SBOT
SOCIEDADE BRASILEIRA DE ORTOPEDIA E TRAUMATOLOGIA

RBO REVISTA BRASILEIRA DE ORTOPEDIA

www.rbo.org.br

Original Article

CT-guided percutaneous sacroiliac stabilization in unstable pelvic fractures: a safe and accurate technique☆

Govind Gandhi[a], Mayank Vijayvargiya[a], Vivek Shetty[a,*], Vikas Agashe[a], Shailendra Maheshwari[b], Joseph Monteiro[c]

[a] Department of Orthopaedics, Hinduja National Hospital, Mumbai, India
[b] Department of Radiodiagnosis, Hinduja National Hospital, Mumbai, India
[c] Department of Anaesthesiology, Hinduja National Hospital, Mumbai, India

ARTICLE INFO

Article history:
Received 27 December 2016
Accepted 2 March 2017
Available online 30 March 2017

Keywords:
Bone screws
External fixators
Fracture fixation, internal
Fractures, bone
Pelvic bones

ABSTRACT

Objective: The use of open reduction and internal fixation (ORIF) for unstable pelvic injuries is associated with extensive blood loss, iatrogenic neurovascular injury, and infection. Moreover, the placement of sacroiliac (SI) screws is a blinded procedure, guided primarily by palpation and two-dimensional radiological screening, which demands expertise. The complex three-dimensional anatomy of SI joint and its proximity to neurovascular structure require a safe and precise technique. Computed tomography (CT)-guided SI joint stabilization allows an accurate intra-operative assessment of screw placement. This study demonstrated a technique of CT-guided closed reduction and screw fixation of the SI joint in unstable pelvic fractures.

Methods: This was a retrospective non-randomized cohort study conducted at a tertiary care hospital. Six patients with unstable pelvic fractures were operated; the anterior rim was stabilized first by ORIF with plate on the superior and anterior aspects of the pubic symphysis. Subsequently, the posterior stabilization was made percutaneously under CT guidance with a 7-mm cannulated cancellous screw.

Results: The mean operative time was 48 min (35–90 min), the mean effective radiation dose was 9.32 (4.97–13.27), and the mean follow-up was 26 months (6–72 months). All patients had satisfactory healing, with near-anatomic reduction and no complications, except in one case where the plate broke at 61 months post surgery, but no intervention was required. The mean VAS score at the final follow-up was 1.8, and all patients returned to their original occupation without any limitations.

Conclusion: CT-guided SI joint stabilization offers many advantages, including safe and accurate screw placement, reduced operating time, decreased blood loss, early definitive fixation, immediate mobilization, and fewer infections and wound complications.

☆ Study conducted at Hinduja National Hospital, Department of Orthopaedics, Mumbai, India.

* *Corresponding author.*
E-mail: vivshetty7777@gmail.com (V. Shetty).

https://doi.org/10.1016/j.rboe.2017.03.013
2255-4971/

Estabilização sacroilíaca percutânea guiada por tomografia computadorizada nas fraturas pélvicas instáveis: uma técnica segura e precisa

RESUMO

Objetivo: O uso de redução aberta e fixação interna (RAFI) em lesões pélvicas instáveis está associado a hemorragia ampla, lesão neurovascular iatrogênica e infecção. Além disso, os parafusos sacroilíacos (SI) são colocados às cegas – o procedimento é guiado principalmente pela palpação e triagem radiológica bidimensional, o que exige especialização. A complexa anatomia tridimensional da articulação SI e sua proximidade à estrutura neurovascular requerem o uso de uma técnica segura e precisa. A estabilização da articulação SI guiada por tomografia computadorizada (TC) permite uma avaliação intra-operatória precisa do posicionamento do parafuso. Este estudo demonstrou uma técnica, guiada por TC, de redução fechada e fixação da articulação SI com parafusos em fraturas pélvicas instáveis.
Métodos: Trata-se de um estudo de coorte retrospectivo, não randomizado, realizado em um hospital terciário. Seis pacientes com fraturas pélvicas instáveis foram operados. A borda anterior foi estabilizada primeiro por RAFI com placa nos aspectos superior e anterior da sínfise púbica. Então, a estabilização posterior foi feita de forma percutânea, guiada por TC, com um parafuso esponjoso canulado de 7 mm.
Resultados: O tempo médio de cirurgia foi de 48 min (35-90 min); a dose média efetiva de radiação foi de 9,32 (4,97-13,27) e o seguimento médio foi de 26 meses (6-72 meses). Todos os pacientes apresentaram cura satisfatória, com redução quase anatômica e sem complicações, exceto em um caso em que a placa quebrou 61 meses após a cirurgia, sem a necessidade de intervenção. O escore EVA médio no seguimento final foi de 1,8 e todos os pacientes retornaram às suas ocupações originais sem quaisquer limitações.
Conclusão: A estabilização da articulação SI guiada por TC apresenta muitas vantagens, incluindo um posicionamento seguro e preciso do parafuso, redução do tempo de cirurgia, diminuição da perda de sangue, fixação definitiva precoce, mobilização imediata e redução no número de infecções e complicações da ferida cirúrgica.

Palavras-chave:
Parafusos ósseos
Fixador externo
Fixação de fraturas, interna
Fraturas ósseas
Ossos pélvicos

Introduction

Unstable pelvic fractures are usually associated with high impact energy trauma with mortality and morbidity rate as high as 10% and 52%. The causes of mortality mostly are: excessive haemorrhage, thromboembolic disease, decubital sepsis and multiorgan failure (MOF).[1] Non-surgical treatment is mostly disappointing as it is associated with frequent malunion, late low back and sacral pain and leg length discrepancy. Early definitive management reduces risk of immediate complications, morbidity and mortality. Most frequently used methods are open reduction and internal fixation (ORIF) of both anterior and posterior injury. These procedures require extensive surgical exposure and hence cannot be applied in the acute stage of treatment, particularly in multiple injuries. The most common complications are extensive blood loss, iatrogenic neurological and vascular injury and postoperative infection. In addition, the placement of sacroiliac screw is a relatively blinded procedure, guided primarily by palpation, which requires significant expertise.[2] Percutaneous iliosacral screw fixation under fluoroscopic control is another method of stabilizing the unstable posterior pelvic ring.[3] Advantages of this method include minimal invasion of compromised soft tissue, limited blood loss and decreased infection rates. On the other hand, it lacks precision for fracture stabilization in deeper layers. The potential dangers of injury to the L5 nerve root anterior to the sacrum, the S1 nerve in its neural canal and the iliac vessels remain.[4] These shortcomings are overcome by CT-guided percutaneous fixation. It offers the advantage of direct visualization of the course of the screws, increasing accuracy of screw placement and decreasing rate of wound problems. It enables early rehabilitation and mobilization of the patient and reduces the risk of complications too. This procedure requires an experienced surgeon and well-coordinated team.[5,6] The purpose of this article is step by step demonstration of operative technique for CT-guided Sacroiliac fixation to improve the accuracy of screw placement and reduce complication rate.

Materials and methods

Six patients with unstable pelvic injury presented to our hospital with disruption of pubic symphysis and sacroiliac joint injury. Scrotal haematoma was present in two patients, one having associated extra-peritonial bladder injury and other with lacerated wound over perineum. Another patient

Fig. 1 – Preoperative radiograph of pelvis.

sustained same side shaft femur fracture and tibial plateau fracture other than pelvic injury.

Injuries

Out of six cases, four cases had a high energy trauma like road traffic accident, one case had railway track accident, and fall from height was the mode of injury in one case. All patients included in the case series sustained unilateral vertically unstable pelvic injury (AO-61-C1) with three cases each of AO 61-C1.2 and AO 61-C1.3. Out of the three cases of A0 61-C1.2, one case sustained posterior injury as transiliac fracture dislocation (crescent fracture) with complete SI displacement and pure SI joint dislocation in two cases. Anteriorly, symphyseal disruption with no associated rami fracture was seen in one case and symphyseal disruption with contralatral superior and inferior pubic rami fracture was seen in two cases. Posteriorly, completely unstable fracture through the sacrum was seen in all the cases with A0 61-C1.3 with anterior symphysis disruption without rami fracture in one

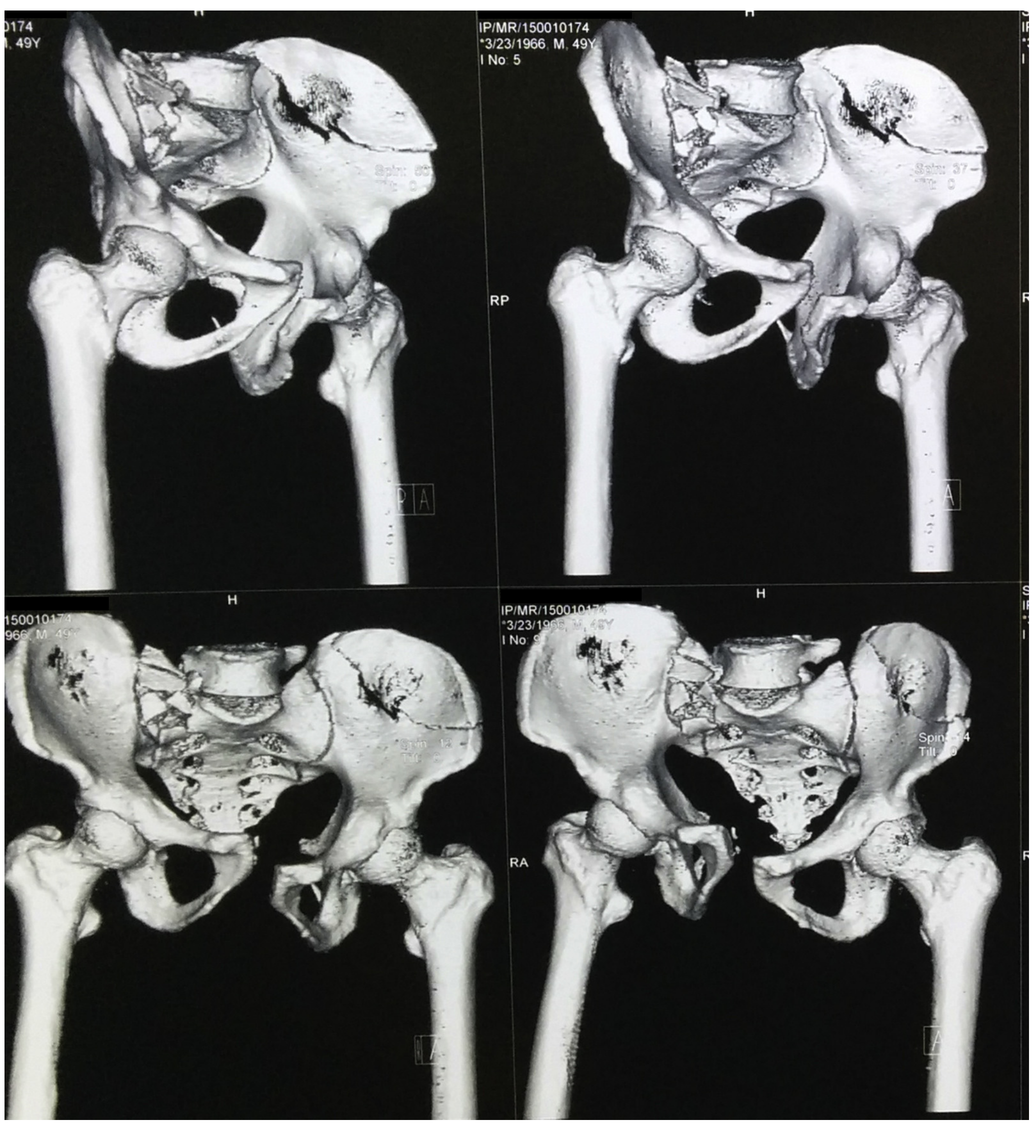

Fig. 2 – 3D-CT scan images showing AO type 61-C1.3 injury.

case and contralateral superior and inferior pubic rami fracture in one case and ipsilateral superior and inferior pubic rami fracture in one case.

After primary resuscitation, anterior pelvic rim was fixed by ORIF in all the patients with two 3.5 mm reconstruction plates on anterior and superior surface of pubic symphysis. In next stage CT-guided sacroiliac stabilization was done with single 7 mm cannulated cancellous screw in two cases and two screws in four cases. These six patients form the basis of this paper.

Technique demonstration

Pelvic radiograph of a 40 year old male who sustained injury to pelvis after a road traffic accident (Fig. 1). CT scan showed posteriorly completely unstable vertical fracture through the sacrum and anteriorly pubic symphysis disruption (AO type 61-C1.3) (Fig. 2).

Pelvic temporizing belt was applied to create external tamponade effect. Bladder injury was diagnosed and repaired by urologist. In first stage, anterior rim was stabilized by open reduction and internal fixation with plates on superior and anterior aspect of pubic symphysis (Fig. 3). In second stage Anesthesiology and Interventional Radiology teams were coordinated for CT guided sacroiliac fixation. Patient was anaesthetized in CT department, on trolley, later shifted to CT table and positioned with affected side up (Fig. 4). Once a working position was achieved, axial images were obtained through the area of interest to determine the skin entry site and angle in which guide wire was to be inserted (Figs. 5 and 6). The entry points were marked on the skin (Fig. 7).

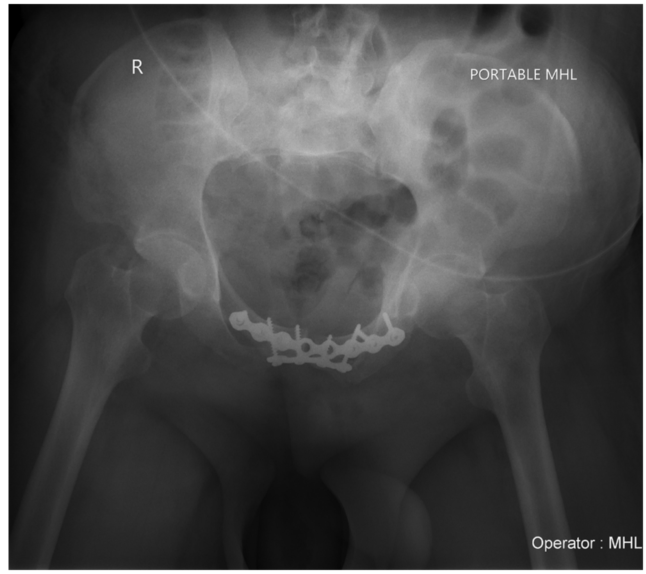

Fig. 3 – Antero-posterior radiographs after anterior stabilization of pelvis.

Procedure

The skin prepared and draped in sterile fashion (Fig. 8). The entry site on the skin was reconfirmed with laser guide. A skin incision of approximately 1 cm was made. A guide pin was inserted through the skin to outer cortex of lateral wall of ilium at previously defined angle. CT images were obtained to define trajectory of the pin (Fig. 9). Guide pin was advanced within the safe zone (Fig. 10). Interval limited CT images were obtained through the pin to confirm if pin position had taken the desired route to provide enough place for screw without violation of sacral foramina (Fig. 10). Screw length was determined using the measure mode of the CT scanner (Fig. 11). Single 7 mm cannulated cancellous screw with washer was inserted over guide wire (Fig. 12). Limited CT images were obtained to confirm the position of screw (Fig. 13A). Procedure lasted for 1 hour with no intraoperative complication. Postoperative X-rays showed

Fig. 4 – Positioning of patient on CT table.

Fig. 5 – Marking the skin entry point under CT scan guidance.

good reduction (Figs. 13B and 14) and at final follow-up of one year, patient was mobilizing well without any complaints and has returned back to his pre-injury level. Radiologically, good union was achieved and no screw related complications were encountered (Fig. 15).

Radiation dose

The effective radiation dose (*E*) {mSv} used during the procedure was calculated by the following formula

$E = \text{DLP} \times T$

where, DLP {mG cm} (dose length product) is the addition of all the DLP values of CT guided sacroiliac joint fixation procedure and *T* (tissue weighting factor) characterizes the loading capacity of body regions.

Fig. 6 – Axial CT images showing the desired trajectory of guide pin.

Results

Mean follow-up was 26 months (6–72 months). All fractures healed satisfactorily and none of them showed evidence of pelvic instability or screw related complications like screw breakage or migration. Mean VAS-score at final follow-up was 1.8 with all patients returned to their original occupation without any limitations. No patients complained of pain in the sacro-iliac area under physical stress leading to incapacity. There was one case in which anterior plate fixed on superior surface of pubic symphysis was found to be broken at 61 months post surgery but did not require any intervention. Mean duration of CT guided sacroiliac fixation procedure was 48 min (35–90 min) with first case duration being 90 min, which eventually reduced to 35 min in the last case. The mean effective radiation dose {mSv} was 9.32 (4.97–13.27) with first case effective radiation dose being 13.27 and last being 4.97. There was a definite learning curve with our first case took a longer time and more radiation exposure as compared to our last cases.

Fig. 7 – Entry point marked on the skin.

Fig. 8 – Patient after Painting and Drapping.

Discussion

With the increase in incidence of high energy trauma, there is a parallel increase in the number of pelvic injuries. Unstable pelvic injuries are not uncommon. Conservative management in these cases leads to residual posterior instability or displacement and as shown before by Henderson[7] and McLaren et al.[8] have worse outcomes. Traditionally many of these injuries have been treated by open procedures. Open treatment of these injuries allows direct visualization and therefore anatomical reduction of the fractures. However the extensile exposures used for these procedures lead to wound-related problems with infection rates as high as 27% reported.[9] Several investigators have suggested that closed reduction and internal fixation (CRIF) may have substantial advantages over open reduction and internal fixation including a reduced chance of intraoperative and postoperative haemorrhage, lower postoperative infection rate, lower risk of neurological and vascular injury, a smaller incision, shorter procedure time and lower cost.[10–12]

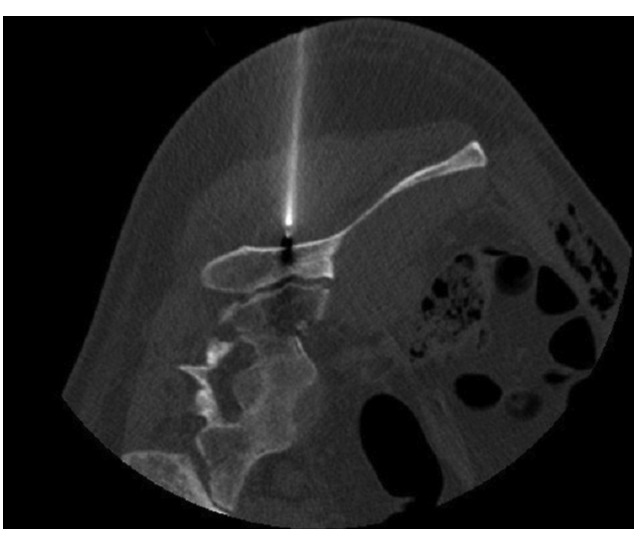

Fig. 9 – Guide pin inserted as per the desired trajectory marked previously.

Fig. 10 – Guide wire progressed in safe zone.

Fig. 11 – Screw length measured using measure mode of CT scan.

A number of different CRIF techniques have been used to place sacroiliac screws. These include fluoroscopy, CT scan[13] and computer assisted placement. The first CT-guided sacral fixation was performed by Ebraheim et al.[14] in 1987. Moreover, CT-guided sacroiliac fixation is advantageous over CRIF through other modalities, by directly visualizing reduced fragments, neural foramina and thus helps in more accurate screw placement.[15] Possibility of neuro-vascular injuries are significantly decreased. Furthermore, the possibility of direct measurement of the screw length and minimal skin scarring is beneficial. Further advantage is short duration of the procedure, however procedure has to be precisely planned and performed by experienced radiologist, anaesthesiologist, and orthopaedic surgeon. The use of CT can cause high radiation exposure to the patient and the intervention team.[16,17] Newer available CT scans have reduced the effective radiation exposure to 47% and stray radiation to 30–60%.[18,19] Also, CT guided sacro-iliac fixation requires lesser radiation dose since only bone structures are evaluated.[20] In our series the mean effective radiation exposure was 9.32 which is three to four times lower in comparison to a diagnostic abdominal CT-scan[17] and is comparable to the applied effective dose of 5.9 ± 3.1 mSv for male and 8.7 ± 4.5 mSv for female patients in the study conducted by Pieske et al.[21] In this study, DLP values were 952.4 mSv $\pm$ 566.5 for male patients and 779.1 mSv $\pm$ 403.0 for female patients which is quite high as compared to mean DLP

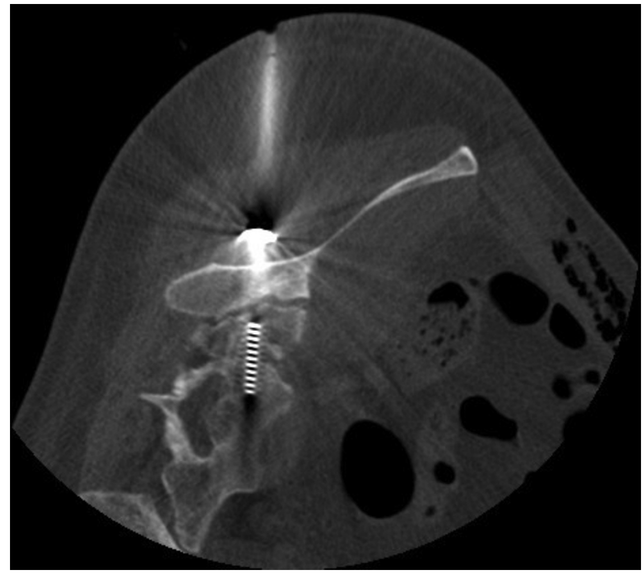

Fig. 12 – 7 mm cannulated cancellous screw with washer inserted over guide wire.

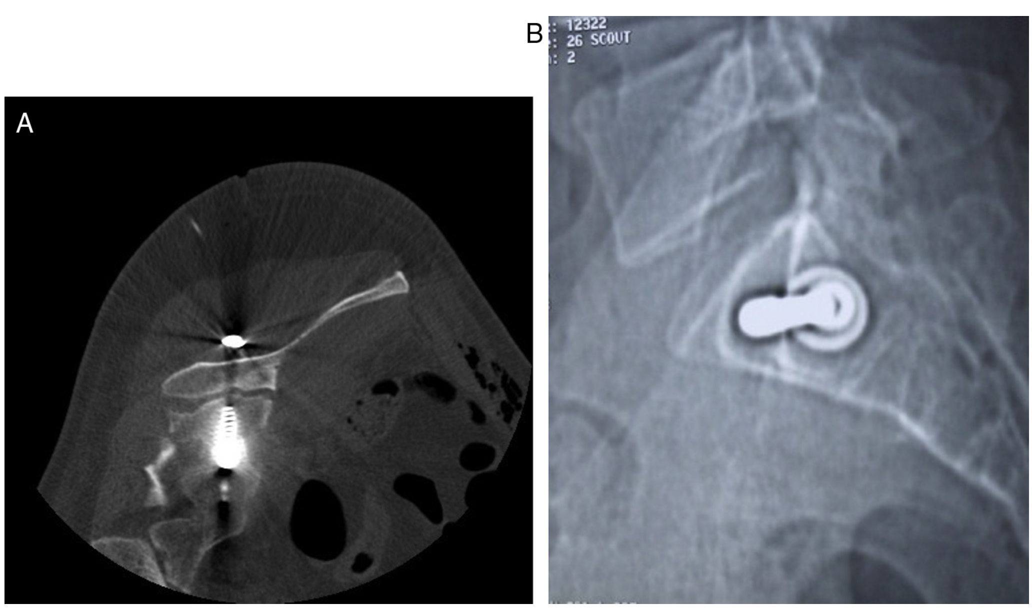

Fig. 13 – Final position of screw confirmed in axial and sagittal CT sections.

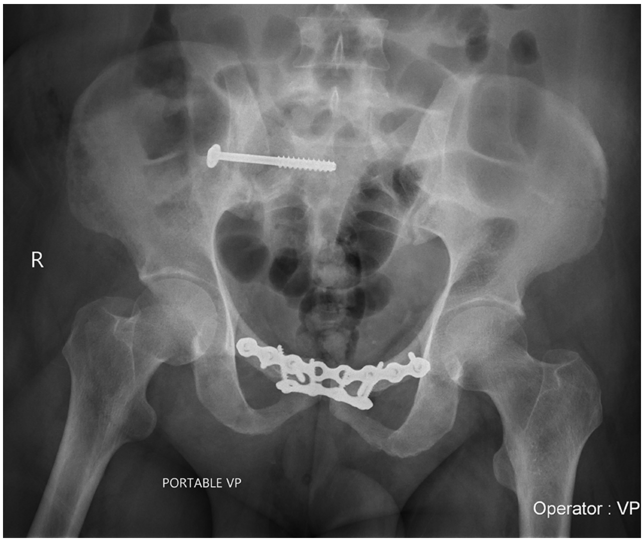

Fig. 14 – Immediate postoperative radiograph showing good reduction.

(490.63) in our study but because of the high tissue weighing factor of our CT scan machine as compared to angular beam modulation (CARE Vision CT with HandCARE, Siemens, Erlangen, Germany) used in the study conducted by Pieske et al., the mean effective radiation exposure in our study is slightly higher.

First limitation of the paper is absence of a control group. We have not compared the CT-guided SI joint fixation with ORIF and other methods of percutaneous fixation available in literature. Second limitation is lack of long term functional outcome results. However, percutaneous and open Sacro-iliac joint stabilization with cannulated cancellous screws is an accepted procedure with good functional outcome in literature.

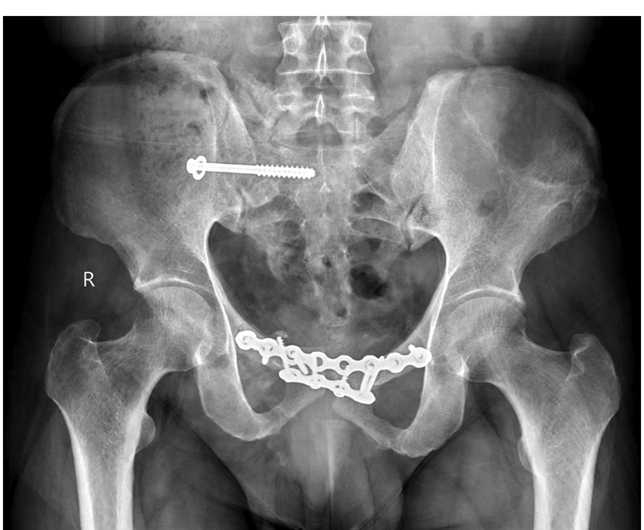

Fig. 15 – Follow-up radiograph at 1 year showing union.

Conclusion

The CT-guided surgical procedure provides exact geometry of fracture fragments. It gives the direction for an implant to be inserted without violating important anatomical structures in the surroundings. It helps to determine the exact length of implants to be used. In conclusion, the CT-guided fixation of unstable pelvic ring fractures is an accurate and safe technique with minimal risk of morbidity with reduced operating time, infection rate and decreased blood loss. Due to a co-ordinated effort between anaesthesiologist, radiologist and orthopaedic surgeon in terms of minimal invasiveness and increased precision.

Conflicts of interest

The authors declare no conflicts of interest.

Acknowledgements

We are thankful to the residents and colleagues at Department of Orthopaedics P.D. Hinduja National Hospital and Research Centre Mumbai for helping in this study. No benefits or funds were received in support of this study.

REFERENCES

1. Michek J, Zelníček P, Wendsche P. Pelvic compartment syndrome. Uraz Chir. 2000;8:24–9.
2. Schmucki D, Gebhard F, Grützner PA, Hüfner T, Langlotz F, Zheng G. Computer aided reduction and imaging. Injury. 2004;35 Suppl 1:S-A96–104.
3. Amiot LP, Lang K, Putzier M, Zippel H, Labelle H. Comparative results between conventional and computer-assisted pedicle screw installation in the thoracic, lumbar, and sacral spine. Spine (Phila PA 1976). 2000;25(5):606–14.
4. Pleva L, Rozum K, Ječmínek V. External fixation into acetabulum. Uraz Chir. 2000;8:1–10.
5. Chmelová J, Pleva L. Percutaneous fixation of pelvic fractures under CT control. Čes Radiol. 2002;56:16–20.
6. Jacob AL, Messmer P, Stock KW, Suhm N, Baumann B, Regazzoni P, et al. Posterior pelvic ring fractures: closed reduction and percutaneous CT-guided sacroiliac screw fixation. Cardiovasc Intervent Radiol. 1997;20(4):285–94.
7. Henderson RC. The long-term results of nonoperatively treated major pelvic disruptions. J Orthop Trauma. 1989;3(1):41–7.
8. McLaren AC, Rorabeck CH, Halpenny J. Long-term pain and disability in relation to residual deformity after displaced pelvic ring fractures. Can J Surg. 1990;33(6):492–4.
9. Kellam JF, McMurtry RY, Paley D, Tile M. The unstable pelvic fracture. Operative treatment. Orthop Clin North Am. 1987;18(1):25–41.
10. Blake-Toker AM, Hawkins L, Nadalo L, Howard D, Arazoza A, Koonsman M, et al. CT guided percutaneous fixation of sacroiliac fractures in trauma patients. J Trauma. 2001;51(6):1117–21.
11. Nelson DW, Duwelius PJ. CT-guided fixation of sacral fractures and sacroiliac joint disruptions. Radiology. 1991;180(2):527–32.

12. Ebraheim NA, Coombs R, Jackson WT, Rusin JJ. Percutaneous computed tomography-guided stabilization of posterior pelvic fractures. Clin Orthop Relat Res. 1994;(307):222–8.
13. Sciulli RL, Daffner RH, Altman DT, Altman GT, Sewecke JJ. CT-guided iliosacral screw placement: technique and clinical experience. AJR Am J Roentgenol. 2007;188(2):W181–92.
14. Ebraheim NA, Rusin JJ, Coombs RJ, Jackson WT, Holiday B. Percutaneous computed-tomography-stabilization of pelvic fractures: preliminary report. J Orthop Trauma. 1987;1(3):197–204.
15. Sen M, Harvey EJ, Steinitz D, Guy P, Reindl R. Anatomical risks of using supra-acetabular screws in percutaneous internal fixation of the acetabulum and pelvis. Am J Orthop (Belle Mead NJ). 2005;34(2):94–6.
16. Deak PD, Smal Y, Kalender WA. Multisection CT protocols: sex- and age-specific conversion factors used to determine effective dose from dose-length product. Radiology. 2010;257(1):158–66.
17. Reiser M, Kuhn F-P, Debus J. Radiologie. 2nd ed. Stuttgart: Thieme; 2006.
18. Hohl C, Suess C, Wildberger JE, Honnef D, Das M, Mühlenbruch G, et al. Dose reduction during CT fluoroscopy: phantom study of angular beam modulation. Radiology. 2008;246(2):519–25.
19. Bohnsack O [thesis] Reduktion der Strahlenexpositionbei CT-Fluoroskopie-gesteuerten Intervention en: Möglichkeiten und Grenzeneinersegmental en Röhrenabschaltung. Munich: Faculty of Medicine, Ludwig Maximilians University Munich; 2005.
20. Wieners G, Pech M, Beck A, König B, Erdmenger U, Stöckle U, et al. Comparison of radiation dose and image quality of Siremobil-IsoC(3D) with a 16-slice spiral CT for diagnosis and intervention in the human pelvic bone. Rofo. 2005;177(2):258–64.
21. Pieske O, Landersdorfer C, Trumm C, Greiner A, Wallmichrath J, Gottschalk O, Rubenbauer B. CT-guided sacroiliac percutaneous screw placement in unstable posterior pelvic ring injuries: accuracy of screw position, injury reduction and complications in 71 patients with 136 screws. Injury. 2015;46(2):333–9.