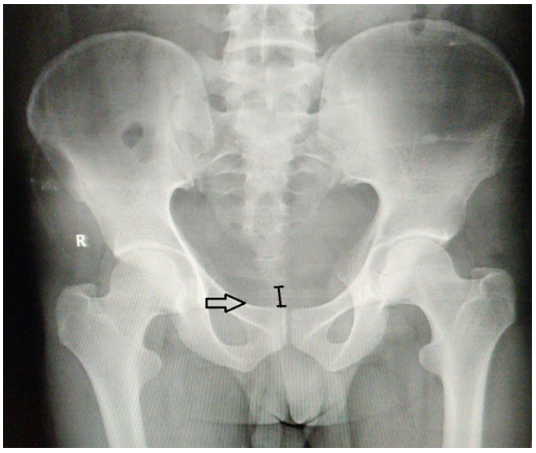

Figure 1. Anteroposterior (AP) Radiograph of pelvis.

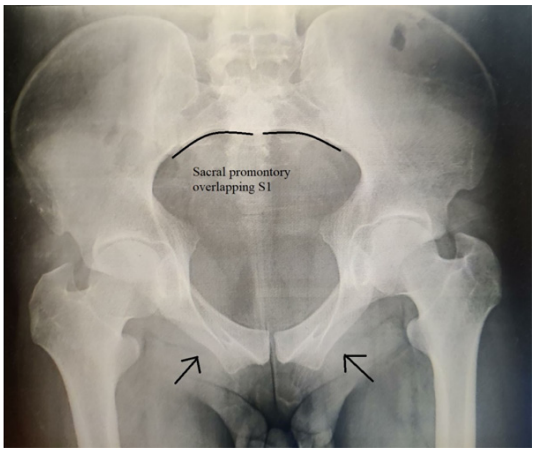

Figure 2. Inlet view of pelvis. Note that sacral promontory overlaps S1 and superior and inferior pubic rami overlap each other.

contrast computed tomography scan) pelvis, on the functional outcome, as measured by Majeed score, in pelvic ring injuries.

Materials and methods

This prospective observational study was conducted from July 2018 to December 2019. All skeletally mature patients who presented with pelvic ring injuries to our level one trauma centre were identified.

We excluded patients not wanting to be a part of study, those with pathological or stress fractures and those with concomitant injuries interfering with locomotion (spine, ipsilateral or contralateral lower limb/acetabulum fracture, head injury). Patients with pre-existing conditions (osteoarthritis knee, gait abnormalities) affecting locomotion were also excluded from the study. Previous health records of patients were used for the selection. A total of 51 patients were identified fitting the inclusion criteria. Two patients died during patient hospital stay and were excluded from the analysis. Thus, a total of 49 patients (which included LC, APC, and VS injuries) were assessed for a follow up period of 6 months.

Data collection was done including patient characteristics, fracture classification on the basis of Young and Burgess classification. The decision regarding management of fracture was done as per institutional protocol. Stable injury patterns (LC1 and APC 1) were managed non-operatively with protected weight bearing. Rest all injuries were operated upon. All the surgeries were performed by two orthopaedic surgeons with considerable experience in pelvi-acetabular trauma. The type of fixation included INFIX, iliosacral screws and reconstruction plates specific to the fracture patterns.

Radiological evaluation

Plain radiographs and three-dimensional reconstruction of computed tomography images was used to create Antero-Posterior (AP), inlet and outlet views using RadiAnt dicom viewer [10] which were defined as follows:

A) AP view (**Figure 1**): the coccyx and symphysis pubis should be in the midline, both sides of the iliac wings and obturator foramina should be symmetric, while the distance between the superior border of the pubic symphysis and the tip of the coccyx should be between one and three cm [11].

B) Inlet view (**Figure 2**): the inferior and superior pubic rami are superimposed and the sacral promontory should overlap the S1 body [11, 12].

C) Outlet view (**Figure 3**): the superior border of the symphysis is at the level of S2 vertebra [11, 12].

The pelvic ring displacements were measured as follows:

Vertical displacement (**Figure 4**): measured as the difference in height of the superior aspect of the sacrum on outlet view [11].

Figure 3. Outlet view of pelvis.

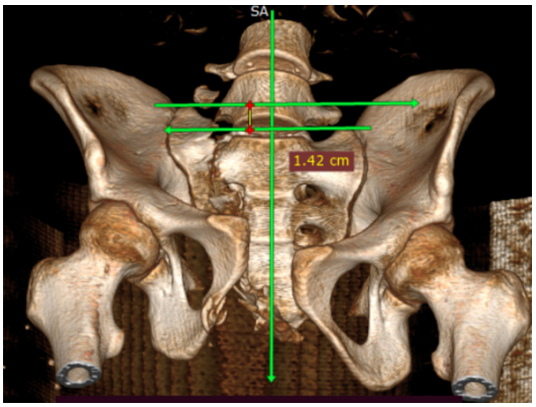

Figure 4. Vertical Displacement of pelvic ring measured as the distance in the heights of the superior aspect of sacrum on outlet view, in this case the vertical displacement being around 14 mm.

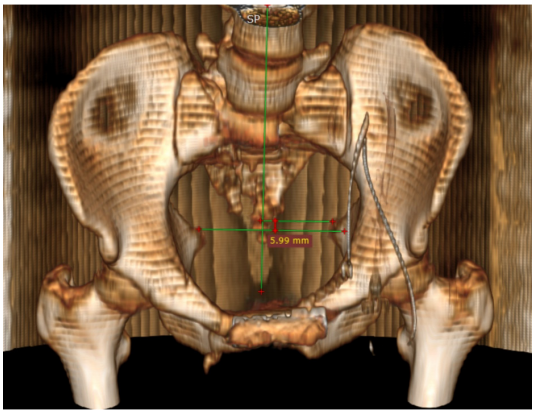

Figure 5. Anteroposterior displacement of Pelvis measured as the perpendicular distance between the two ischial spines on inlet view.

Anteroposterior (AP) displacement (**Figure 5**): measured by using the inlet view of the pelvis. Two perpendiculars to the midline were drawn across each ischial spine. The distance between these two lines corresponds to the AP displacement.

Resultant displacement of the ring was calculated as vector sum of AP and vertical displacements as follows:

$$\text{Resultant displacement} = \sqrt{(y + x\sin 30)^2 + (x\cos 30)^2}$$

x= AP Displacement

y= Vertical Displacement

AP and vertical displacement are perpendicular to each other but since the AP measurement is in Inlet view and Vertical in AP, both of which have a 30-degree angle between them, the angle between the two displacements is 60 degrees and the resultant displacement can be measured using the rules of vector addition as mentioned above.

In the postoperative period, computed tomography scan of pelvis was done and same measurements were taken again (residual displacement) which were used to grade the reduction as excellent (0-5 mm), good (6-10 mm), fair (11-15 mm), and poor (>15 mm) [13]. At 6 months follow-up, repeat NCCT pelvis was done to look for any loss of reduction. All these measurements were done by a senior orthopaedic surgeon with appropriate blinding.

Outcome evaluation

All patients were initially kept on strict non weight bearing mobilisation for the initial three to six weeks along with gentle range of motion exercises and light strengthening exercises; following which protected weight bearing was commenced, gradually leading to full weight bearing as tolerated by the patient.

Functional assessment of patients was done at a minimum of six months follow-up using Majeed score. This was also graded as excellent, good, fair or poor and complications were noted at six months follow-up.

Statistical analysis

All data was analysed using SPSS 22.0 software. Normality of data was assessed using the Kolmogorov-Smirnov test. The means were compared using the t test or ANOVA test. For categorical variables, the Fischer exact test

Table 1. Summary of results

Variable	Operative group (n=29)	Non-operative group (n=20)
Age	32.12±12.03	38.25±13.51
Gender (M/F)	17/12	14/6
Mechanism of Trauma		
Road Traffic Accident	19	16
Fall from height	8	4
Crush Injury	2	0
Injury to surgery time	6.89±4.42 days	-
Young and Burgess Classification		
LC1	0	13
LC2	9	0
LC3	9	0
APC 1	0	7
APC 2	4	0
APC 3	2	0
VS	5	0
Majeed Score (Mean ± SD)	82.2±9.73	92±6.56

was used. For all tests of association, a *P* value less than 0.05 was considered to be statistically significant.

This study was approved by the Institutional Ethics Committee via letter No. INT/IEC/2019/000403 in their meeting held on 28/02/2019.

Results

During the study period, 51 patients were included of which two patients died. Thus, a total of 49 patients were included in the study. Of these, 29 patients were operated and 20 were managed non-operatively.

In the operative group, there were 17 males and 12 females with average age of 32.12± 12.03. The injury to surgery time was 6.89± 4.42 days. In the non-operative group, there were 14 males and 6 females with average age of 38.25±13.51 years. These are illustrated in **Table 1**.

Four patients were lost to follow up in the operative group. Thus, a total of 25 patients in the operative group and 20 patients in the non-operative group were followed for a period of six months.

Radiological outcomes

The resultant displacement was evaluated at the time of injury and at six months follow up in both groups and additionally in the post-operative period for the operative group. No loss of reduction was observed in any case. Union was observed in all cases. As per Matta reduction criteria, quality of reduction in operative cases was excellent in nine, good in 12, fair in three and poor in one at final follow-up. In the non-operative group, it was excellent in 13, good in five and fair in two cases. The radiological outcome of a case with APC 3 injury is shown (**Figures 6**, **7**).

Functional Outcomes

The Majeed score in the operative group was 82.2±9.73 which was excellent in 13, good in nine and fair in three cases. In the non-operative group, the outcome was excellent in 16 and good in four cases with a Majeed score of 92±6.56.

Correlation of residual displacement with functional outcome

We compared the means of residual displacement in accordance to quality of functional outcome (Excellent/Good/Fair) and found that there was no significant difference between the groups in operative (P=0.33) or non-operative patients (P=0.09). This showed that patients with relatively higher residual displacement also had satisfactory functional outcomes.

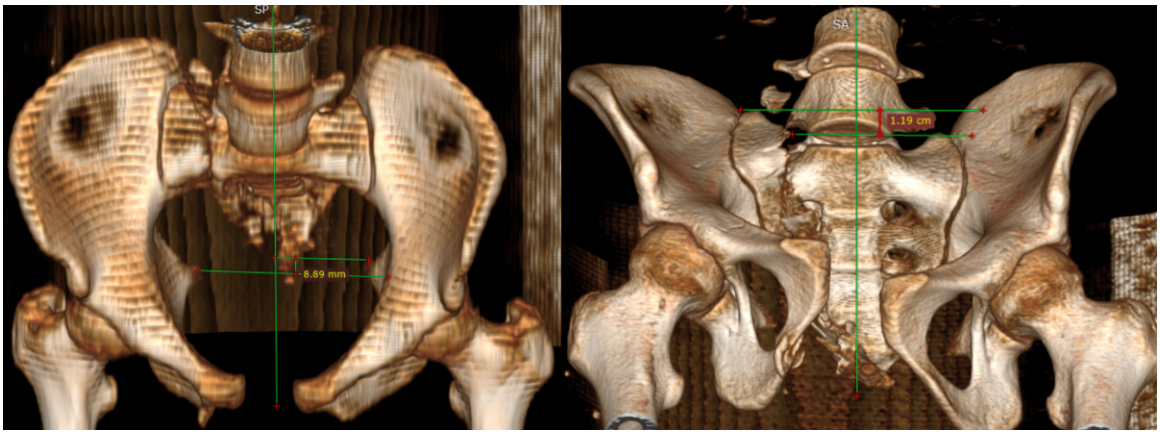

Figure 6. Preoperative anteroposterior and vertical displacement of a case with APC 3 injury.

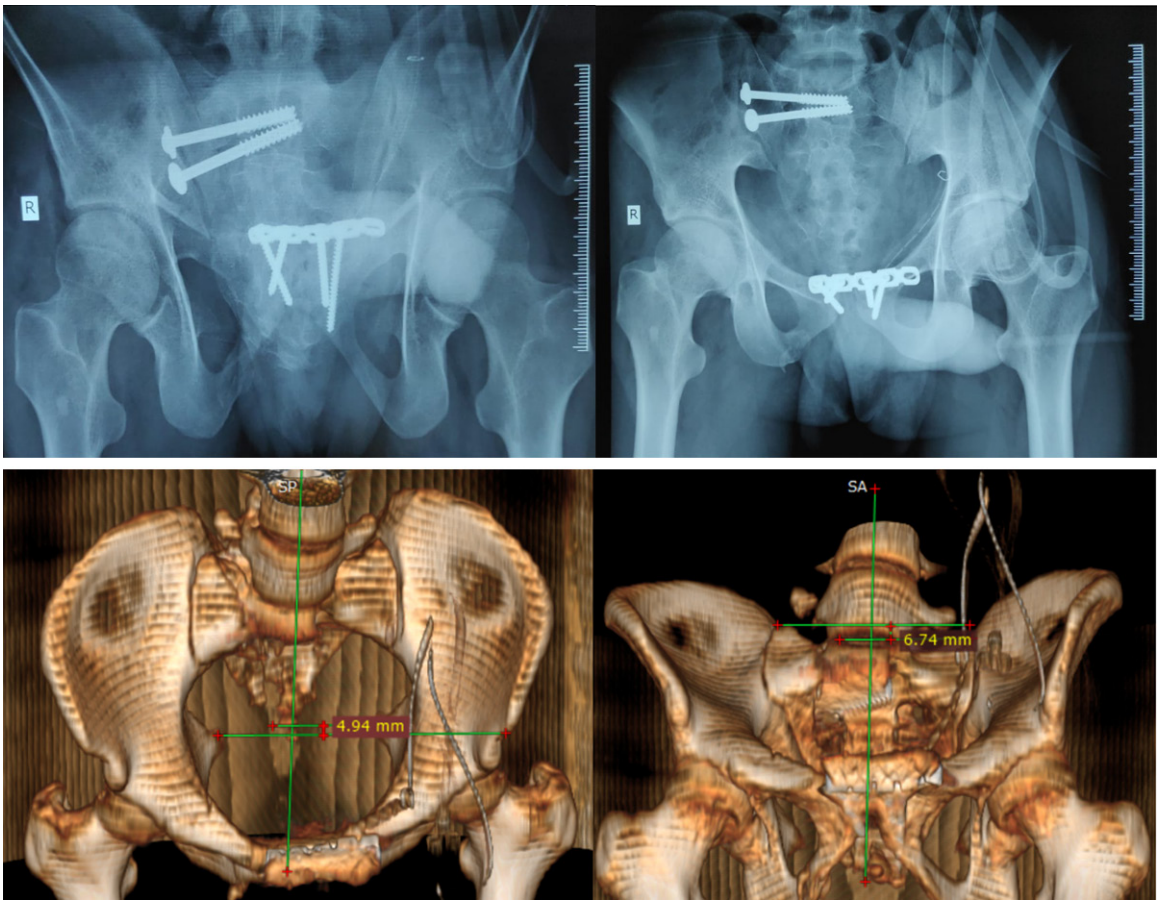

Figure 7. Post operative Radiology and displacement of same case.

We also compared the outcomes after dividing the residual displacement into 2 groups: <10 mm and >10 mm and did not find any significant difference in outcomes for either operative or the non-operative patients.

Four patients had complications. One patient had radicular pain following sacral fixation which could not be relieved with medication and warranted implant removal three months after surgery. Two patients had surgical site

infection. Both patients had MSSA in the culture and were given antibiotics according to sensitivity. Wound healing occurred in both patients and operative intervention was required. One patient had Deep vein thrombosis despite being on a prophylactic anticoagulant. It was managed with Inferior Vena Cava filter (prophylaxis for pulmonary thromboembolism) and Enoxaparin.

Discussion

Pelvic ring injuries are relatively rare and associated with significant morbidity and mortality. The incidence of pelvic ring injuries in trauma patients ranges between 3% and 8.2% and instability occurs in 13% to 17% of cases [14, 15]. Most common mode of a pelvic ring injury is road-side accident which was also observed in our study. These injuries are indicative of high amount of energy transfer to the body and hence are associated with concomitant injuries.

Most pelvic injuries were managed non-operatively prior to the introduction of the concept of pelvic stability by Tile, following which operative fixation became a mainstay for unstable fractures. Although the reduction of pelvic ring injuries is thought to correlate with good functional outcomes [16, 17], however, most previous studies on this subject have not mentioned about the residual displacement and its correlation with functional outcomes. Also, the few studies having reported resultant displacement have included patients with concomitant injuries to the acetabulum and lower limb. We excluded such patients as we believe that these injuries affect functional outcome thereby preventing direct analysis of impact of residual displacement on functional outcome.

Previously, few studies have used Matta's criteria for categorizing the reduction [6, 16, 17]. Shetty AP et al. studied the radiologic and functional outcome (using Majeed score) of pelvic injuries in 15 patients managed with INFIX [6]. Kabak S et al. evaluated the residual displacement with the affective status of the patient (HDARS) [16]. Mardanpour et al. [17] compared the radiologic and functional outcome with respect to the fracture type and concluded that unstable pelvic fractures required rigid internal fixation as soon as the general condition permits. Pastor et al. [18] established a moderate correlation between clinical outcome and radiographic quality of reduction in their case series of 31 patients.

In present study, reduction was graded as excellent in 22 cases, good in 17 cases, fair in five cases and poor in one case. Previous studies have used the larger of the two dimensions for grading [6, 16, 17], while we have taken the resultant of the AP and vertical displacement for comparison. Although using this resultant displacement in place of larger of the two dimensions did not change the grading as per Matta's scoring system, however, we still believe that our resultant displacement is more indicative of maximal displacement for pelvic fractures.

We observed that 18 of the 21 patients in the operative group and all 18 patients in the non-operative group with <10 mm of residual displacement on CT scan had excellent or good outcomes signifying that 10 mm residual pelvic ring displacement is acceptable. We also observed that three patients who had a worse outcome (fair) also had resultant displacement of <10 mm, showing that other factors such as patient compliance with rehabilitation therapy, affective status, etc. also play important role in the outcome [19, 20].

We did not observe any significant difference in the outcomes whether the displacement was less than or more than 10 mm. However, we believe the main reason for this is that most patients with less displacement were managed non-operatively while those with larger displacements were reduced adequately to achieve satisfactory outcomes (selection bias).

Our study was limited by the short duration of follow up, which was only six months. There was lack of randomisation, as the decision to operate was guided by the surgeon according to the fracture classification and instability, introducing selection bias which prevented us to compare operative and non-operative treatments. Patients with concomitant severe injuries were excluded from the study, possibly causing under representation of severe injuries.

However, we believe that stable pelvic injuries can be managed non-operatively while operative management should be reserved for unstable injuries. A resultant displacement of 10 mm

is acceptable in pelvic ring injuries, however further studies with larger sample size are required to validate the same.

Conclusion

Residual displacement up to 10 mm in pelvic ring injuries is associated with satisfactory functional outcomes. More prospective studies with a longer follow up are needed for determination of correlation between reduction and functional outcome.

Disclosure of conflict of interest

None.

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References

[1] Yoshihara H and Yoneoka D. Demographic epidemiology of unstable pelvic fracture in the United States from 2000 to 2009: trends and in-hospital mortality. J Trauma Acute Care Surg 2014; 76: 380-385.

[2] Khurana B, Sheehan SE, Sodickson AD and Weaver MJ. Pelvic ring fractures: what the orthopedic surgeon wants to know. Radiographics 2014; 34: 1317-1333.

[3] Banierink H, ten Duis K, de Vries R, Wendt K, Heineman E, Reininga I and IJpma F. Pelvic ring injury in the elderly: fragile patients with substantial mortality rates and long-term physical impairment. PLoS One 2019; 14: e0216809.

[4] Verma V, Sen RK, Tripathy SK, Aggarwal S and Sharma S. Factors affecting quality of life after pelvic fracture. J Clin Orthop Trauma 2020; 11: 1016-1024.

[5] Wu K, Posluszny JA, Branch J, Dray E, Blackwell R, Hannick J and Luchette FA. Trauma to the pelvis: injuries to the rectum and genitourinary organs. Curr Trauma Rep 2015; 1: 8-15.

[6] Shetty AP, Bosco A, Perumal R, Dheenadhayalan J and Rajasekaran S. Midterm radiologic and functional outcomes of minimally-invasive fixation of unstable pelvic fractures using anterior internal fixator(INFIX) and percutaneous iliosacral screws. J Clin Orthop Trauma 2017; 8: 241-248.

[7] Nepola JV, Trenhaile SW, Miranda MA, Butterfield SL, Fredericks DC and Riemer BL. Vertical shear injuries: is there a relationship between residual displacement and functional outcome? J Trauma 1999; 46: 1024-1030.

[8] Henderson RC. The long-term results of nonoperatively treated major pelvic disruptions. J Orthop Trauma 1989; 3: 41-47.

[9] Sen RK and Veerappa LA. Outcome analysis of pelvic ring fractures. Indian J Orthop 2010; 44: 79-83.

[10] RadiAnt DICOM Viewer. https://www.radiantviewer.com/. Accessed 14 Oct 2020.

[11] Mataliotakis GI and Giannoudis PV. Radiological measurements for postoperative evaluation of quality of reduction of unstable pelvic ring fractures: advantages and limitations. Injury 2011; 42: 1395-1401.

[12] Pekmezci M, Rotter P, Toogood P, Morshed S and Kandemir U. Reexamination of pelvic inlet and outlet images using 3-dimensional computed tomography reconstructions. J Orthop Trauma 2014; 28: 324-329.

[13] Lindahl J, Hirvensalo E, Böstman O and Santavirta S. Failure of reduction with an external fixator in the management of injuries of the pelvic ring. Long-term evaluation of 110 patients. J Bone Joint Surg Br 1999; 81: 955-962.

[14] Mucha P Jr and Farnell MB. Analysis of pelvic fracture management. J Trauma 1984; 24: 379-386.

[15] van Veen IH, van Leeuwen AA, van Popta T, van Luyt PA, Bode PJ and van Vugt AB. Unstable pelvic fractures: a retrospective analysis. Injury 1985; 26: 81-85.

[16] Kabak S, Halici M, Tuncel M, Avsarogullari L, Baktir A and Basturk M. Functional outcome of open reduction and internal fixation for completely unstable pelvic ring fractures (type C): a report of 40 cases. J Orthop Trauma 2003; 17: 555-562.

[17] Mardanpour K and Rahbar M. The outcome of surgically treated traumatic unstable pelvic fractures by open reduction and internal fixation. J Inj Violence Res 2013; 5: 77-83.

[18] Pastor T, Tiziani S, Kasper CD, Pape HC and Osterhoff G. Quality of reduction correlates with clinical outcome in pelvic ring fractures. Injury 2019; 50: 1223-1226.

[19] Halawi MJ. Pelvic ring injuries: surgical management and long-term outcomes. J Clin Orthop Trauma 2016; 7: 1-6.

[20] Pavelka T, Dzupa V, Stulík J, Grill R, Báca V and Skála-Rosenbaum J. Our results of surgical management of unstable pelvic ring injuries. Acta Chir Orthop Traumatol Cech 2009; 74: 19-28.