New technique and strategy for posterior column, posterior wall, ischium, and quadrilateral plate fixation from the anterior approach for acetabular fractures

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Technical advance

Keywords: acetabular fractures, posterior column, posterior wall, ischium, quadrilateral plate, anterior approach, sleeve guide technique

Posted Date: March 11th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-16869/v1

Abstract

Background

Acetabular fractures are relatively common, but management of the ischial fragment is a considerable problem when determining whether to use only the anterior approach or to add the posterior approach for anterior column and posterior hemitransverse acetabular fractures, T-type fractures, and both column fractures. This study is the first to demonstrate how to screw or drill around the quadrilateral space, posterior column, posterior wall, and near the ischial tuberosity from the anterior approach by a novel "sleeve guide technique".

Methods

First, a nozzle, drill, depth gauge, and driver were prepared from DepuySynthes. Periosteum of the internal obturator muscle was detached from the quadrilateral plate to near the ischial tuberosity, while paying attention not to injure Alcock’s canal. The skin was cut about 1.5 cm opposite to the side of the fracture, and the nozzle was inserted as an external sleeve. Drilling, measuring screw length, and screwing were performed through this nozzle. With this technique, the approach angles of drilling and screwing to the posterior wall and ischium were inclined, and plating from the ischium to the ilium could be performed from the anterior approach.

Results

Two cases are presented. Case 1 was a 63-year-old man who had a left both column fracture with a free bone fragment of the joint surface. After plating a 14-hole plate from the pubis to the ilium, a bent 14-hole plate was placed at the quadrilateral space as a buttress, and a screw was inserted from the posterior wall to the ilium using sleeve guide technique. Case 2 was a 66-year-old man with a quadrilateral fracture. After a 13-hole plate was bent and placed at the quadrilateral space, screws were inserted to the ischium and posterior wall using sleeve guide technique

Conclusions

Sleeve guide technique is very easy, useful, and safe to drill and insert screws to the quadrilateral space, posterior wall, and near the ischial tuberosity from the anterior approach. This technique can be used for simple drilling and screwing of a small T buttress plate held by a ball spike at the quadrilateral space from the surgical window. We believe that these techniques lead to new strategies for acetabular fractures.

Background

Acetabular fractures are relatively common, but their surgical treatment is still challenging. Recently, their incidence has been increasing with the rising elderly population with osteoporosis and poor bone quality. Anterior column and posterior hemitransverse acetabular fractures, T-type fractures, and both column

fractures are particularly bothersome and complicated to reduce and fix. Depending on fracture complexity, anterior fixation, posterior fixation, or both have been performed [1]. From the anterior approach, management of the ischial fragment is a considerable problem, and it is important to determine whether to use only the anterior approach or to add the posterior approach.

To fix the ischial fragment from the anterior approach, a couple of techniques are well known. Posterior column screws or quadrilateral area screws have usually been chosen. In a biomechanical study of anterior column and posterior hemi-transverse acetabular fractures, the result of an anterior column plate combined with posterior screws was worse than of an anterior column plate with quadrilateral area screws or double column plates [2]. If the fracture is associated with medial displacement of the quadrilateral surface, the major technique is buttress plating [3, 4], and a unique technique is buttress screws on the inner surface of the quadrilateral plate [5] or wire plate composite fixation [6]. If the ischial fragment can be fixed solidly from the anterior approach, it may reduce the need for another incision. If a quadrilateral fragment can be fixed by inserting screws into the ischium, re-dislocation may be reduced, and the timing of loading may be accelerated.

To detach the internal obturator muscle from the quadrilateral plate is a common technique to set a buttress plate. However, inserting a screw to the buttress plate near the sciatic spine or ischial tuberosity has not been reported, despite the thick and strong bone mass there. Recently, He et al. reported a study of the safe zone around this area [7]. We considered that the difficulty in inserting a screw to the buttress plate arises from the approach angle to the plate by drilling or screwing. Although the drilling or screwing approach angle is dependent on the approach and the skin incision, the angle is too sharp to insert into a plate hole. The current report is the first to demonstrate a novel technique involving tilting the approach angle of the screw or drill around the quadrilateral space, posterior wall, and near the ischial tuberosity, and the anatomical problem around the ischial tuberosity from the anterior approach is clarified.

These techniques are very easy, useful, and safe for drilling and inserting a screw to the quadrilateral space, posterior wall, and near the ischial tuberosity. They make it possible to connect the ilium and ischium by plate and screw from the anterior approach.

Methods

Preoperative planning

This technique adjusts the approach angle of the screw or drill to the plate around the quadrilateral space and ischial tuberosity by making a portal around the anterior superior iliac spine (ASIS) on the opposite side of the abdomen. (Fig. 1A, Ci, D).

Before the operation, contrast-enhanced CT was checked for the next three points. As an example, the CT of case 1 showed the 1) anatomical structure at the insertion point around the ASIS on the opposite side. It must be confirmed that there is no inferior epigastric artery or other vascular structures around the portal site (Fig. 2A). 2) Organs between the portal site and the screw point must be visualized. On the

route from the portal site to the quadrilateral space or ischial tuberosity, the organs must be confirmed (Fig. 2B,C,D). Intestine or colon can be retracted over the peritoneal membrane to the proximal side. The bladder can be retracted to the posterior side. The external iliac artery and vein were close to the insertion root. After making a portal, it is usually loose and can be adjusted medially. If it is tight to aim around the quadrilateral space or more distal site due to the iliac artery and vein, the portal can be made wider or more to the medial side. 3) The approach angle to the quadrilateral space and ischial tuberosity must be determined. The allowed angle to insert a screw into a plate hole differs by plate type (at most 30°: wide angle plate, DepuySynthes). The approach angle to the position plate was measured to insert the screw under 30°. To measure the approach angle, 3D-CT viewer (AquariusNET viewer, V4,4, 13, P2) was used to show the portal site and posterior wall in the same image in an inclined axial plane (Fig. 2B,C,D). Angles were measured by estimation of reduced fragment location. At the center level of the femoral head, the angle range was 24.8° to 35.0° (Fig. 2B). At the distal level of the femoral head, the angle range was 21.1° to 30.3° (Fig. 2C). At the ischium level, the angle range was 26.5° to 34.2° (Fig. 2D). The normal surface of quadrilateral space was overhung about 3.5° from vertical (Fig. 2E). If the approach angle was over 30°, the plate could be rotated externally. In the inclined coronal plane, the insertion point and posterior wall are shown in the same image. The angle to the femoral head level was 15.7°. The length from the fragment edge of QLS to about the 30° line was about 7.8 cm, in which the plate has 5 holes. The length from the portal to the fragment of the 30° line was about 176 mm (Fig. 2F). Nozzle length (19.5 cm) was adequate to use.

Sleeve Guide Technique

Briefly, a nozzle (Fig. 3A, No.831230, DepuySynthes, CEMVAC 8.5 REVIS NOZZLE), Drill (Fig. 3B, No.324 – 210, Drill Bit φ2.5 mm, calibrated, length 300 mm, with Quick Coupling, for Percutaneous Insertion), depth gauge (Fig. 3C, No.356–835, Measuring Device for Locking Bolt), and driver (Fig. 3D, No.03-100-032, Ratcheting Handle with AO/ASIF Quick Coupling, No.03-100-033, Screwdriver Shaft, hexagonal, for Screws φ3.5 mm, length 250 mm) were prepared. All products were from DepuySynthes. After detaching the internal obturator muscle, the periosteum was elevated from the quadrilateral plate. The tendinous arch of the levator ani muscle was observed and retracted with the obturator muscle, paying attention to avoid injuring the obturator nerve and vascular structures. First, the skin was cut about 1.5 cm around the ASIS opposite to the side of the fracture, and a hand was slipped between the abdominal muscle and peritoneal membrane from the surgical field just below the skin incision. The subcutaneous fat and all abdominal muscles were divided toward the hand using a mosquito clamp or other tool. The nozzle was inserted as an external sleeve and grabbed, and the nozzle head was led to the screw point. The nozzle head was adjusted to aim at the screw insertion point (Fig. 1A, Ci, D). Drill (Fig. 3B,E), screw length was measured by a depth gauge for PFNA (Fig. 3C,F), and the driver was inserted (Fig. 3D,G) through the nozzle. The screw was held near the drilling hole and set to the driver and screwed in. With this technique, one can drill and insert the screw to the blue area (Fig. 1B). This blue area has also been suggested by He et al. as the safe zone [7].

Results

Case 1

A 63-year-old man had been climbing a mountain alone. He fell 12 m off a cliff and was injured. The next evening (2 days after injury), he was fortunate to be rescued by helicopter and taken to a hospital nearby. His vital signs indicated no problem. Diagnostic imaging showed a left acetabular fracture with a free bone fragment of the joint surface (Fig. 4A,B,D,E, both column fracture according to the AO classification) and bilateral pubic bone fractures. On the next day (3 days after injury), he was transferred to our hospital, and open reduction and internal fixation for the acetabular fracture were performed using a low-profile pelvic plate system (DePuySynthes Trauma, West Chester, PA, USA) the following day (4 days after injury). First, the iliac crest fracture was reduced and fixed by an 8-hole plate in the right lateral position. Next, the patient was repositioned to the supine position, and the ilioinguinal approach was used to reach retroperitoneal area and the fracture area. The free bone fragment was returned, and dislocation of the pelvic brim was reduced and fixed by screws and a 14-hole plate from the pubis to the ilium. After the internal obturator muscle was retracted, a bent 14-hole plate was placed at the quadrilateral space as a buttress, and a screw was inserted from the posterior wall to the ilium using sleeve guide technique (Fig. 4C,F,G,H,I). Six weeks after the operation, partial weight-bearing was started. After 3 months, he walked without a gait abnormality. After 1 year, he climbed the mountain again.

Case 2

A 66-year-old man was injured in a fall during a sudden convulsion. He could not move his left lower extremity due to pain and rested in his house. After 3 days, he developed a fever (> 38 °C) and was admitted to a hospital nearby. Diagnostic imaging showed a quadrilateral fracture (Fig. 5A,B,D,E). Twelve days after injury, open reduction and internal fixation for the acetabular fracture were performed using a low-profile pelvic plate system by the ilioinguinal approach. As in case 1, after a 13-hole plate was bent and placed at the quadrilateral space, screws were inserted to the ischium and posterior wall using sleeve guide technique (Fig. 5C,F,G,H and I). Six weeks after the operation, partial weight-bearing was started.

Discussion

With this technique, the approach angle of the screw or drill to the plate around the quadrilateral space and ischium is inclined, which makes it possible to fix a plate to the posterior wall or ischium by making the insertion point on the opposite side of the abdomen. This can be used for posterior column fractures, transverse fractures, posterior column and posterior wall fractures, transverse and posterior wall fractures, T-type fractures, anterior column and posterior hemitransverse fractures, and both column fractures. Additionally, a dislocated quadrilateral plate can be fixed or compressed rigidly by this technique. The safe zone study of the infrapectineal area suggested the possibility of a two-ended buttress plate as a viable alternative to single-ended elastic fixation for quadrilateral fractures [7]. The present technique makes it possible to fix a quadrilateral fracture with a two-ended buttress plate.

This technique needs understanding of the retroperitoneal area, since the sleeve is handled through this area. Any approach that opens the retroperitoneal area and the quadrilateral space, such as the ilioinguinal approach [8], modified Stoppa approach [9, 10], pararectus approach [11], anterior intrapelvic approach or supra-ilioinguinal approach [12], is possible for this technique. In general, the approach angle to the plate by the drill or driver is closer to vertical in the modified Stoppa approach (Fig. 1Cii) than in other approaches (Fig. 1Ciii). However, the angle with the present technique is closer to vertical (Fig. 1 Ci) than any other approach, including the modified Stoppa approach.

In this technique, there are some tricks and traps to be aware of, including: vascular structures at the insertion point on the abdominal wall; separation and retraction of the internal obturator muscle; and the drilling point.

First, it must be confirmed that the insertion point of the abdominal wall has no vascular structures such as the inferior epigastric artery on CT or other imaging examinations before surgery. Second, release of the obturator muscle is sometimes expanded near the obturator foramen. The origin of the internal obturator muscle, muscle fiber direction, the obturator foramen, and the obturator canal must be confirmed. One must be careful not to injure the obturator nerve and vessels. A sharp retractor should not be inserted into the obturator muscle near the ischial tuberosity. Alcock's canal, including the pudendal vessels and nerve, was folded inside the wall of the obturator muscle [13, 14], and attention must be paid not to injure them (Fig. 1E). The pudendal nerve, which has three branches (inferior rectal nerve, perineal nerve, dorsal nerve of the penis in males and dorsal nerve of the clitoris in females), is associated with urinary and sexual function [15]. The tendinous arch of the levator ani muscle is seen after release of the obturator muscle. This tendinous arch is sometimes tight to retract the obturator muscle near the obturator tuberosity (Fig. 1E). The levator ani and the iliococcygeus muscle anchor above this tendinous arch. Although levator ani muscle avulsion is thought to be associated with pelvic organ prolapse, injury or avulsion of only this tendinous arch has not been reported [16]. Third, since the sciatic nerve is close to the posterior wall, overdrilling must be avoided.

How to access the ischium from the anterior approach and how to adjust the approach angle to the plate by drilling or screwing closer to vertical were presented. They facilitated drilling and screwing and plating the posterior wall and ischium from the anterior approach. Furthermore, this technique reduces vessel, nerve, and abdominal organ injuries. If screwing the ischium is not needed, this technique can be used for simple drilling and screwing of a small T buttress plate held by a ball spike at the quadrilateral space from the surgical window, such as a modified Stoppa approach.

Conclusion

A novel technique to insert screws to the posterior wall and ischium from the anterior approach by inclining the approach angle of drilling and screwing was presented. Since this was a preliminary study that showed the utility of the sleeve guide technique and plating of the ischium to the ilium, complications and functional results need to be examined in future studies. The methods are very simple,

easy, safe, and useful, and the 4 devices are all easily available from DePuySynthes and are used worldwide for fracture surgery. We believe that enlargement of the screw area provides the benefit of an expanded fixation and plating strategy for acetabular fractures.

Abbreviations

AO
Arbeitsgemeinschaft für Osteosynthesefragen
ASIF
Association for the Study of Internal Fixation
PFNA
Proximal Femoral Nail Antirotation

Declarations

Ethics approval and consent for publication:

Written, informed consent was obtained from each patient. All patients gave consent for publication. Institutional Review Board was waived because of the nature of the study. All procedures performed in studies involving human participants were in accordance with the Helsinki declaration.

No formal ethics approval was required. Reports of cases don't need to be deliberated by ethical committee in our institution. This institutional policy is based on “Ethical Guidelines for Medical and Health Research Involving Human Subjects” and “Guidance for Handling Personal Information by Medical and Nursing professionals” from Japanese Ministry of Health, Labour and Welfare.

Availability of data and materials

The datasets supporting the conclusions of this article are available in the article.

Competing interests:

All authors declare no competing interests.

Funding:

The authors received no funding support for their work.

Author Contributions Statement:

KA operated all patients and wrote the main manuscript text and prepared all figures and tables. GM, TN and TH joined operation of case 1 and contributed to data collection. YS, HS, KY and TH joined operation of case 2 and contributed to data collection. TU performed initial treatment and rehabilitation after

operation and contributed to data collection. NT and YA critically reviewed the manuscript. AS supervised this study. All authors have read and approved the manuscript

Acknowledgment

The authors would like to thank Kuniyuki Kato and Shohei Yamaguchi, staff and District Sales Manager of DepuySynthes, for helping us to realize our concept.

References

1. Pierannunzii L, Fischer F, Tagliabue L, Calori GM, d'Imporzano M: Acetabular both-column fractures: essentials of operative management. *Injury* 2010, 41(11):1145-1149.
2. Lei J, Dong P, Li Z, Zhu F, Wang Z, Cai X: Biomechanical analysis of the fixation systems for anterior column and posterior hemi-transverse acetabular fractures. *Acta orthopaedica et traumatologica turcica* 2017, 51(3):248-253.
3. Peter RE: Open reduction and internal fixation of osteoporotic acetabular fractures through the ilio-inguinal approach: use of buttress plates to control medial displacement of the quadrilateral surface. *Injury* 2015, 46:S2-S7.
4. White G, Kanakaris NK, Faour O, Valverde JA, Martin MA, Giannoudis PV: Quadrilateral plate fractures of the acetabulum: an update. *Injury* 2013, 44(2):159-167.
5. Karim MA, Abdelazeem AH, Youness M, El Nahal WA: Fixation of quadrilateral plate fractures of the acetabulum using the buttress screw: A novel technique. *Injury* 2017, 48(8):1813-1818.
6. Farid YR: Cerclage wire-plate composite for fixation of quadrilateral plate fractures of the acetabulum: a checkrein and pulley technique. *Journal of orthopaedic trauma* 2010, 24(5):323-328.
7. He L, Sun Y, Hou Z, Zhang Q, Hu Y, Bai X, Yi C: The "safe zone" for infrapectineal plate-screw fixation of quadrilateral plate fractures: An anatomical study and retrospective clinical evaluation. *Medicine* 2019, 98(19):e15357.
8. Shazar N, Eshed I, Ackshota N, Hershkovich O, Khazanov A, Herman A: Comparison of acetabular fracture reduction quality by the ilioinguinal or the anterior intrapelvic (modified rives–Stoppa) surgical approaches. *Journal of orthopaedic trauma* 2014, 28(6):313-319.
9. Laflamme G, Hebert-Davies J, Rouleau D, Benoit B, Leduc S: Internal fixation of osteopenic acetabular fractures involving the quadrilateral plate. *Injury* 2011, 42(10):1130-1134.
10. Tannast M, Keel MJB, Siebenrock KA, Bastian JD: Open Reduction and Internal Fixation of Acetabular Fractures Using the Modified Stoppa Approach. *JBJS Essent Surg Tech* 2019, 9(1):e3.
11. Keel M, Ecker T, Cullmann J, Bergmann M, Bonel HM, Büchler L, Siebenrock K-A, Bastian JD: The Pararectus approach for anterior intrapelvic management of acetabular fractures: an anatomical study and clinical evaluation. *The Journal of bone and joint surgery British volume* 2012, 94(3):405-411.

12. Chen K, Ji Y, Huang Z, Navinduth R, Yang F, Sun T, Xiong Z, Yao S, Ahn J, Guo X: Single Modified Ilioinguinal Approach for the Treatment of Acetabular Fractures Involving Both Columns. *J Orthop Trauma* 2018, 32(11):e428-e434.
13. Insola A, Granata G, Padua L: Alcock canal syndrome due to obturator internus muscle fibrosis. *Muscle & nerve* 2010, 42(3):431-432.
14. Kaur J, Singh P: Pudendal Nerve Entrapment Syndrome. In: *StatPearls.* edn. Treasure Island (FL): StatPearls Publishing StatPearls Publishing LLC.; 2019.
15. Possover M, Forman A: Voiding dysfunction associated with pudendal nerve entrapment. *Current bladder dysfunction reports* 2012, 7(4):281-285.
16. Handa VL, Roem J, Blomquist JL, Dietz HP, Munoz A: Pelvic organ prolapse as a function of levator ani avulsion, hiatus size, and strength. *American journal of obstetrics and gynecology* 2019, 221(1):41.e41-41.e47.

Figures

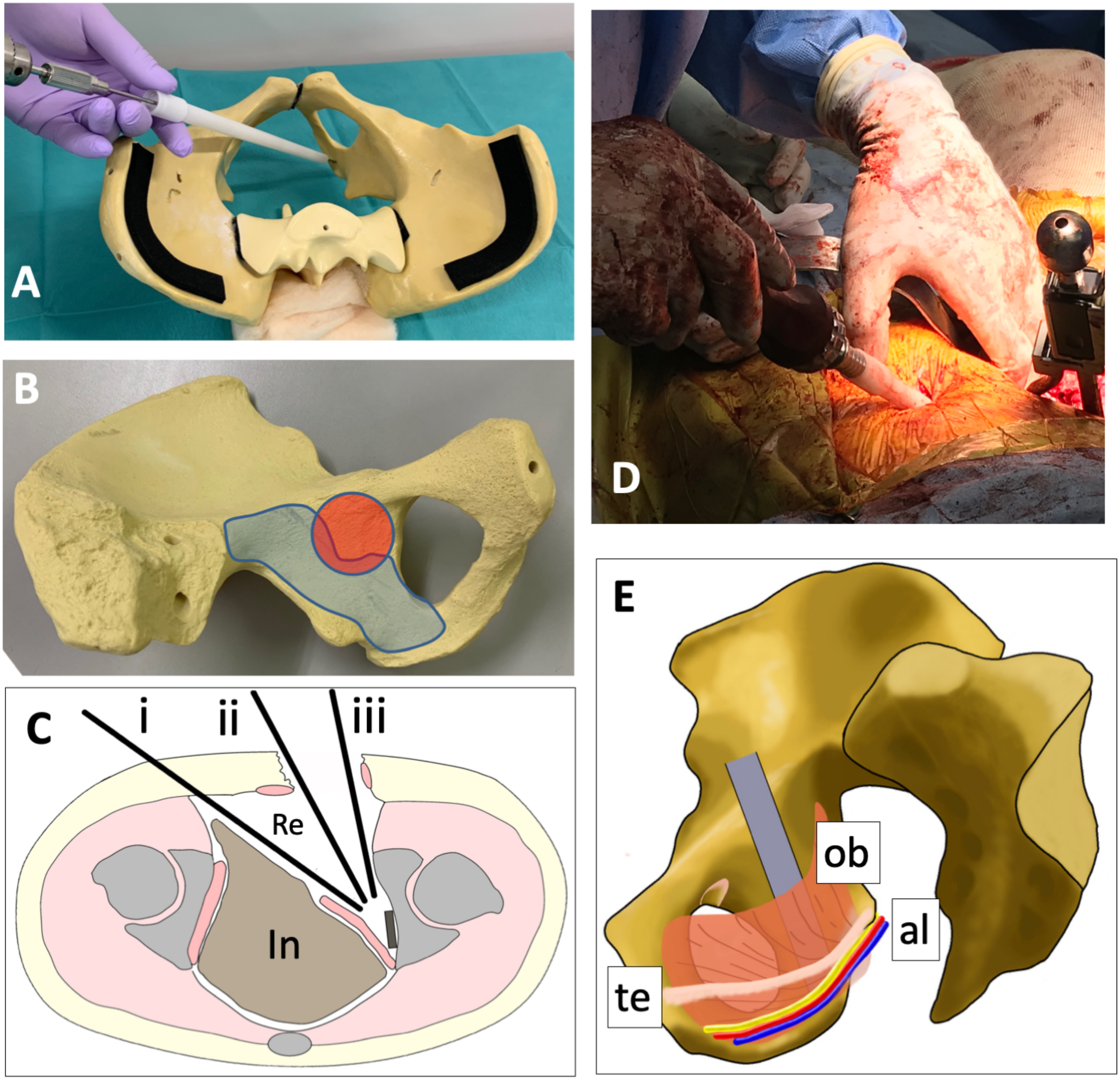

Figure 1

Approaching images A. Actual direction of the nozzle using a pelvic model. B. In the blue area, screws can be inserted. The red area indicates the acetabular joint. C. i) Drilling and screwing direction by the sleeve guide technique. ii) Drilling and screwing direction of the modified Stoppa approach. iii) Drilling and screwing direction of the ilioinguinal or pararectus approach. Re. retroperitoneal area. In. Intra-abdominal area. D. Screwing though the sleeve nozzle. E shows the anatomical relationships of the internal obturator muscle, Alcock's canal, and the tendinous arch of the levator ani muscle. Ob: internal obturator muscle, al: Alcock's canal (pudendal vessels and nerve), te: tendinous arch of levator ani muscle.

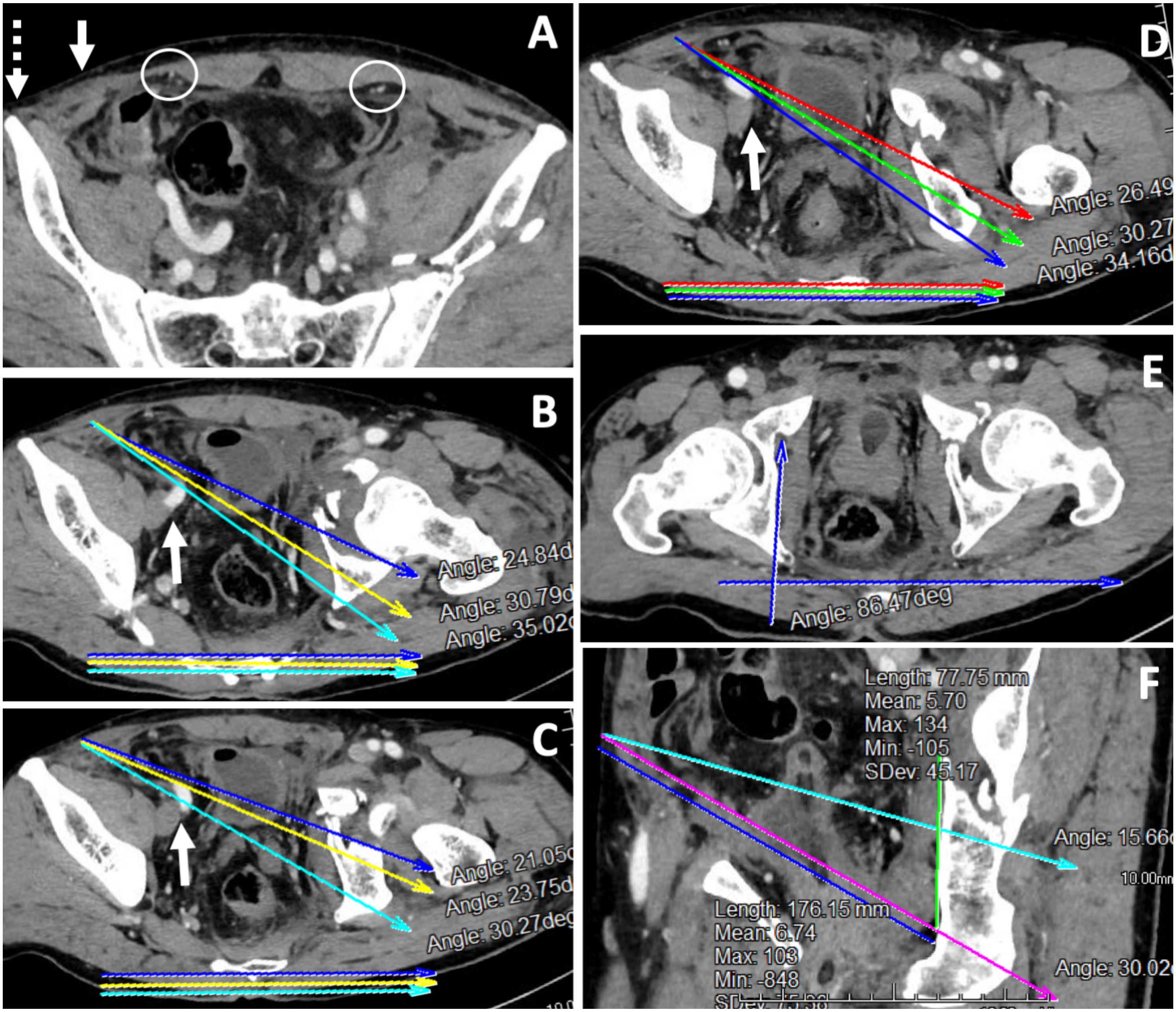

Figure 2

Preoperative planning images A. Axial plane at the ASIS level. The circle shows the inferior epigastric artery. The solid arrow indicates the portal site. The dotted arrow indicates the ASIS. B. Inclined axial plane at the center level of the femoral head. Angles are measured from superficial to the deep site. C. Inclined axial plane at the distal level of the femoral head. D. Inclined axial plane at the ischium level. E. QLS surface of the no fracture side is overhung about 3.5° (90°-84.67°= 3.5°). F. Inclined coronal plane. Angles are measured from the proximal to the distal site. Length is measured from the fragment edge to the 30° line and from the portal site to the bone surface by the 30° line.

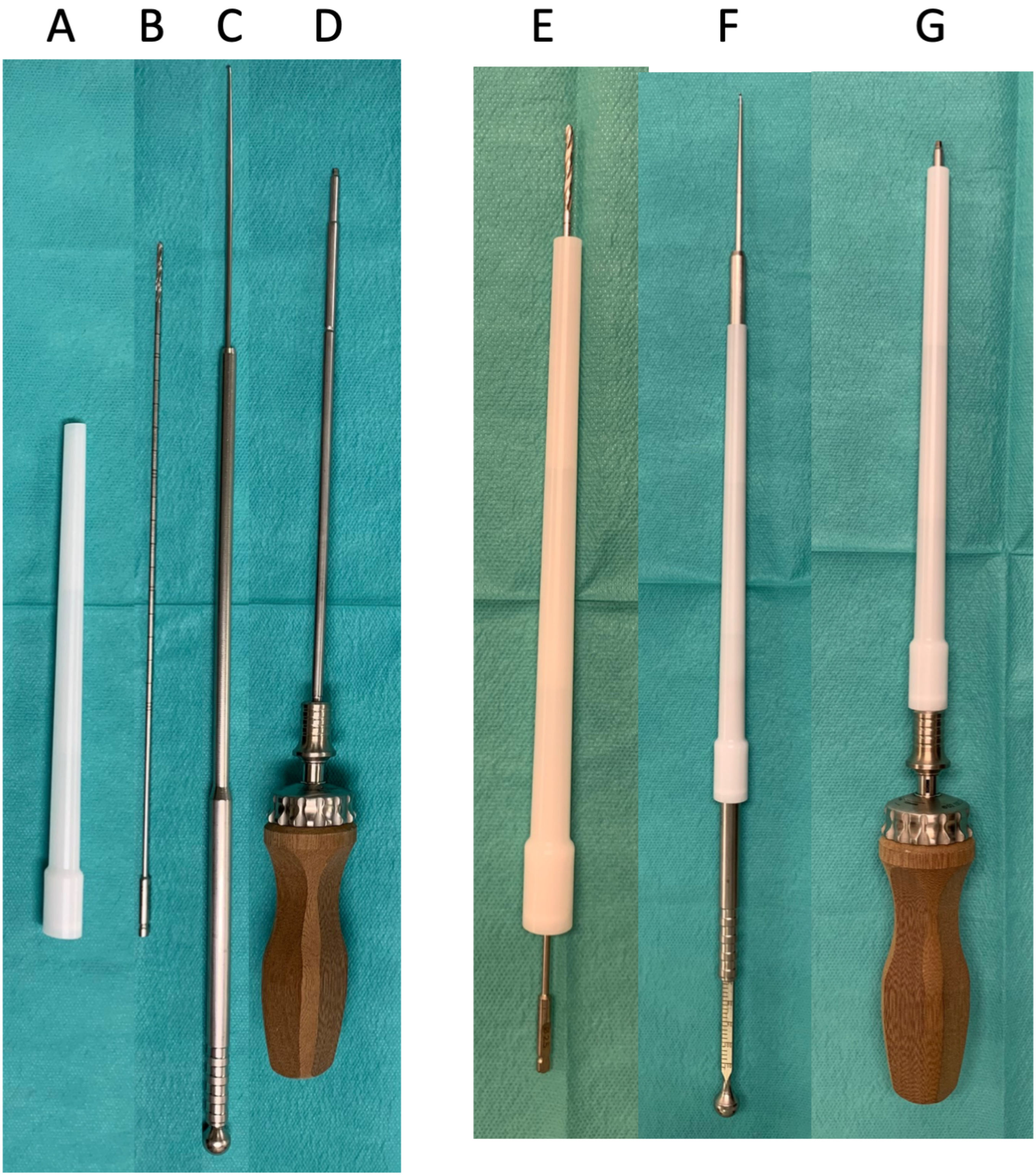

Figure 3

Devises for Sleeve guide technique A. nozzle, B. drill, C. depth gauge, D. driver. Product name and number are in the text. E. insert drill into the nozzle, F. insert depth gauge into the nozzle, G. insert the driver into the nozzle.

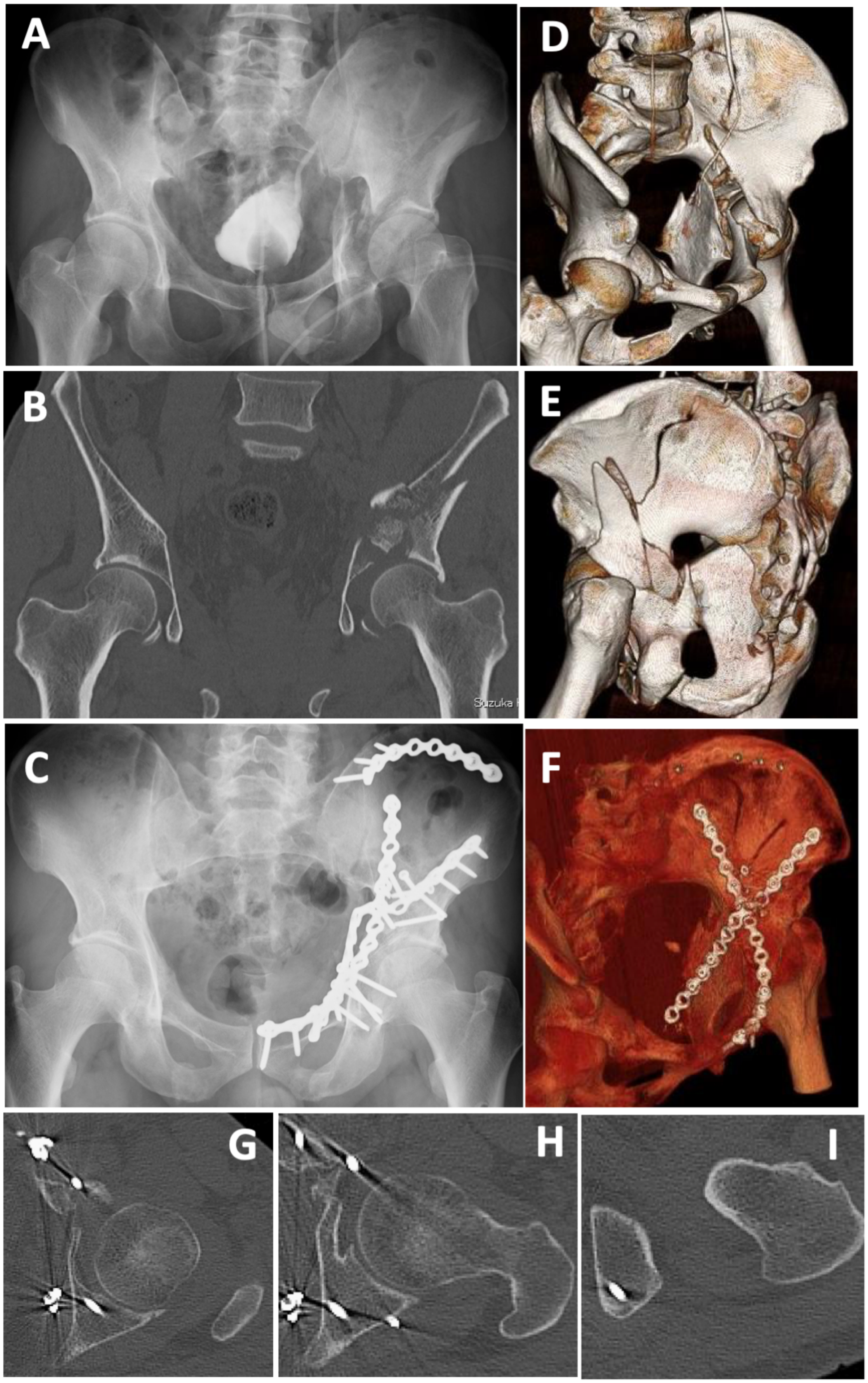

Figure 4

Case 1 images A. Preoperative X-ray, B. Preoperative CT coronal image, C. Postoperative X-ray, D. Preoperative 3D-CT, E: Preoperative CT, F. Postoperative 3D-CT, G,H,I. Postoperative CT axial image. Screws are inserted into the posterior wall (G,H) and near the ischial tuberosity (I).

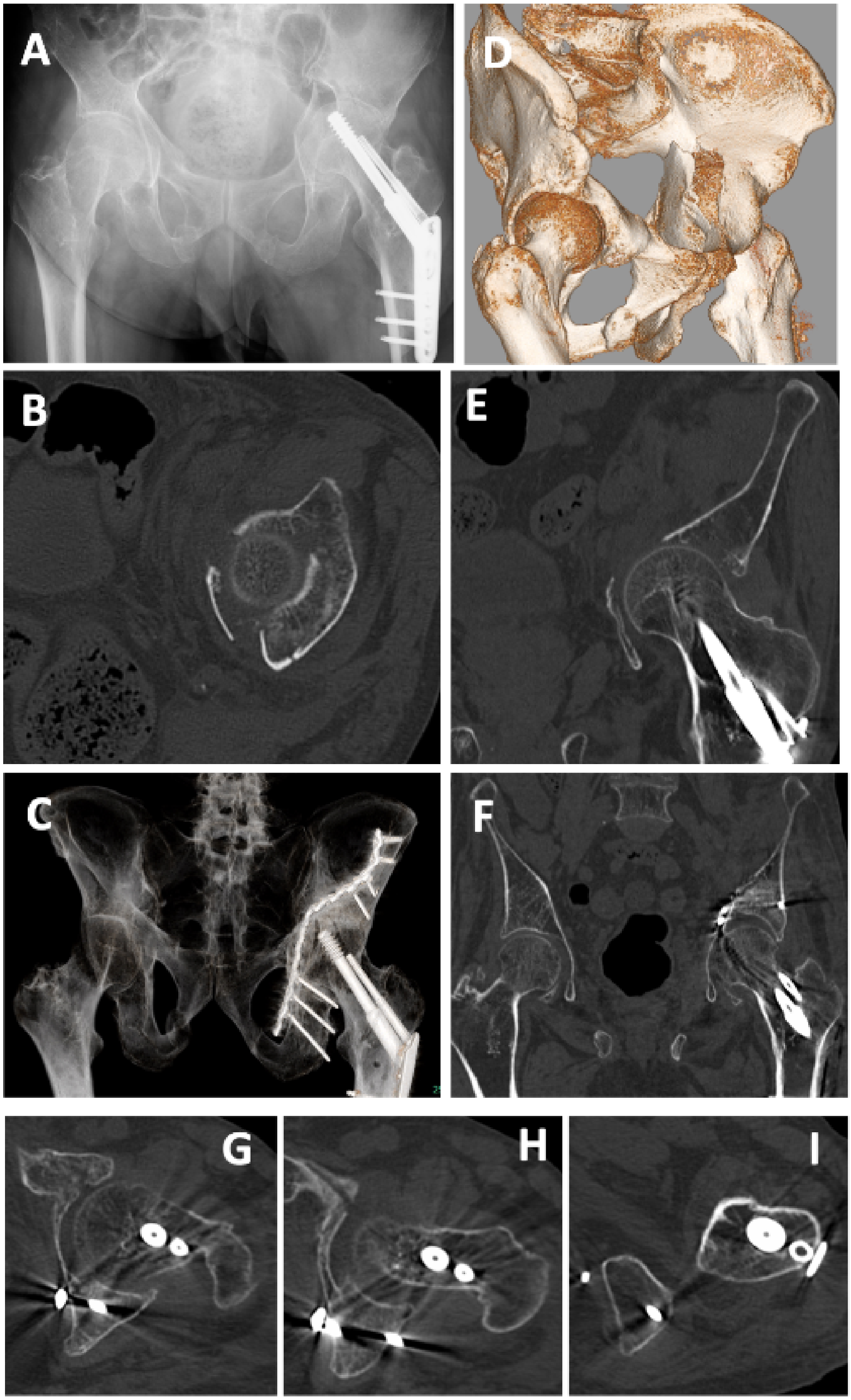

Figure 5

Case 2 images A. Preoperative X-ray, B. Preoperative CT axial image, C. Postoperative X-ray, D. Preoperative 3D-CT, E. Preoperative CT coronal image. F. Postoperative 3D-CT, G,H,I. Postoperative CT axial image. Screws are inserted into the posterior wall (G,H) and near the ischial tuberosity (I).