Observational Study

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Comparison of 2 different fixation techniques of comminuted acetabular quadrilateral surface fractures using square bracket-shaped tubular plate or interfragmentary screws in addition to supra/infrapectineal plate fixation

An observational study

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Abstract

The management of comminuted quadrilateral fractures remains challenging, and treatment options are constantly evolving. The purpose of the present study was to examine the outcomes of 2 different fixation techniques in the management of comminuted quadrilateral fractures. Twenty-two patients with comminuted quadrilateral acetabular fractures were surgically treated with interfragmentary lag screw (group 1) and square bracket-shaped tubular (SBST) plate technique (group 2), in addition to suprapectineal and infrapectineal pelvic reconstruction plate fixation between January 2016 and July 2019 at our clinic. 2 years follow-up control data of each group were compared in terms of radiological and functional results, and complications. According to the functional score comparison, the mean Merle d'Aubigne Postel scoring system (MAP) score was 15.2/15.6 ($P = .632$), and the mean Harris hip scoring (HHS) system score was 74.65/77.3 ($P = .664$) in groups 1 and 2, respectively. Radiological comparison was performed according to matta radiological criteria (MRC), and 2 excellent, 6 good, 2 poor, 4 excellent, 4 good, and 4 poor radiological results were observed in groups 1 and 2, respectively. intraarticular screw penetration was detected in 3 patients in group 1, while there was no articular implant penetration in group 2 ($P = .001$). We believe that satisfactory results can be obtained with the SBST plate technique, offering functional and clinical outcomes that are similar to those of the interfragmentary screw technique. The SBST plate technique is superior in terms of avoiding intraarticular screw penetration and related revision surgery.

Abbreviations: CT = computed tomography, HHS = Harris hip scoring, MAP = Merle d'Aubigne Postel, MRC = matta radiological criteria, QLS = quadrilateral surface, SBST = square bracket-shaped tubular.

Keywords: acetabulum quadrilateral surface fractures, functional scores, interfragmentary lag screw, radiological scores, SBST plate

1. Introduction

As new surgical intervention methods, implant development, and application techniques have been described, increasing surgical success and decreasing complication rates have made significant contributions to patient mortality and morbidity. Despite improvements in pelvic surgery, these interventions remain challenging for trauma surgeons.

Anterior, posterior, extensive, or combined approaches are preferred for acetabular fracture surgery. In recent years, the modified Stoppa technique, also known as the anterior intrapelvic approach, has been used widely.[1] An anterior intrapelvic approach is appropriate for fractures of the anterior wall and column, the quadrilateral region, and both columns.[2] This approach has extended the possible fixation alternatives by

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The datasets generated during and/or analyzed during the current study are not publicly available, but are available from the corresponding author on reasonable request.

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enabling the use of long infrapectineal and vertical infrapectineal plates in addition to classically located suprapectineal reconstruction plates for complex fractures.[3] Fixation of quadrilateral and ischial fractures was also possible using the modified Stoppa approach.[4] However, reduction and fixation remain difficult due to the anatomical deep location, and comminuted fracture patterns are occasionally observed.[5,6] Reduction and fixation of intrapelvic deep localized bony surfaces, such as the quadrilateral and ischial regions, are more challenging to intervene due to adjacent neurovascular structures and close proximity to the hip joint.

Recently, various implants have been used to treat comminuted quadrilateral surface (QLS) fractures. As anticipated, these implants require more surgical experience.[6] Among the various implants that can be used in patients with acetabular QLS fractures, we most frequently use the interfragmentary screw technique and the square bracket-shaped tubular (SBST) plate technique in clinical applications. In this study, we aimed to compare the outcomes of column acetabular fractures involving comminuted quadrilateral acetabular fractures surgically treated with 2 different surgical techniques, the interfragmentary lag screw, and SBST plate technique, in addition to suprapectineal and infrapectineal pelvic plate fixation.

Therefore, we asked: Is the SBST plate technique as reliable as the interfragmentary screw technique in terms of clinical and radiological results in patients with acetabular QLS fractures? Does fixation of acetabular QLS fractures using a SBST plate reduce the incidence of revision surgery?

2. Methods

A total of 22 patients (2 females and 20 males) with both-column fractures according to the Judet classification involving quadrilateral comminuted fractures, admitted to our institute between January 2016 and July 2019, were included in the study. The study was approved by the ethics committee of our institution. The inclusion criteria were patients presenting with both-column acetabular fractures involving comminuted QLS and those who had complete medical records and follow-up data. The exclusion criteria were pathological fractures, neglected fractures (>3 weeks), pediatric fractures, open fractures, patients who were followed up in a different medical center, prolonged immobile patients due to other comorbidities, and simple and minimally displaced QLS fractures. The patients were divided into 2 groups according to the surgical technique used to fix QLS fractures. All patients included in this study underwent both infrapectineal and suprapectineal plate fixation, in addition to QLS fixation. The interfragmentary screw fixation technique was used in addition to supra/infrapectineal plate fixation in patients from January 2016 to June 2017, and the SBST plate technique was used in patients who underwent surgery between June 2017 and June 2019. Patients who underwent surgery using the interfragmentary screw technique in the fixation of QLS fractures were included in group 1, and those who underwent surgery using the SBST plate technique in the fixation of QLS fractures were included in group 2.

All patients underwent surgery under general anesthesia in the supine position on a radiolucent fracture table. All surgeries included in this study were performed using the anterior intrapelvic approach by an experienced trauma surgeon for acetabular and pelvic fractures. In the anterior intrapelvic approach, vertical midline incision is preferred. Following midline dissection of the anterior rectus fascia and rectus abdominis, the fracture line was reached using blunt dissection on the corresponding pelvis side. After the corona mortis was dissected, tied, or cauterized to avoid bleeding, the iliac artery and vein were protected. Subsequently, the obturator neurovascular bundle was dissected and protected using a blunt retractor placed on a large sciatic notch. Thus, a clear field of view of the quadrilateral surface was obtained. After achieving QLS reduction with ball-spike pushers, pelvic reduction clamps, and collinear reduction clamps, fracture fixation was performed.

All patients included in this study had both-column acetabular fractures involving comminuted QLS fractures. In cases with comminuted QLS fractures, suprapectineal and/or infrapectineal plate fixation may not be sufficient and may require additional fixation materials to preserve reduction and fixation. In such cases, we used interfragmentary screws or SBST plates to preserve reduction in our clinic. In group 1, after the reduction of the QLS and columns was achieved, 1 or 2 interfragmentary lag screws were placed at the QLS where the bony width was the greatest by paying attention to avoid joint penetration, to preserve reduction, and to achieve fixation between both columns and QLS. Subsequently, suprapectineal and infrapectineal plate fixation was performed according to the fracture configuration (Fig. 1). In group 2, after the reduction of the QLS and both columns were achieved, a square bracket shape was given to a 3.5 tubular plate by bending 90° in both distal ends while 1 hole remained in the bent distal parts. Then, the SBST plate was placed on the QLS with one side at the greater or lesser sciatic notch depending on the fracture configuration and the other side at the anterior column (Fig. 2). The 90° bent distal part and distal hole of the SBST plate were placed at the anterior column and under the suprapectineal and infrapectineal plates. A screw was placed at the bent hole in the anterior column to prevent plate displacement and strengthen the fixation. After placement of the SBST plate, suprapectineal and infrapectineal plate fixation was added according to the fracture formation (Figs. 3 and 4).

Intravenous antibiotic prophylaxis (minimum 3 days postoperatively, 1 g cefuroxime 3 times a day) was administered. For antithrombotic prophylaxis, 0.4cc enoxaparin sodium was administered twice a day until the patient was mobilized.

Preoperative and postoperative pelvic Judet radiography and pelvic computed tomography (CT) were performed. Postoperative fracture reduction quality was evaluated according to matta radiological criteria (MRC).[7] The residual displacement staging was classified as excellent (0–1 mm), good (1–2 mm), or poor (≥3 mm).

All patients were followed up for a minimum of 2 years postoperatively. At the postoperative 2-year follow-up; pain, hip range of motion, and walking ability were assessed for each patient and scored according to the Merle d'Aubigne scoring system (MAP) and Harris hip scoring System (HSS) to determine functional outcomes.[8,9]

Statistical analysis was performed using SPSS version 22.0 statistical software (SPSS Inc., IBM Corporation, Armonk, NY). The chi-square test was used to determine categorical variables. Fisher exact test was preferred for analyzing the relationship between clinical/radiological outcomes because some expected cell counts were lower than 5.

3. Results

A total of 22 patients with comminuted acetabular QLS fractures treated using the interfragmentary screw and SBST plate techniques in addition to suprapectineal/infrapectineal pelvic reconstruction plates were included in this study. The mean age was 53.8 years (range 39–65 years). All the patients were exposed to severe high-energy trauma. The mechanism of injury was determined to be; 18 road accidents and 4 falls.

Postoperative 2-year follow-up data, including the MAP and HHS scores, were evaluated to determine functional outcomes. In group 1; 2 patients had excellent, 6 had good and 2 had poor results according to MAP; the mean MAP and HHS were 15.2 and 74.65 respectively. In group 2; 2 had excellent, 6 good, 2 fair, and 2 poor results according to MAP; the

Figure 1. (Group 1) (A) Preoperative AP X-ray. (B) Postoperative AP X-ray. (C) Obturator oblique view. (D) Iliac oblique view.

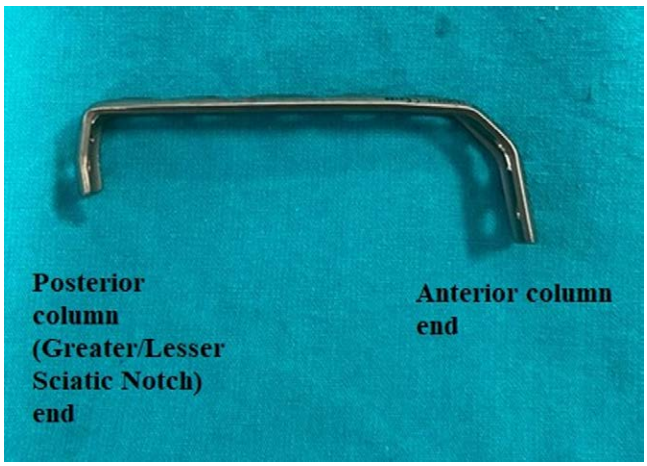

Figure 2. Square bracket-shaped tubular (SBST) plate.

mean MAP and mean HHS were 15.6 and 77.3, respectively (Table 1). When the mean scores were compared, there was no statistically significant difference in MAP scores between the 2 groups (P = .632). Again, there was no significant difference between the 2 groups in terms of HHS score as well (P = .664).

MRC were used to assess the radiologic results in both groups. In group 1, we had excellent results in 2 patients, good results in 6 patients, and poor results in 2 patients. In group 2, excellent results in 4 patients, good results in 4 patients, and poor results in 4 patients in terms of radiological outcomes according to MRC (Table 2). There was no significant difference between the 2 groups (P = .230).

In group 1, intraarticular screw penetration was detected in 3 patients at the postoperative control CT scans and these patients underwent revision surgeries. In contrast, in group 2, the patients who were treated with the SBST plate technique, no revision necessity was observed. There was a significant difference between the 2 groups in terms of screw penetration into the hip joint (P = .001).

4. Discussion

The main objective of surgical treatment of acetabular fractures is to provide anatomical reduction and stable fixation. The inability to reduce joint anatomy and fixation without joint penetration can cause poor clinical and radiological results.[7,10] QLS fractures are a challenging group of acetabular injuries because of the anatomy of the deep pelvic region, fracture fragmentation due to the thin bony surface in the QLS, the possibility of medial protrusion of the femoral head, and dome impaction.[6,11,12] Anatomical reduction and stable fixation are often difficult because of the complex anatomy of the acetabulum and pelvis.[13]

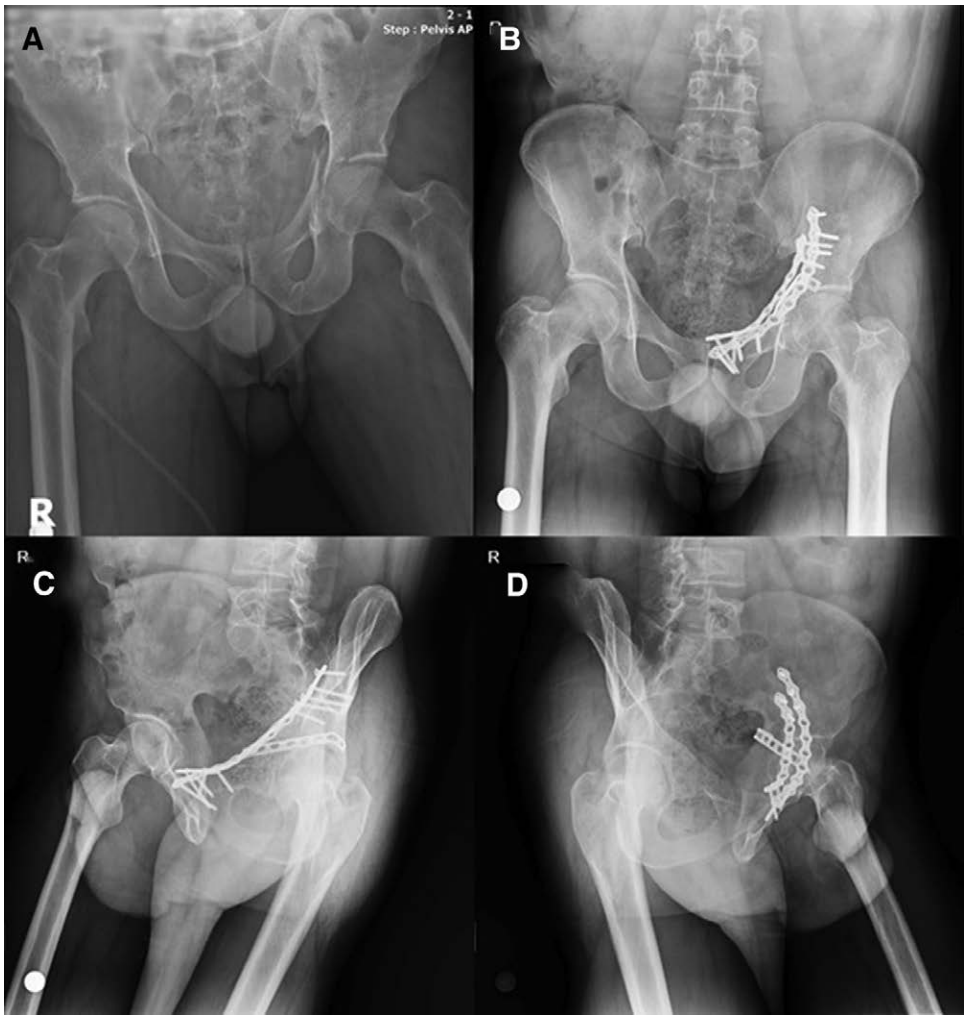

Figure 3. (Group 2) (A) Preoperative AP X-ray. (B) Postoperative AP X-ray. (C) Obturator oblique view. (D) Iliac oblique view.

In the surgical treatment of acetabular fractures involving the QLS, various surgical techniques include interfragmentary lag screws, percutaneous screws, reconstruction plates, and anatomical plates.[6] Pelvic brim plates are successful in preventing medial displacement, but it is quite difficult to insert screws into these plates without penetrating the articular space.[14] The application of the pelvic brim plate was first described by Hirvensalo et al.[15] Cole and Bolhofner described the infrapectineal plate for the treatment of acetabular fractures involving the QLS using a modified Stoppa approach and stated that one should pay attention not to place the screws directly adjacent to the QLS as they may penetrate the joint and care should be taken to protect all neurovascular structures.[1] Keel et al described the results of 20 patients with an average age of 59 years who underwent surgery for fractures involving the anterior column and QLS with 3.5 mm reconstruction plates. They stated that anatomical reduction was achieved in 95% of the patients, and all fractures healed.[16] Laflamme et al conducted a study of 21 patients over 60 years of age who had displaced QLS fractures. They used the infrapectineal plating technique for fixation and evaluated reduction quality and functional outcome scores. They evaluated functional results according to MAP and HHS, which showed satisfactory results.[5] Chen et al conducted a study comparing 4 different fixation techniques involving infrapectineal QLS buttress plate, suprapectineal QLS buttress plate, suprapectineal reconstruction plate, and infrapectineal reconstruction plate. They stated that the infrapectineal QLS buttress plate is at least comparable to standard forms of fixation in resisting fracture motion and medial subluxation.[17] Spring plates are also used in acetabular comminuted fracture fixation. There are studies in the literature reporting a low risk of intraarticular implant penetration and implant failure, and excessive soft tissue dissection is not required during the application of these plates. In a study by De Mauro et al involving 46 patients, successful results were obtained using Spring plates and it was concluded that these plates can be used as additional support in posterior fractures.[18]

In cases where suprapectineal and/or infrapectineal plate fixation may not be sufficient to preserve the reduction of the QLS, we used interfragmentary screws or square bracket-shaped tubular plates to conserve the reduction in addition to suprapectineal and/or infrapectineal reconstruction plate fixation.[14] In comminuted fractures of the QLS, an infrapectineal plate is usually placed using a modified Stoppa approach to reconstruct the QLS. However, in comminuted QLS fractures accompanying both-column fractures, these plating techniques may be inadequate in preserving the reduction and preventing medial protrusion of the femoral head. Even if the QLS is reduced during surgery, reduction loss can often occur in the postoperative period, because there is no additional implant that directly supports the QLS. In such circumstances, an additional fixation method will provide a buttress effect on the QLS and reduce the number of displaced fragments. Karim et al described a novel technique for fixation of QLS fractures of the acetabulum using buttress screws with satisfactory results.[12] They used 1, 2, or 3 screws inserted through a suprapectineal plate rubbing on the

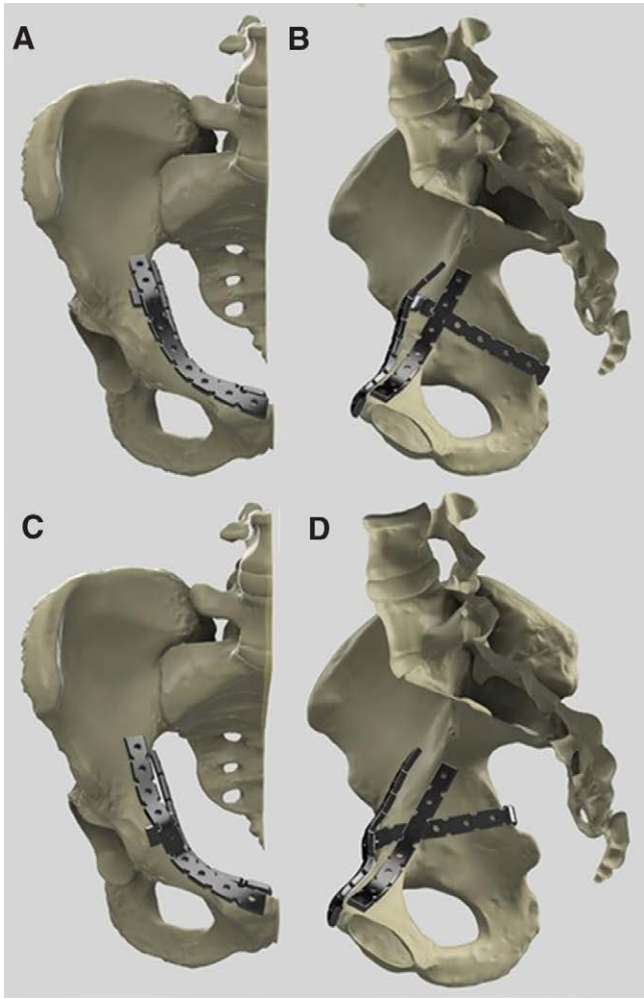

Figure 4. (A and B) Coronal and sagittal pelvis view of SBST plate placed to lesser sciatic notch. (C and D) Coronal and sagittal pelvis view of hook plate placed to greater sciatic notch. SBST = square bracket-shaped tubular.

Table 1

The distribution of patient number, proportion, mean MAP, and HHS scores of each group.

	MAP scores distribution					
Patients	**Excellent**	**Good**	**Fair**	**Poor**	**Mean MAP**	**Mean HSS**
Group 1	2 (20%)	6 (60%)	0 (0%)	2 (20%)	15.2	74.65
Group 2	2 (16.6%)	6 (50%)	2 (16.6%)	2 (16.6%)	15.6	77.3

HHS = Harris hip score, MAP = Merle d'Aubigne – Postel scoring system.

inner surface of the QLS, thus maintaining the reduction of the QLS component into position in their study. This surgical technique aims to preserve the reduction in the QLS by providing a buttress effect with screws placed inside the pelvic brim and outside the pelvic bone structures. We believe that screws placed out of the bone structures may cause bleeding in the venous plexuses in the pelvic brim if they are exposed in the deep parts of the pelvis. Tranexamic acid, which is also used in other major orthopedic surgeries, can be utilized to reduce the amount of bleeding in acetabular fixation surgeries.[19] Considering this, the SBST plate technique reduces the fracture by acting like a collinear clamp and also provides a buttress effect similar to the buttress screw technique in the study by Karim et al without disturbing the adjacent anatomical structures.[12]

Table 2

The distribution of patient numbers and proportion in terms of MRC scores of each group.

	Matta radiologic criteria			
Patients	**Excellent**	**Good**	**Fair**	**Poor**
Group 1	2 (20%)	6 (60%)	0 (0%)	2 (20%)
Group 2	4 (33.3%)	4 (33.3%)	0 (0%)	4 (33.3%)

MRC = matta radiological criteria.

In the present study, we investigated the outcomes of 2 different surgical techniques. MAP and HHS were used to determine functional outcomes in each group. When the functional outcomes were compared, there was no statistically significant difference between the 2 groups, but there were slightly better results in group 2. MRC was also used to determine the radiological results in each group. According to the MRC scores, there was no significant difference between the 2 groups. Based on the clinical and radiologic scores evaluated at the postoperative 2-year follow-ups, we investigated whether both surgical methods were successful in the surgical treatment of patients with acetabular fractures with both-column fractures accompanied by comminuted quadrilateral fractures. When the results of the 2 surgical techniques were compared, the most important difference was the rate of revision surgery due to intraarticular screw penetration. In group 1, joint penetration was detected in 3 patients on postoperative control CT scans, and these patients underwent revision surgeries. In contrast, in group 2, the patients who were treated with the SBST plate technique did not require revision necessity was observed. In the interfragmentary lag screw technique, we think that joint penetration in this group is more common because of the limited area of screw insertion and its proximity to the hip joint. The screws must be placed to avoid entering the joint or pelvic brim; on the other hand, the screw length must be adequate to fix the fracture fragments. It is challenging to place these long screws without confirmation of intraoperative BT. On the other hand, in the SBST plate technique, fixation is achieved by the SBST plate body, as there is no risk of joint penetration. Revision surgery due to intraarticular screw penetration, as anticipated, creates an additional surgical complication risk for the patient and also causes an increase in treatment costs due to the necessity of a secondary surgery.

The limitations of our study are the relatively small number of patients and follow-up periods. Further studies conducted on a larger patient population with longer follow-up periods will shed more light on this issue.

5. Conclusion

Our experience with comminuted QLS fractures shows that satisfactory results can be obtained with the SBST plate technique, and we believe that it is beneficial to use the SBST plate during surgeries for comminuted quadrilateral fractures. The application of the SBST plate is advantageous in terms of avoiding joint penetration, and it can provide additional support as a buttress plate to the QLS. Functional and clinical outcomes were similar to those of the interfragmentary screw technique, and a low revision surgery rate was observed with the SBST plate technique. To determine the effectiveness of this technique, long-term, prospective, randomized controlled studies with a large number of groups are required for comparison with other surgical techniques.

Author contributions

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Supervision: Cem Yalin Kilinç.
Writing – review & editing: Cem Yalin Kilinç, Fatih ilker Can.
Writing – original draft: Emre Gültaç.

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