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How to Solve Anatomical Mismatch in Fixation of Acetabular Fractures Using an Anatomical Quadrilateral Surface Plate

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The anatomical quadrilateral surface buttress plate developed for the quadrilateral surface in an acetabular fracture, a type of fracture difficult to reduce using screws and plates due to its thinness, is a useful implant that makes surgical treatment easier. However, the anatomical structure is different for each patient, and it often does not match the contour of this plate, making detailed bending difficult. Here, we introduce a simple method for controlling the degree of reduction using this plate.

Keywords: *Acetabulum, Fractures, Bone plate, Reduction*

Factors that determine the clinical results of acetabular fractures include not only the type of fracture but also the degree of comminution, displacement, and articular impaction.[1] Despite many difficulties, obtaining anatomical reduction and stable fixation are essential for good clinical results.[2] One of the challenges that surgeons have to overcome is displaced fractures of the quadrilateral surface.[3] Since it is anatomically thin, joint penetration occurs readily during screw fixation. Also, it can be fixed by various methods such as spring plate or infrapectineal plate technique, but sturdy fixation is difficult to obtain when comminution is accompanied.[2,4] If rigid fixation of the quadrilateral surface fails, medial migration of the femoral head can cause posttraumatic arthritis in the hip joint.[5]

To overcome these shortcomings, the anatomical quadrilateral surface buttress plate (Quadrilateral Surface [QLS] plate; Stryker, Selzach, Switzerland) was developed and various clinical results have been reported recently.[6,7] Among the QLS plates, the suprapectineal type plate has a triangular shape plate connected to the pelvic reconstruction plate by two bridges (Fig. 1). The manufacturer claims that it is anatomically angled to fit the suprapectineal area and the superior dome of the acetabulum and the quadrilateral surface. Indications for this plate include anterior column fracture, anterior column with a posterior hemitransverse fracture, and a quadrilateral surface fracture of the acetabulum. This plate also has the advantage of easily controlling fragile bone fragments by simply pressing the

Fig. 1. Suprapectineal type quadrilateral surface plate (Stryker, Selzach, Switzerland).

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plate in acetabular fractures that occur in elderly patients over 65 years of age.[6] Although the gross contour matches the shape of the pelvis, the detailed contour does not cover the pelvic shapes of our population. The improperly fit plate compresses each fracture fragment in varying degrees. Thus, we often experienced insufficient restoration of either the superior dome or quadrilateral surface. Also, there were cases in which bending the plate to change its contour was not satisfactory, leading to difficulty in adjusting the angle between the superior and medial components of the plate.

Therefore, we would like to introduce a surgical technique that can help overcome the mismatch between the anatomy of the acetabulum and the QLS plate and achieve anatomical reduction in acetabular fracture surgery using the suprapectineal type QLS plate.

TECHNIQUE

This study was approved by the Institutional Review Board of Daejeon Eulji Medical Center (No. EMC 2022-05-004). The requirement of written informed consent was waived owing to the retrospective nature of the study.

A 59-year-old male patient was admitted to the emergency room of Daejeon Eulji Medical Center due to a 2-m fall down injury. On computed tomography (CT) taken in the emergency room, an acetabular fracture with displaced quadrilateral surface and superior dome was observed, and surgical treatment using the QLS plate was planned (Fig. 2).

The patient was prepared in the supine position and the pelvic cavity was exposed by the modified Stoppa approach. First, the QLS plate was bent to match the patient's anatomy. After the QLS plate was pushed over the superior dome and quadrilateral surface, we figured out that the reduction was not satisfactory with insufficient compression on certain parts of fragments. In our case, mismatching areas occurred in just anterosuperior and medial aspects of the iliopubic eminence (Figs. 3 and 4). Second, we performed the following two techniques to add compression on the fragment in the mismatching area of the displaced fragment. A surgeon can choose either technique with his or her decision to compress fracture fragments. (1) After drilling the unicortex to prevent joint penetration, a 3.5-mm cortical screw was inserted with several washers. In the present case, the anterosuperior aspect of the iliopubic

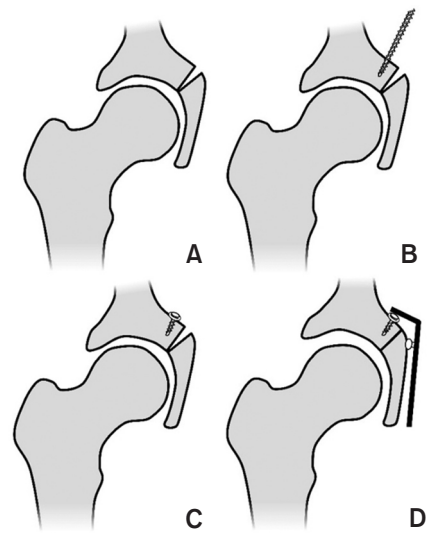

Fig. 3. Images for surgical procedures. (A) An acetabular fracture with displaced quadrilateral surface and superior dome of the hip joint was observed. (B) The unicortical drilling was performed in the mismatching area between the bony contour and the plate. (C) A 3.5-mm cortical screw with a washer was inserted. If the needed length of a screw was shorter than the minimum provided length, cutting a screw into a proper length would be required. A fine adjustment of compression can be done by adding an additional washer in this step. (D) We cut the 5.0-mm cannulated screw short and tied it with a nonabsorbable suture. The screw was inserted into the hole of the quadrilateral surface (QLS) plate in the opposite direction of the screw insertion. Then, the fracture site and screw were pressed with the QLS plate and a ball spike.

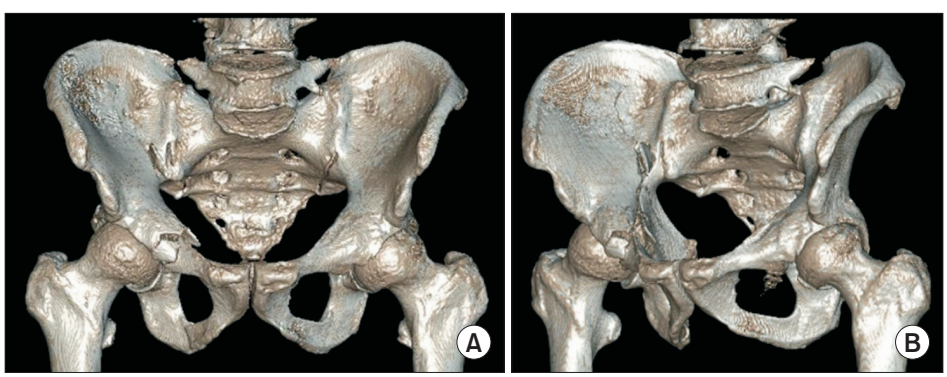

Fig. 2. Three-dimensional reconstruction images of computed tomography of a 59-year-old male patient. (A) On preoperative three-dimensional computed tomography, an acetabular fracture with displaced quadrilateral surface and superior dome of the hip joint was observed. (B) On the oblique view, there were several fragments in the fracture site.

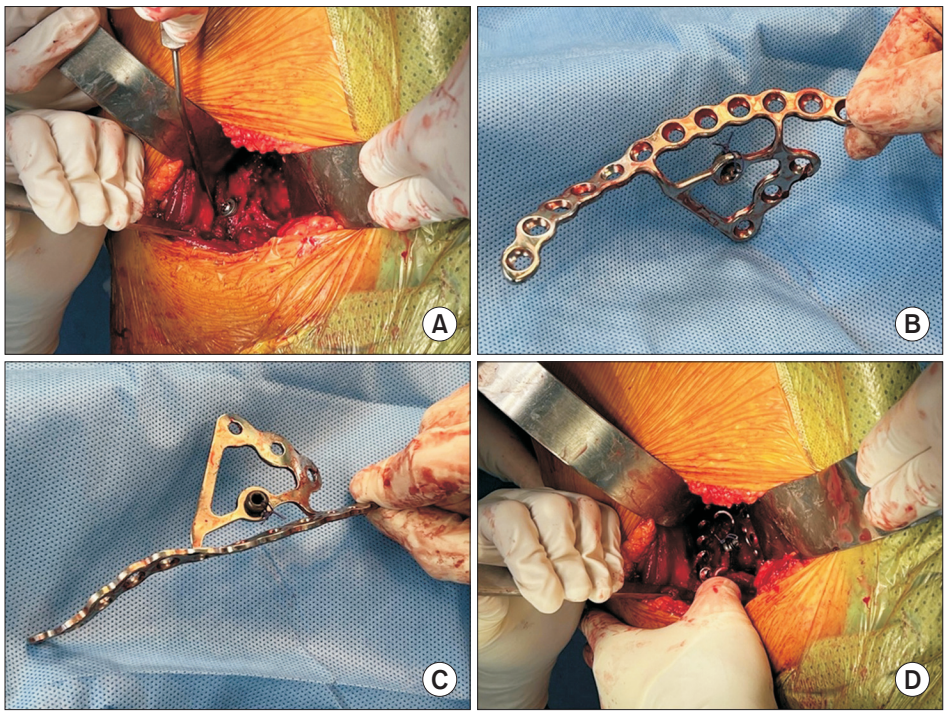

Fig. 4. Surgical procedures. (A) After unicortical drilling at the most displaced portion of the acetabular superior dome, we inserted a 3.5-mm cortical short cut screw with washers. (B) We cut the 5.0-mm cannulated screw short and tied it with Vicryl. (C) The screw was inserted into the hole of the quadrilateral surface (QLS) plate in the opposite direction of the screw insertion. (D) The state of reduction was confirmed by pressing the QLS plate to the fracture site.

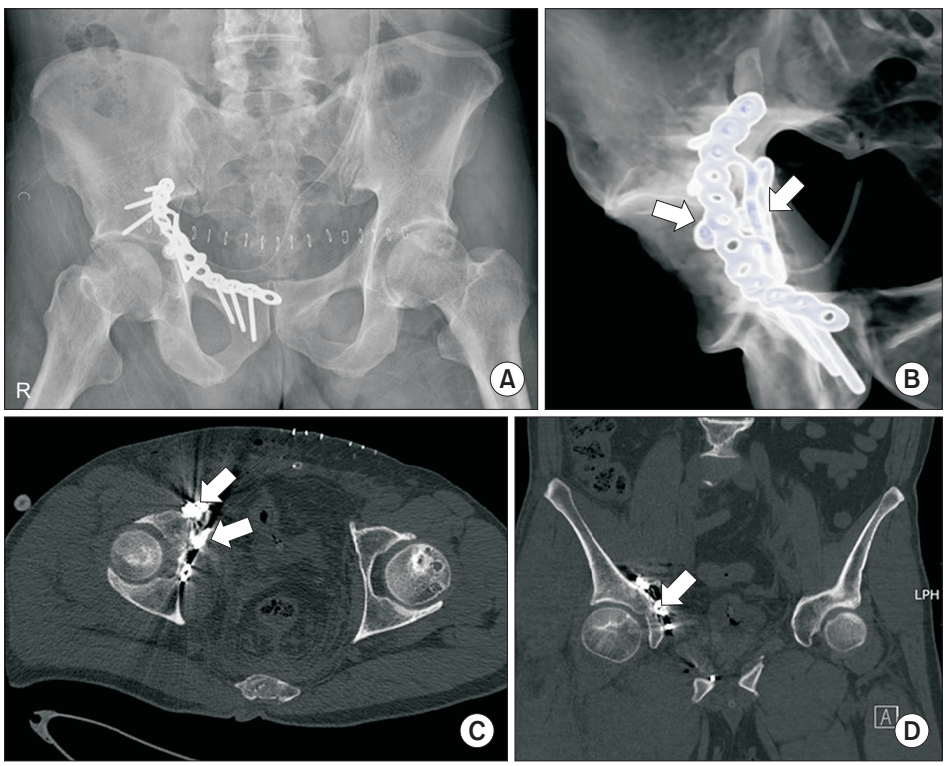

Fig. 5. Immediate postoperative radiographs. (A) An immediate postoperative pelvic anteroposterior radiograph. (B) A three-dimensional reconstruction computed tomography (CT) image. (C) An axial CT view showing the heads of screws (white arrows) pushing the displaced fragments by the quadrilateral surface (QLS) plate. (D) A coronal view CT showing anatomical reduction achieved and the head of screw (white arrow) pushing the displaced fragment by the QLS plate.

eminence was compressed with the first technique. In the case where the compression is still not enough only with screw heads, washers can be used. The number of washers can be determined depending on surgeon's need. The length of screws should be determined in consideration of washers. The depth gauge with washers of the number a surgeon determined would help the proper measurement. If the needed length of a screw is shorter than the mini-

mum provided length, cutting a screw into a proper length would be required. A fine adjustment of compression can be made by adding one more washer in this step. (2) At the site needing compression where adding a cortical screw is not possible, a cut head of a 5.0-mm cannulated screw can be tied under the plate with suture material to add compression. The remnant of a screw shank is inserted into a screw hole to limit the translational displacement. As the vertical displacement is also limited by the compression between the cortical bone and the plate, the risk of displacement will be low. In the present case, the medial aspect of the iliopubic eminence was compressed with the second technique. Vicryl was used to hold screw heads under the plate in this case, and nonabsorbable material could be used if a surgeon has a concern of potential displacement of screw heads. Finally, the QLS plate was inserted in the usual way and reduction was performed using a ball spike pusher. A surgeon can choose either technique according to the site requiring compression. The first technique can be used at any position allowing the insertion of a unicortical screw. Although the second technique does not require any screw insertion, the placement of screw head is limited to the screw hole of the QLS plate. We confirmed that the inserted short cutting screws and washers pushed the bone fragments sufficiently by the QLS plate on postoperative CT, and anatomical reduction of the fracture was obtained (Fig. 5).

DISCUSSION

Contouring of the pelvic plate during acetabular fracture surgery is a time-consuming process.[6] The QLS plate, a pre-contoured anatomical plate, may help surgeons reduce the stress of surgery in this regard. In addition, since it has a large contact area, it can distribute stress, which can be useful for reduction in osteoporotic bones.[11] However, when using this plate, anatomical reduction and rigid fixation are possible only by obtaining secure stable bone contact. Therefore, if the plate contour and bony curvature do not match due to anatomical variations in patients, proper bone contact may not be achieved, and anatomical reduction may fail. However, using our technique, surgeons can reduce the stress caused by differences in anatomical variations in each patient with plate contouring, ultimately lowering the risk of joint penetration by screws. Also, asymmetric pushing is possible in the rotated fragment, and we can obtain accurate anatomical reduction by adjusting the size of the screw head or the number of washers. In addition, preserving the periosteal blood supply between the plate and bone may aid in fracture healing and it can also be applied to other types of quadrilateral buttress plate.[11]

Previous studies reported on the reduction of the quadrilateral surface (Table 1). These methods can be classified into those using two implants or one. Yang et al.[8] used both bended calcaneal plate and reconstruction plate. They reduced the quadrilateral surface with a bended calcaneal plate. And then, a reconstruction plate was superimposed on it. Wan et al.[9] used the suprapectineal reconstruction plate and the infrapectineal quadrilateral plate simultaneously. The length of the pelvic anterior column was maintained as the reconstruction plate, and the quadrilateral surface was reduced using the infrapectineal quadrilateral plate. Although these methods have the advantage of being easily contoured to the two implants, caution is required because there is a possibility that the fragment to be reduced next may not be as mobile due to the plate and screw installed first. Kwak et al.[10] used a suprapectineal quadrilateral plate and a ball spike as reported in our study, but there was a difference in pulling the femoral head to the lateral aspect with a

Table 1. Reduction Techniques for Quadrilateral Surface of Acetabular Fractures in Previous Literatures

Study	Publication year	Used implant	Technique
Yang et al.[8]	2020	Reconstruction plate and calcaneal plate	The quadrilateral surface fracture was pressed with the bent calcaneal plate and a reconstruction plate was positioned on it.
Wan et al.[9]	2022	Reconstruction plate and infrapectineal quadrilateral plate	The length of the pelvic ring was adjusted with the reconstruction plate and the quadrilateral surface fracture was reduced with the infrapectineal quadrilateral plate.
Kwak et al.[10]	2022	Suprapectineal quadrilateral plate	Reduction was performed while pressing the suprapectineal quadrilateral plate with a ball spike pusher and pulling the femoral head to the lateral aspect with a Schanz screw.
Karim et al.[2]	2017	Reconstruction plate	First, the suprapectineal reconstruction plate was properly positioned at the medial edge of the pelvic brim. Then 3.5-mm screws were inserted through the plate, rubbing on the inner surface of the quadrilateral surface.

Schanz screw. We performed gentle traction on the lower extremity in distal and lateral directions to reduce the pressure at the fracture site caused by the femoral head. Karim et al.[2] used a rather difficult technique. First, the suprapectineal reconstruction plate was properly positioned at the medial edge of the pelvic brim. Then 3.5-mm screws were inserted through the plate, rubbing on the inner surface of the quadrilateral surface. Since the quadrilateral surface is supported by two to three screws in this method, the mechanical strength is considered to be weaker than when fixed by a plate.

We believe that our technique also has weaknesses. First, it has not yet been proven whether adequate mechanical strength can be obtained when our technique is used. Nevertheless, we believe that our technique can secure adequate mechanical strength at the fracture site, as we can see that the displaced fragment can be maintained by pushing the plate and screws. Also, long-term follow-up is necessary to ensure that the implants are well maintained in the pelvic cavity and do not cause problems. Second, in order to reduce the inferiorly displaced posterior column fragment, it may be necessary to use other methods such as a reduction clamp or a posterior column screw.

In conclusion, our technique is considered to be a very useful method for obtaining anatomical reduction and solving a mismatch between the bony contour and plate contour in the surgery for an acetabular fracture using a pre-contoured anatomical quadrilateral buttress plate.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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