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ORIGINAL ARTICLE

Fixation of bilateral acetabular fractures using the modified Stoppa approach: Two-year clinical outcomes

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ABSTRACT

Objectives: This study aims to evaluate the two-year clinical results of bilateral acetabular fractures operated via a single incision with the modified Stoppa approach.

Patients and methods: Between January 2013 and January 2020, a total of 22 acetabular fractures of 11 patients (7 males, 4 females; mean age: was 42.9±13.7 years; range, 19 to 62 years) who were operated via the modified Stoppa approach were retrospectively analyzed. The medical records were analyzed in terms of time to surgery, fracture patterns, Injury Severity Score (ISS), operation duration, blood loss, reduction quality, perioperative complications and concomitant injuries. Reduction quality was assessed according to Matta's criteria. The Harris Hip Score (HHS) and modified Merle d'Aubigne score (MDS) were utilized for functional assessment.

Results: The mean follow-up was 49±15 (range, 30 to 79) months. The mean ISS was 28.2±7.2. The mean modified MDS was 15.90±1.57. The mean HHS was 84.27±8.85. For both sides, reduction was anatomical-anatomical (63.6%) in seven patients, anatomical-imperfect in three (27.3%) patients, and imperfect-poor in one (9.1%) patient. According to the Kellgren-Lawrence radiological evaluation at 24 months of follow-up bilaterally, Grade 0-1 osteoarthritis was observed in six (54.5%) patients, Grade 1-1 in four (36.4%) patients, and Grade 1-2 osteoarthritis in one (9.1%) patient.

Conclusion: The modified Stoppa approach in bilateral acetabular fractures seems to be more preferable than other approaches, as it can be performed with a single incision and provides less bleeding, shorter operation duration, and satisfactory results.

Keywords: Anterior intrapelvic approach, bilateral acetabular fractures, functional outcomes, modified Stoppa approach, radiological outcomes.

Acetabulum fractures are common traumatic injuries.[1] It has been reported that high-energy impacts such as motor vehicle accidents and falls from height are usually the main causes of these fractures.[2] Little is known about bilateral acetabular fractures and studies published on this subject are limited. To the best of our knowledge, there is no comprehensive study or patient follow-up series presenting the clinical outcomes regarding bilateral acetabular fractures.

The most decisive goal in acetabular surgeries is the anatomical fixation of the fractures and preventing surgical complications.[3] Non-anatomical reduction may cause malunion, nonunion and post-traumatic arthrosis, resulting in a serious decrease in the patient's quality of life and may also cause necessity of additional surgical interventions, such as arthroplasty in the future.[4] Acetabular fractures may present with a high mortality rate due to accompanying neurovascular and adjacent internal organ injuries.[4-6] Therefore, it would not be wrong to predict that bilateral acetabular fractures would progress with higher mortality and morbidity rate compared to unilateral fractures.[7]

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Various approaches can be used in the treatment of acetabular fractures. The most commonly used techniques are Kocher-Langenbeck, anterior intrapelvic (AIP) approach (modified Stoppa), ilioinguinal, iliofemoral, extended iliofemoral and combined anterior/posterior approaches.[8-12] The most appropriate surgical intervention is selected according to the surgeon-based factors and patient-based factors which should be evaluated together. The modified Stoppa approach, which was first defined in 1994 by Cole and Bolhofner,[13] has gained popularity in recent years. Its main advantages are to provide a wide viewing angle to the intrapelvic area to reach the inner side of both acetabula, to provide effective access into the anterior wall and column fractures, anterior column-posterior hemitransverse fractures and fractures involving both columns, and also to ensure proper fixation of the quadrilateral surface.[14-16] This approach also provides advantages in securing the iliac neurovascular structures. As it is widely accepted, anatomical fixation of the quadrilateral surface is essential for restoring the joint surface. It has also been reported in the literature that the modified Stoppa approach is correlated with less surgical time and intraoperative blood loss.[17,18] In addition, although there are few studies regarding unilateral acetabular fractures, no studies investigating the incidence, mechanism and clinical outcomes of treatment of bilateral acetabular fractures is available in the literature.

In the present study, we aimed to evaluate the two-year clinical results of bilateral acetabular fractures operated via a single incision with the modified Stoppa approach and to contribute to the literature about the clinical outcomes of bilateral acetabular fractures for which there is little information.

PATIENTS AND METHODS

This single-center, retrospective study was conducted at Muğla Sıtkı Koçman University Training and Research Hospital, Department of Orthopaedics and Traumatology between January 2013 and January 2020. A total of 243 patients with acetabular fractures surgically treated in our clinic were reviewed. The patient's age, sex, injury mechanism, Injury Severity Score (ISS), fracture classification, duration of the surgical procedure, amount of intraoperative bleeding, and radiological images were retrieved from the hospital database. Patients who were surgically treated for bilateral acetabular fractures via the modified Stoppa approach were included. General anesthesia was used in all patients. The fracture sites were exposed by a midline vertical incision. Corona mortis was tied, if encountered. Reduction was achieved after reaching the fracture sites bilaterally and fixation was accomplished with reconstruction plates and screws. After the excluded cases, a total of 11 patients (7 males, 4 females; mean age: was 42.9±13.7 years; range, 19 to 62 years) were enrolled. Exclusion criteria were as follows: pediatric patients, unilateral fractures, age over 70 years, missing medical data and external center follow-ups, patients operated in more than one session, patients who were operated using other approaches.

Acetabular fractures were analyzed by a radiologist using pre- and postoperative X-ray images and computed tomography (CT) images and classified based on the Letournel classification (Figure 1).[11] Follow-up was performed on postoperative Day 15, at one, three, six, 12 months and every two years, thereafter. The modified Merle D'Aubigné Score (MDS) and Harris Hip Score (HHS) at postoperative second year follow-up data were also extracted.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 22.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were presented in mean ± standard deviation (SD), median (min-max) or number and frequency, where appropriate.

RESULTS

Demographic data, trauma mechanisms, and accompanying internal organ injuries are presented in Table I. The mechanism of trauma was traffic accidents in eight (72.7%) cases and falling from a height in three (27.3%) cases. The mean follow-up was 49±15 (range, 30 to 79) months.

Fracture types are shown in Table I for each case, as right and left. Among 22 acetabular fractures operated in 11 patients, the fracture types were as follows: anterior column (n=8), double column (n=6), transverse (n=5), T-type (n=2), and anterior column + posterior hemitransverse (n=1). The mean ISS of the patients was 28.2±7.2.

Reduction quality was evaluated using the Matta's reduction criteria by measuring the postoperative maximum residual displacement (MRD). The MRD was utilized to grade the quality of reduction as anatomical (MRD <2 mm), imperfect (MRD between 2 and 3 mm) and poor (MRD >3 mm).[19] When bilateral acetabulum reductions were evaluated postoperatively according to Matta's criteria, for both sides, reduction quality was

TABLE I
Demographic data, trauma mechanism and accompanying internal organ injuries of each patient

Patient number	Trauma mechanism	Fracture type (bilaterally)	Concomitant injuries	Follow-up period (mo)
1	Motor vehicle accident	Anterior column/double column	Bladder injury + pulmonary contusion	30
2	Motor vehicle accident	Anterior column/T-type	Multiple rib fractures	40
3	Motor vehicle accident	Anterior column/double column	Cerebral contusion + pulmonary contusion	54
4	Motor vehicle accident	Transverse/transverse	Bladder injury	50
5	Fall from height	Anterior column/double column	Liver capsule injury + cerebral contusion	59
6	Motor vehicle accident	T-type/double column	Pulmonary contusion + pneumothorax	40
7	Motor vehicle accident	Anterior column/transverse	None	32
8	Fall from height	Anterior column/posterior hemitransverse	Cerebral contusion	62
9	Motor vehicle accident	Transverse/double column	None	36
10	Motor vehicle accident	Anterior column/transverse	Cerebral contusion	79
11	Fall from height	Anterior column/double column	Pulmonary contusion + pneumothorax	58

mo: Months

TABLE II
Clinical outcomes of patients

Patient number	Blood loss (mL)	Matta's Reduction Criteria (right)	Matta's Reduction Criteria (left)	Kellgren-Lawrence Classification (right)	Kellgren-Lawrence Classification (right)	Harris Hip Score	Merle d'Aubigne Score
1	700	Anatomic	Anatomic	0	1	89	18
2	550	Anatomic	Anatomic	0	1	86	16
3	650	Anatomic	Imperfect	0	1	87	17
4	400	Anatomic	Anatomic	1	1	74	14
5	570	Anatomic	Anatomic	1	1	84	15
6	1250	Poor	Imperfect	2	1	65	13
7	550	Anatomic	Anatomic	1	1	78	15
8	800	Anatomic	Imperfect	0	1	96	18
9	750	Anatomic	Imperfect	1	1	93	17
10	870	Anatomic	Anatomic	0	1	88	16
11	400	Anatomic	Anatomic	0	1	87	16

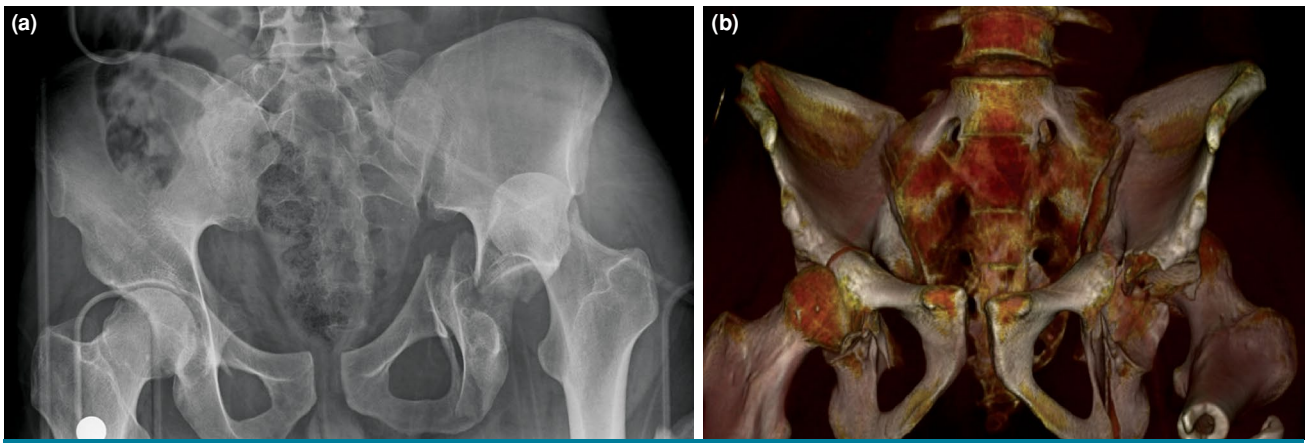

FIGURE 1. (a) Preoperative X-ray and **(b)** three-dimensional computed tomography images showing a bilateral acetabular fracture.

anatomical-anatomical in seven (63.6%) patients, anatomical-imperfect in three (27.3%) patients, and imperfect-poor in one (9.1%) patient (Table II). According to the Kellgren-Lawrence radiological evaluation measured at 24 months of follow-up bilaterally, Grade 0-1 osteoarthritis was observed in six (54.5%), Grade 1-1 in four (36.4%), and Grade 1-2 osteoarthritis in one (9.1%) patient. The MDS score recorded at 24 months was excellent in two (18.2%), good in seven (63.6%), and moderate in two (18.2%) patients. The mean modified MDS was 15.90±1.57. While HHS was recorded as excellent in two patients (18.2%), it was good in six (54.5%), moderate in two (18.2%), and poor in one (9.1%) patient. The mean HHS was 84.27±8.85. The mean amount of intraoperative blood loss was 680±241 mL. The mean operation duration was 195±23.6 (range, 160 to 240) min. Although no prophylaxis was applied, heterotopic ossification was not encountered in any of our patients. Infection or femoral nerve damage was not observed.

DISCUSSION

Bilateral acetabular fractures are encountered less frequently than unilateral fractures, as well as bilateral traumatic dislocations.[20,21] There are only a few sporadic case reports and reviews regarding surgery of bilateral acetabular fractures.[22-24] The main strength of our study is that it is the only study with a follow-up period -up to seven years- regarding bilateral acetabular fractures and presenting clinical outcomes. In our series, the incidence of bilateral acetabular fractures was 4.52% among all acetabular fractures. When the fracture patterns among 22

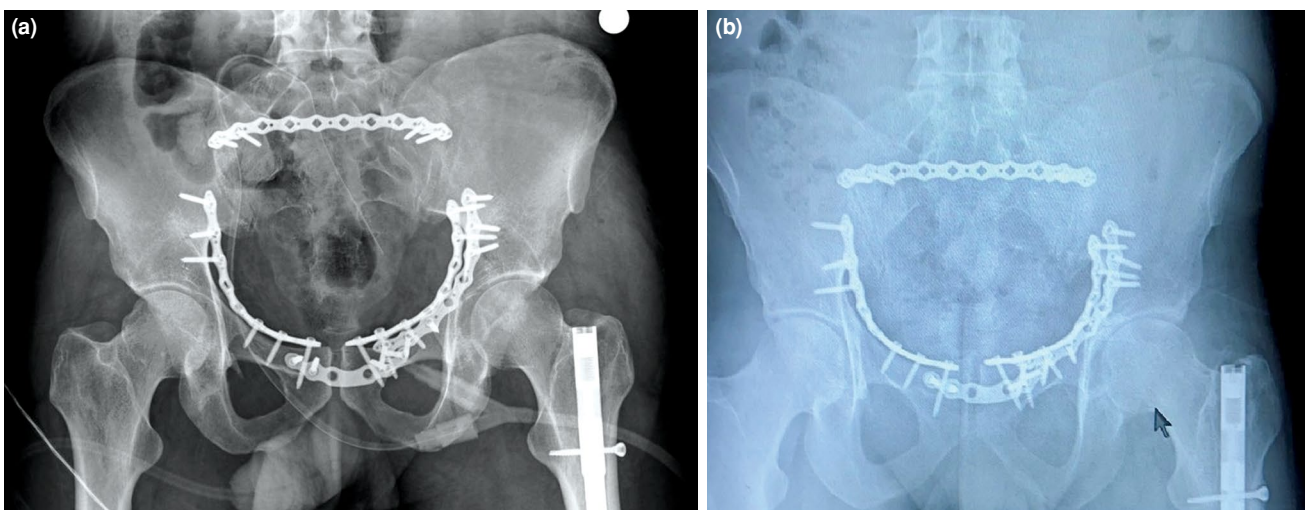

FIGURE 2. (a) Postoperative first day X-ray and **(b)** third year X-ray images showing the fixation of the bilateral acetabular fracture using reconstruction plates.

acetabular fractures were examined, anterior column fractures (n=8), double column fractures (n=6) and transverse fractures (n=5) were the most common types. Other recorded fracture types were T-type fractures (n=2) and posterior hemitransverse fractures (n=1). Reviewing the literature, Stevens et al.[7] reported that the incidence of anterior column fractures varied between 1.8 and 3.7% among all acetabular fractures, but this rate was much higher in bilateral acetabular fractures. Although eight anterior column fractures were observed in a total of 22 acetabulum fractures of the 11 patients, this finding is consistent with the literature.

Since bilateral acetabular fractures arise from high-energy traumas, the ISS of these patients is expected naturally high. In a study reported by Mauffrey et al.[25] in which they examined 883 acetabular fractures, the mean ISS score was 12±7, while the mean ISS score was found to be 28±7.2 in our study. When the causes of acetabular fractures are examined, it would not be wrong to expect that the amount of energy required for the formation of bilateral acetabular fractures would be even higher. The fact that the ISS of these patients in our study was higher than the ISS of the patients with unilateral acetabular fractures in the literature also supports this theory.

The ilioinguinal and the modified Stoppa approaches are the two common procedures that can be preferred in bilateral acetabulum fractures. The ilioinguinal approach is a method defined by Letournel and Judet.[26] for accessing the anterior acetabulum and it provides a chance to intervene in the internal iliac fossa, anterior of the sacroiliac joint and quadrilateral surface. On the other hand, the modified Stoppa approach is an alternative approach defined by Cole and Bolhofner[13] to intervene in the anterior acetabulum. Although access to affected quadrilateral surface fractures can be achieved by both methods, it has been reported that a more advanced and wide visualization is achieved with the modified Stoppa approach.[27,28] Compared to the ilioinguinal approach, the other benefits of the modified Stoppa technique are that it is easier to apply, as intervention of the inguinal canal is not required and better vision is provided, particularly for the quadrilateral surface.[14] In addition, plate-screw fixation can be easily applied with this intervention as a result of direct visualization of the anterior column.[29] As a matter of fact, we also experienced the possibility of easy access to both comminuted quadrilateral surfaces with the modified Stoppa approach. One of the main advantages of the modified Stoppa approach in bilateral acetabular fractures is that it requires a single incision. Considering that wide incisions are required for the fixation of acetabular fractures, it is superior to the ilioinguinal approach by providing the opportunity to intervene in both acetabula from a single incision. We consider that the modified Stoppa approach is more preferable in other problems such as wound infection, cosmetic concerns, and minimal damage to soft tissue and iliac neurovascular bundle integrity. On the other hand, the shorter operation duration and the possibility of reducing the complications that may develop due to the prolonged operation duration can be considered the main factors for the single incision preference. There is no study in the literature comparing operation durations in bilateral fractures; however, it is obvious that using a single incision and requiring minimal additional soft tissue dissection of the other side would reduce the total operation time. In a meta-analysis of unilateral acetabular fractures conducted by Wang et al.,[18] when the modified Stoppa and ilioinguinal interventions were compared in terms of efficacy and safety, there was a significant difference in favor of the modified Stoppa in terms of the mean operation time and median blood loss. In a randomized study by Ma et al.[16] on 60 acetabular fractures operated via the Stoppa and ilioinguinal approaches, less bleeding and transfusion necessity were reported with the Stoppa approach due to a shorter operation duration. The average blood loss was 776 (range, 350 to 1,500) mL with the Stoppa approach and 1,107 (range, 600 to 1,820) mL with the ilioinguinal approach. In the study of Fan et al.,[30] the mean blood loss was found to be 320 (range, 100 to 1,200) mL with the modified Stoppa approach. Açan et al.[31] reported a mean value of 473 to 717 mL intraoperative blood loss. Also, Sagi et al.[32] used the Stoppa approach in 57 acetabular fractures and reported an average blood loss of 750 mL. We believe that the duration of the operation and the amount of bleeding would be significantly less in the single incision method. In our study, the mean amount of blood loss was 680±241 mL, consistent with the literature. Considering the studies comparing the incisions used in acetabular fractures in terms of operation duration, ilioinguinal approach demands a longer operative duration than the Stoppa approach in the surgery of acetabular fractures.[18] In a meta-analysis of 717 patients and 10 studies compiled by Srivastava et al.,[33] the modified Stoppa approach showed a shorter mean surgical duration, fewer overall complications, less intraoperative blood loss, and less infection rate. Considering

that the modified Stoppa approach has a shorter operation duration than ilioinguinal approach even in unilateral acetabular fractures, this difference has become more significant in bilateral acetabular fractures that we included in our study.

Successful clinical outcomes of unilateral fractures operated with the modified Stoppa approach have been reported in the literature. In a study conducted by Kilinc et al.,[17] 57 patients who were operated using the modified Stoppa approach were followed for an average of 28 months, and the mean HHS and MDS were reported as 86.6 and 16.7, respectively. The authors reported that the clinical results were mostly good-to-excellent, and they reported satisfactory results with the modified Stoppa approach in unilateral acetabular fractures. Other studies using the modified Stoppa approach also reported successful results ranging between 69 and 93%. In the current study, we reported satisfactory results in terms of clinical results in bilateral acetabular fractures that we operated using the modified Stoppa approach. In our study, the mean HHS and modified MDS were found to be 84.27±8.85 and 15.90±1.57, respectively, and although there were bilateral fractures, the results were close to unilateral fracture results reported in the literature. Of note, anatomical-anatomical reduction according to Matta's criteria could not be achieved in four of 11 patients in our study. Multiple fragmentation of some fractures and posterior column involvement are thought to be among the possible causes of this concern. In a study conducted by Kim et al.,[34] communication of the fracture was a substantial cause of the non-anatomic reduction and finally unsatisfactory clinical outcomes. According to Isaacson et al.,[35] the posterior column involvement was also a factor regarding the non-anatomical reduction of acetabular fractures and, thus, they concluded that dual approach might be required for this double column involvement.

Nonetheless, our study has some limitations. First, the low number of our cases due to the rare presentation of bilateral acetabular fractures (4.5% of all patients) is the main limitation. Second, the study has a single-center, retrospective design. Third, we were unable to compare the modified Stoppa approach with another surgical approach.

In conclusion, the modified Stoppa approach seems to be a more preferable method in bilateral acetabular fractures than other approaches, as it can be performed with a single incision and provides less bleeding, shorter operation duration, and satisfactory results. However, further large-scale, prospective studies are needed to confirm these findings.

Ethics Committee Approval: The study protocol was approved by the Muğla Sıtkı Koçman University Clinical Research Ethics Committee (date: 09.08.2018, no: 03). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from each patient.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Study design, writing: F.İ.C.; Radiological evaluation: R.M.K.; Statistical analysis: E.G.; Database compilation: C.Y.K.; Editing and revision: İ.G.Ş.

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