

Early weight bearing in acetabular and pelvic fractures

Luigi Murena¹, Gianluca Canton¹, Bramir Hoxhaj², Andrea Sborgia¹, Roberto Fattori¹, Stefano Gulli¹, Enrico Vaienti³

¹ Orthopaedics and Traumatology Unit, Cattinara Hospital - ASUGI, Department of Medical, Surgical and Life Sciences, Trieste University, Trieste (Italy); ² Orthopaedics and Traumatology Unit, Piove di Sacco Hospital, ULSS6, Padova (Italy); ³ Orthopaedics and Traumatology Clinic, Department of Medicine and Surgery, University of Parma (Italy).

Abstract. *Background and aim of the work:* The incidence of pelvic and acetabular fractures is increasing during the years, counting 37 pelvic fractures per 100000 people annually. No weight bearing or toe touch weight bearing are usually chosen in the initial management to allow fracture and ligamentous healing and avoid fracture displacement and fixation failure. On the other hand, early weight bearing may stimulate fracture healing and allow prompt functional recovery, faster return to work and recreational activities and reduce complications linked to late rehabilitation. Aim of the study is to review the literature about weight bearing indications for pelvic and acetabular fractures to highlight clinical and biomechanical evidence supporting early weight bearing. *Methods:* Two independent reviewers independently extracted studies on early weight bearing of pelvic and acetabular fractures. All selected studies were screened independently based on title and abstract. Then the full text of any article that either judged potentially eligible was acquired and reviewed again. Any disagreement was resolved by discussing the full text manuscripts. *Results:* 44 studies including reviews, meta-analysis, clinical and biomechanical studies were selected. *Conclusions:* Despite biomechanical data, few clinical evidences can be found to support early weight bearing in pelvic and especially acetabular fractures treatment. The promising results of some clinical experiences, however, should direct further studies to clearly define the indications and limits of early weight bearing in these injuries. Recognizing intrinsic lesion stability and bone and fixation technique quality, together with patient age and compliance, should be the mainstay for post-operative management choice. (www.actabiomedica.it)

Key words: Early weight bearing, acetabular fracture, pelvic fracture, weight bearing

Introduction

The incidence of pelvic and acetabular fractures is increasing, counting 37 pelvic fractures per 100000 people annually, predominantly in elderly patients (1).

According to the AO principles of fracture management, no weight bearing or toe touch weight bearing should be chosen in the initial management of unstable pelvic and acetabular fractures. Weight bearing restriction for 10 -12 weeks, followed by progressive weight bearing (25% increase per week),

is considered the gold standard protocol for the vast majority of surgeons (2,3). This choice is motivated by the reduced forces at the fracture site in order to allow bony and ligamentous healing, reduce the risk of implant failure, fracture displacement, malunion or nonunion. However, postoperative indications are often based on empirical medical knowledge acquired through many years of clinical practice. There is lack of evidence-based studies about postoperative indications for surgically managed unstable pelvis and acetabular fractures (4). Consequently, surgeons tend to

be more conservative on postoperative weight bearing at the expense of fast recovery, muscle strength and edema resorption (4). However, biomechanical studies challenge the rationale of restrictive weight bearing (5, 6).

Moreover, patients are not always compliant with non-weight or limited weight bearing protocols (3, 4). Even if post-operative indications on restricted or limited weight bearing may be clear, numerous studies show that patient compliance is poor, exceeding the prescribed amount of weight bearing even with real time feedback devices (3). Nonetheless, few complications are reported in the clinical practice due to overloading.

On the other hand, weight bearing may evoke micro-movements between fracture fragments stimulating fracture healing (7). Moreover, it may allow prompt functional recovery, faster return to work and recreational activities and reduce complications linked to late rehabilitation.

Aim of the present study is to review the literature about weight bearing indications for pelvic and acetabular fractures to highlight clinical and biomechanical evidence supporting early weight bearing.

Materials and methods

The electronic databases Embase, Pubmed, Scopus and Medline were searched from inception of the database to September 16th, 2019. Two of the authors (B.H and A.S) independently extracted studies using various combinations of the search terms and keywords: “full” OR “partial” OR “restricted” AND “weight bearing”; “rehabilitation” OR “exercise”; “acetabular” OR “acetabulum” OR “pelvic ring” AND “fracture”; “joint loading”. Retrospective, prospective, comparative and also experimental, observational and case report studies were included. All selected studies were screened independently by the two reviewers (B.H. and A.S.) based on title and abstract. Then the full text of any article that either judged potentially eligible was acquired and reviewed again. Duplicate were eliminated and references were hand-screened for relevant citations. Any disagreement was resolved by discussing the full text manuscripts.

Results

Applying inclusion and exclusion criteria, 44 studies including reviews, meta-analysis, clinical and biomechanical studies were selected.

Pelvic fractures

There are several classifications of pelvic fractures (8). According to Young – Burgess classification pelvic fractures are divided in lateral compression (LC), antero-posterior compression (APC), vertical shear (VS) and combined mechanisms (9).

In type I APC injuries (symphysis widened < 2.5 cm) the pelvic ring is considered stable, thus non-surgical management is preferred and full weight bearing can be allowed (10). In case of a type II APC injury surgical stabilization is preferred [11]. In a survey study on this fracture type 11% of the surgeons allowed full weight bearing, 46% partial weight bearing and 43% non-weight bearing. There was no correlation between early full weight bearing and chosen method of fixation. Regarding time until full weight bearing to the affected side, 11% allowed immediate full weight bearing, 29,7% allowed weight bearing within 4 weeks and 59.5% within 8–12 weeks post operatively [12].

Lateral compression (LC) type I-II injury is represented by a lesion to the superior and inferior pubic rami associated with an impaction fracture of the sacrum. Bruce et al. conducted a study on 117 lateral compression pelvic fractures without acetabular fractures treated conservatively. Weight bearing was allowed as tolerated unless restricted by concomitant lower limb injuries and none of the patients was treated with bed rest. The authors concluded that incomplete lateral compression sacral fractures associated with ipsilateral rami fractures are unlikely to displace. Therefore, nonoperative treatment and early weight bearing as tolerated might be allowed in these injuries. In contrast, a complete sacral fracture with associated bilateral rami fractures is associated with a significant displacement rate (13, 14).

In case of APC type III and LC type III with vertical displacement or in vertical shear injury, both posterior and anterior osteosynthesis is needed (11, 14, 15). Weight bearing restriction on the affected side

until 8 – 12 weeks for these injuries is still considered the treatment of choice according to most authors (14, 16). To date, there is no optimal surgical fixation construct (14). However, surgical technique might influence the possible choice for early weight bearing. Nonetheless, Schildhauer et al. in 1998 described a technique of triangular osteosynthesis (spino–pelvic fixation in addition to ileo–sacral fixation) that can allow early weight bearing for vertical unstable sacral fractures according to the authors [17]. In case of spinopelvic fixation of posterior pelvic ring injuries different studies have reported that early progressive weight bearing should be the proper postoperative indication (17, 18).

Acetabular fractures

According to the AO principles of fracture management, the postoperative treatment of acetabular fractures (as other intra-articular fractures of the lower limb) consists of no weight bearing or toe touch weight bearing for 6 to 12 weeks to reduce joint reactive forces (2).

Immediate post-operative weight bearing is usually not recommended, motivated by concern for the risk of loss of reduction especially at the articular surface.

The literature on early weight bearing in this kind of fractures is restricted. Indeed, only few studies have been published reporting the result of weight bearing allowed any earlier than AO postoperative management indications.

Meys G. et al. have described a protocol for permissive weight bearing (PWB) in surgically treated fractures of the pelvis and lower extremities (PRO-METHEUS protocol). Level of weight bearing and therapy intensity were established based on patient's characteristics, predictors of fracture consolidation and clinical symptoms screened at the beginning of each therapy session. Seventy-six out of 150 patients had pelvic/acetabular fractures, with mean time to full weight bearing 12.6 weeks (range 2-52). The authors reported a complication rate of 10%, which was considered to be in line with the published data on more restrictive postoperative protocols (4). Mouhsine et al. conducted a study on 21 elderly patients (mean age,

81 years) with non-displaced or minimally displaced column, transverse or T-type fractures fixed percutaneously. All patients were allowed to weight bearing as tolerated at 4 weeks. The authors described no loss of fixation or screw failures at any time of the study (mean follow-up: 3.5 years, range 2 to 5 years) and 17 of 18 surviving patients had satisfactory clinical results (19). Kazemi et al. described 28 patients with anterior column or anterior column posterior hemitransverse acetabulum fractures treated with closed reduction and percutaneous screw fixation followed by immediate full weight bearing postoperatively. None of the 22 patients (6 were lost to follow-up) had fracture reduction loss on postoperative radiograph at any time of the study (mean follow-up: 39 months, range: 12-74 months). Furthermore, at final follow up all patients had excellent clinical and functional outcomes assessed with modified d'Aubigné Score and Short Musculoskeletal Function Assessment (mean 17,4 and 20,2 respectively) (20).

Bozzio et al. in their study on anterior and posterior column acetabular fractures treated with percutaneous fixation allowed weight bearing as tolerated protected with crutches or a walker. They report good clinical outcomes and low risk of secondary displacement (21).

In a study on 27 patients with acetabular both column fractures treated surgically using exclusively the ileoinguinal approach, Gansslen et al allowed immediate partial weight bearing for 8-12 weeks, starting from 2nd postoperative day. No loss of reduction and excellent/good outcomes were described by the authors at 2 years follow up (22).

Caviglia et al. in a recent review reported that both anterior and posterior columns treated with percutaneous fixation can begin 50% weight bearing 48 hours after surgery (23).

A review of surgically managed posterior wall fractures found no difference on functional scores or complication rates between immediate postoperative weight bearing (152 cases) and late weight bearing (302 cases) (24).

Discussion

Surgical decision making of pelvic and acetabular fractures is challenging. Post-operative indications on

weight bearing may depend on several factors, including fracture pattern, type of osteosynthesis, bone and soft tissue quality, associated injuries, comorbidities, age, sex and implant conditions (25, 26).

The major concern about early weight bearing is the risk of fixation failure and fracture displacement. This concern is particularly relevant among surgeons since the literature demonstrates that loss of reduction is associated with bad patient outcome and development of posttraumatic arthritis, especially after acetabular fractures (27, 28). Matta et al. in a study on 262 acetabular fractures reported that clinical results were closely related to anatomical reduction. However, the author did not report any association of further fracture displacement with weight bearing (27). On the other hand, multiple studies have shown that pressure on the acetabulum during non-restricted movements such as sit-to-stand far exceed the strains achieved during normal ambulation (5, 6). Furthermore, it has been shown that the peak pressure during standing up and sitting down is directed to posterior wall of acetabulum and results to be 2.8 times that of normal walking (5). Wasterman et al. in a study on 11 healthy young patients reported that restriction of weight bearing results in 4-fold increase in energy required for ambulation compared with full weight bearing. Furthermore, the authors sustained that toe touch weight bearing may be more tolerable and less tiring compared to restricted weight bearing (29). Moreover, toe touch weight bearing or partial weight bearing alters gait biomechanics and shifts load from forefoot to rearfoot (30).

Therefore, early weight bearing might be of advantage in many pelvic and acetabular fractures treatment. Many studies report that in case of stable and partially unstable pelvic ring fractures early weight bearing can be allowed without progression of fracture displacement (Figures 1 and 2) (13, 14).

Conversely, in totally unstable pelvic ring fractures weight bearing restriction is still considered the treatment of choice. However, the exact healing time of ligamentous injuries in order to allow full weight bearing is still unclear (14). Few evidences can be found to sustain early weight bearing in these injuries, depending mostly on treatment modality. However,

results of early weight bearing with spinopelvic fixation or combined spinopelvic and ileo-sacral (triangular) fixation are promising.

In the elderly population, partially unstable or non-displaced anterior and posterior complete fractures can be mobilized with partial weight bearing (20 kg) on the injured side (10). However, partial weight bearing is not always possible in this population due to associated diseases and scarce compliance. In a study on 34 elderly patients (> 75 years old) with hip fractures treated with antegrade intramedullary nail (PFNA) and weight bearing restriction resulted that only 1 patient was compliant for a limited time. The authors recommended for this population that partial weight bearing should be abandoned (31). In this frail

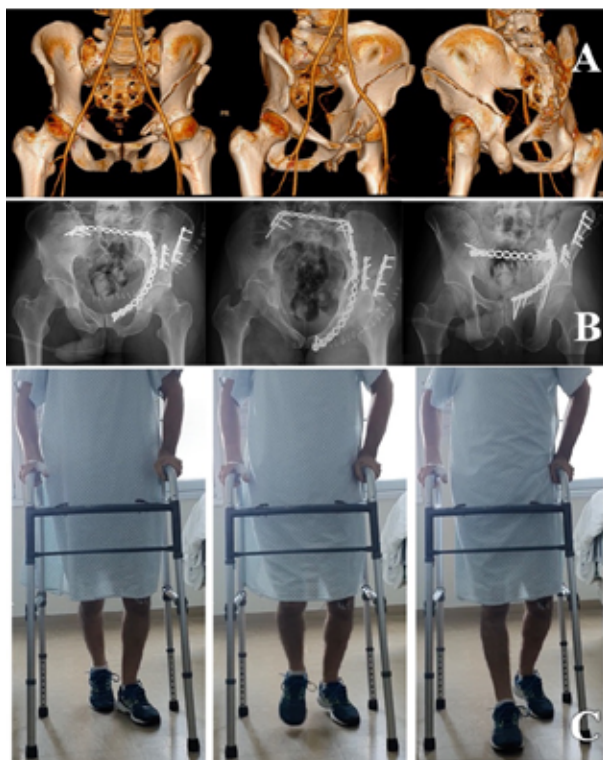


Figure 1. Clinical case of early weight bearing after ORIF for unstable pelvic ring fracture. A) Preoperative 3D-CT scan demonstrating a bilateral lateral compression pelvic ring fracture (AO B.2.1 fracture of the left hemipelvis, isolated sacral wing compression fracture of the right hemipelvis). B) post-operative pelvis X-rays in standard view, inlet and outlet view. C) Clinical pictures of the patient walking with partial weight bearing on the left side and full weight bearing on the right side 7 days after surgery.

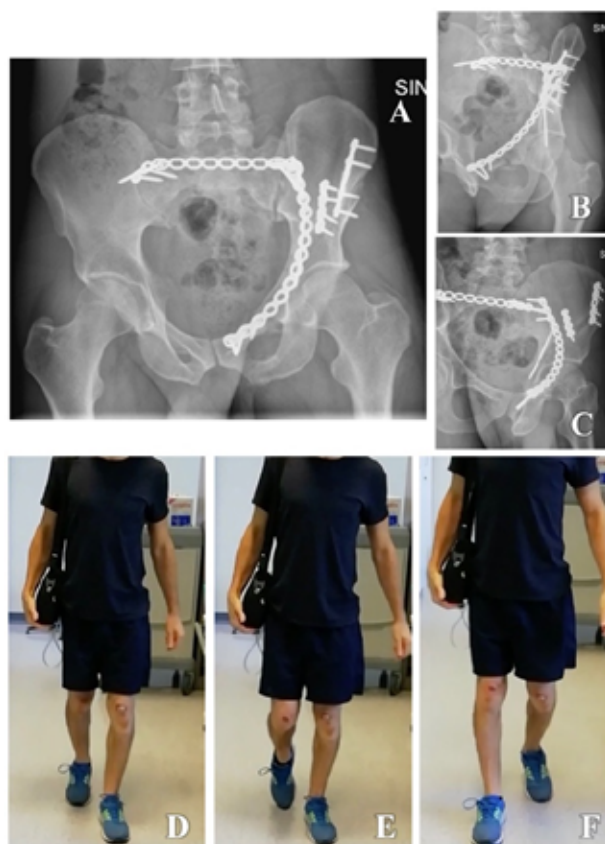


Figure 2. Same case of figure 1. Post-operative pelvis X-rays at 6 weeks in AP (A), obturator (B) and iliac view (C). D, E, F) Clinical pictures of the patient walking without crutches with bilateral full weight bearing at 6 weeks follow up.

population of patients, however, the benefits and risks of prolonged bed rest compared to surgical management should be weighted case by case, taking care to identify all the lesions stable enough to allow early full weight bearing without surgery. Given the above data, Küper et al. in a review study recommend allowing full weight bearing and a CT scan control at 10 to 12 days in the geriatric population with this pattern of pelvic fractures (10).

In acetabular fracture treatment scenario, some evidence supporting early weight bearing can be found in the literature. For non-displaced or minimally displaced (< 2mm) anterior column and anterior column posterior hemitransverse fractures treated with percutaneous fixation different authors allow early weight bearing reporting no secondary displacement and good clinical results (19, 20, 23). Despite the advantages in

terms of minimal invasiveness and post-operative pain with percutaneous fixation, the reasons for these results should be better attributed to the intrinsic stability of non-displaced and minimally displaced fractures (Figure 3 and 4).

However, some studies reporting good results and substantial absence of fixation failure or loss of reduction with displaced fracture both treated percutaneously and with open (posterior or anterior) reduction and fixation are reported. (19, 22, 24).

Despite these promising results, concerns about fixation failure and loss of reduction are still considered too high by most surgeons and the vast majority of published papers still recommend weight bearing restriction for most acetabular fractures.

(32, 33). These considerations are more so relevant in case of severely comminuted fractures of the acetabulum in the elderly population, where acute primary hip arthroplasty is considered by most authors to be the only treatment modality that may allow for immediate post-operative weight bearing on the affected side (34).

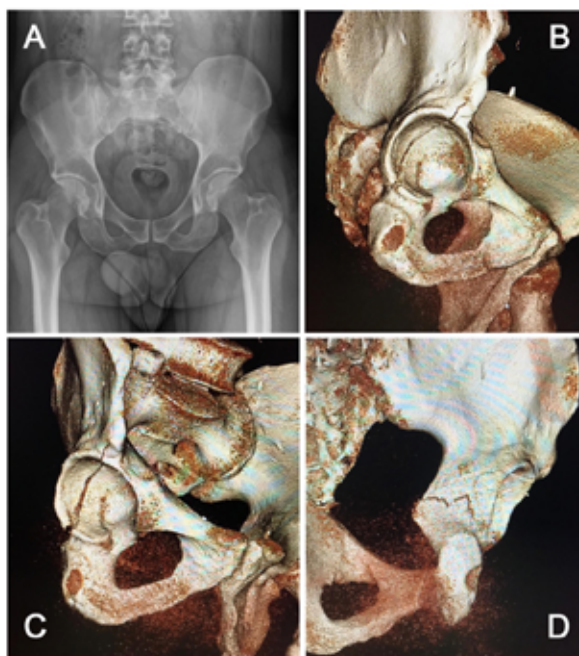


Figure 3. a) Preoperative pelvis X-Ray of a posterior column right acetabulum fracture. b, c, d) 3D CT scan of the same case showing minimal displacement of the posterior column.

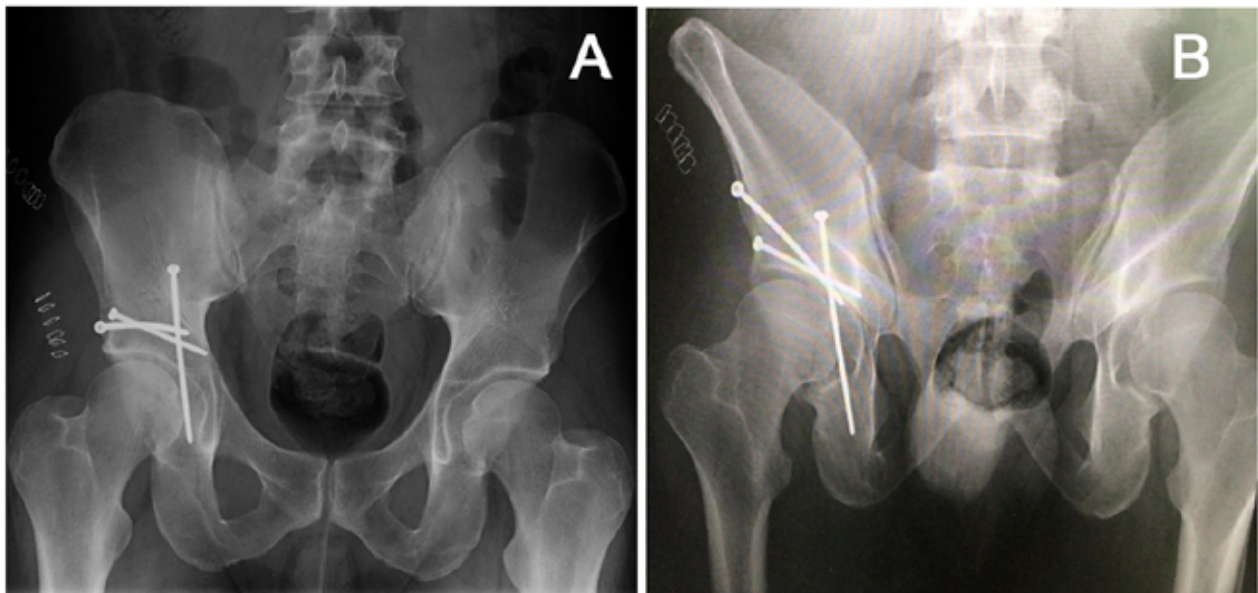


Figure 4. Same case of figure 1. a) Intraoperative fluoroscopy and b) postoperative pelvis X-Ray showing percutaneous fixation of the right acetabular fracture

Conclusions

Despite biomechanical data, few clinical evidences can be found to support early weight bearing in pelvic and especially acetabular fractures treatment. The promising results of some clinical experiences, however, should direct further studies to clearly define the indications and limits of early weight bearing in these injuries. Recognizing intrinsic lesion stability and bone and fixation technique quality, together with patient age and compliance, should be the mainstay for post-operative management choice.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

References

- Mears DC, Velyvis JH, Chang CP. Displaced acetabular fractures managed operatively: indicators of outcome. *Clin Orthop Relat Res.* 2003; 407: 173–186.
- Ruedi TP, Buckely RE, Moran CG. *AO principles of fracture management.* 2nd edition. New York: Thieme; 2008.
- Hustedt JW, Blizzard DJ, Baumgaertner MR, et al. Is it possible to train patients to limit weight bearing on a lower extremity? *Orthopedics.* 2012; 35: 31–7.
- Meys G, Kalmes P, Sanduleanu S, van Horn Y, Maas GJ, Poeze M, et al. A protocol for permissive weight-bearing during allied health therapy in surgically treated fractures of the pelvis and lower extremities. *J Rehabil Med.* 2019; 51(4): 290–297
- Yoshida H1, Faust A, Wilckens J, Kitagawa M, Fetto J, Chao EY. Three-dimensional dynamic hip contact area and pressure distribution during activities of daily living. *J Biomech.* 2006;39(11): 1996–2004.
- Bergmann G, Deuretzbacher G, Heller M, Graichen F, Rohlmann A, Strauss J et al. Hip contact forces and gait patterns from routine activities. *J Biomech.* 2001; 34: 859–71.
- Magee DJ, Zachazewski JE, Quillen WS. *Scientific foundations and principles of practice in musculoskeletal rehabilitation.* St Louis: Saunders Elsevier; 2007.
- Tile M, Pennal GF. Pelvic disruption: Principles of management. *Clin Orthop Relat Res* 1980; 151: 56–64.
- Young JWR, Burgess AR, Brumback RJ, Poka A. Pelvic fractures: value of plain radiography in early assessment and management. *Radiology.* 1986; 160: 445–451.
- Küper MA, Trulsson A, Stuby FM, Stöckle U. Pelvic ring fractures in the elderly. *EFORT Open Rev.* 2019; 4: 313–320.
- Matta JM. Indications for anterior fixation of pelvic fractures. *Clin Orthop Relat Res* 1996; 329: 88–96.
- Gill J, Murphy C, Quansah B, Carrothers A. Management of the open book APC II pelvis: Survey results from pelvic

- and acetabular surgeons in the United Kingdom. *J Orthop*. 2017; Aug 9; 14(4): 530-536.
13. Bruce B, Reilly M, Sims S. OTA Highlight Paper Predicting Future Displacement of Nonoperatively Managed Lateral Compression Sacral Fractures: Can It Be Done?. *J Orthop Trauma*. 2011; 25: 523-7.
 14. Langford J, Burgess A, Liporace F, Haidukewych G. Pelvic Fractures: Part 2. Contemporary Indications and Techniques for Definitive Surgical Management. *J Am Acad Orthop Surg*. 2013; 21: 458-468.
 15. Wojahn R, Gardner M. Fixation of Anterior Pelvic Ring Injuries. *J Am Acad Orthop Surg*. 2019; 27: 667-676.
 16. Tile M, Pennal GF. Pelvic disruption: Principles of management. *Clin Orthop Relat Res* 1980; 151: 56-64.
 17. Schildhauer TA, Josten C, Muhr G. Triangular osteosynthesis of vertically unstable sacrum fractures: a new concept allowing early weight-bearing. *J Orthop Trauma*. 2006; 20 (Suppl.1): 44-51.
 18. Verbeek D, Routt M. High-Energy Pelvic Ring Disruptions with Complete Posterior Instability: Contemporary Reduction and Fixation Strategies. *J Bone Joint Surg Am*. 2018; 100: 1704-1712.
 19. Mouhsine E, Garofalo R, Borens O, Wettstein M, Blanc CH, Fischer JF, et al. Percutaneous retrograde screwing for stabilization of acetabular fractures. *Injury*. 2005; 36(11): 1330-6.
 20. Kazemi N, Archdeacon MT. Immediate full weight bearing after percutaneous fixation of anterior column acetabulum fractures. *J Orthop Trauma*. 2012; 26: 73-9.
 21. Bozzio A, Wydra F, Mitchell J, Ackerson R, Mauffrey C. Percutaneous Fixation of Anterior and Posterior Column Acetabular Fractures. *Orthopedics*. 2014; 37: 675-678.
 22. Gänsslen A, Krettek C. Internal fixation of acetabular both-column fractures via the ilioinguinal approach. *Oper Orthop Traumatol*. 2009; 21(3): 270-82.
 23. Caviglia H, Mejail A, Landro ME, Vatani N. Percutaneous fixation of acetabular fractures. *EFORT Open Rev*. 2018; 3: 326-34.
 24. Heare A, Kramer N, Salib C, Mauffrey C. Early versus late weight-bearing protocols for surgically managed posterior wall acetabular fractures. *Orthopedics*. 2017; 40(4): e652-e657.
 25. Gaston MS, Simpson AH. Inhibition of fracture healing. *J Bone Joint Surg Br*. 2007; 89: 1553-1560.
 26. Hernandez RK, Do TP, Critchlow CW, Critchlow CW, Dent RE, Jick SS. Patient-related risk factors for fracture-healing complications in the United Kingdom General Practice Research Database. *Acta Orthop*. 2012; 83: 653-660.
 27. Matta JM. Fractures of the acetabulum; accuracy of reduction and clinical results in patients managed operatively within three weeks after the Injury. *J Bone Joint Surg Am*. 1996; 78: 1632-45.
 28. Tannast M, Najibi S, Matta JM. Two to twenty-year survivorship of the hip in 810 patients with operatively treated acetabular fractures. *J Bone Joint Surg Am*. 2012; 94(17):1559-67.
 29. Westerman R, Hull P, Hendry RG, Cooper J. The physiological cost of restricted weight bearing. *Injury*. 2008;39: 725-7. 10.1016/j.injury.2007.11.007.
 30. North K, Potter MQ, Kubiak EN, Bamberg SJ, Hitchcock RW. The effect of partial weight bearing in a walking boot on plantar pressure distribution and center of pressure. *Gait Posture*. 2012; 36(3): 646-9.
 31. Kammerlander C, Pfeufer D, Lisitano L, Mehaffey S, Böcker W, Neuerburg C. Inability of Older Adult Patients with Hip Fracture to Maintain Postoperative Weight-Bearing Restrictions. *J Bone Joint Surg Am*. 2018; 100: 936-941.
 32. Zhang L, Yin P, Zhang W, Li T, Li J, Chen H et al. An Effective and Feasible Method, "Hammering Technique," for Percutaneous Fixation of Anterior Column Acetabular Fracture. *BioMed Res Int*. 2016; 1-6.
 33. Magu NK, Gogna P, Singh A, Singla R, Rohilla R, Batra A, et al. Long term results after surgical management of posterior wall acetabular fractures. *J Orthop Traumatol*. 2014; 15: 173-179.
 34. Cochu G, Mabit C, Gougam T, Fiorenza F, Baertich C, Charissoux JL, et al. Total hip arthroplasty for treatment of acute acetabular fracture in elderly patients. *Rev Chir Orthop*. 2007; 93: 818-27.

Correspondence:

Received: 10 October 2020

Accepted: 3 November 2020

Bramir Hoxhaj,

Orthopaedics and Traumatology Unit,

Piove di Sacco Hospital, ULSS6, Padova (Italy),

Via S. Rocco 8, 35028 Piove di Sacco PD,

E-mail: bramirhoxhaj@gmail.com