Randomized, Controlled Trial of the Modified Stoppa Versus the Ilioinguinal Approach for Acetabular Fractures

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abstract

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The objective of this study was to determine whether the modified Stoppa approach or the ilioinguinal approach is better for the treatment of acetabular fractures by comparing the results of those 2 approaches. A randomized trial was undertaken of 60 consecutive patients with acetabular fractures treated with either the modified Stoppa or the ilioinguinal approach. In addition to the patients’ demographics, the assessed preoperative parameters included fracture pattern, associated injuries, time to surgery, and Injury Severity Score; intraoperative parameters included blood loss and operative time for each procedure; and postoperative parameters included wound drainage, blood transfusion, perioperative complications, early operative complications, late operative complications, quality of reduction, radiological results, and clinical outcomes.

The study showed no significant differences in all measured preoperative variables between the 2 groups (all \( P > .05 \)). In addition, no significant differences were found in the intraoperative complication rate, early operative complication rate, late operative complication rate, quality of reduction, radiological results, and clinical outcomes (all \( P > .05 \)). However, compared with the ilioinguinal approach, the modified Stoppa approach reduced intraoperative blood loss—and in doing so decreased wound drainage and the need for blood transfusion—and shortened operative time (all \( P < .05 \)).

The authors recommend using the modified Stoppa approach rather than the classical ilioinguinal approach to treat acetabular fractures when anterior exposure of the acetabulum is required.

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Much progress has been made in the treatment of acetabular fractures in the past 40 years, but the optimal operative techniques are still under scientific evaluation and critical discussion.\textsuperscript{1,2} The surgical approach used for acetabular fractures is critical to achieving the goal of anatomic reduction of fractures with a minimum of complications.\textsuperscript{3}

Since the ilioinguinal approach, a classical anterior exposure, was introduced by Letournel\textsuperscript{4} in 1961, it has been widely used for the treatment of pelvic ring and acetabular fractures. This approach is often used for anterior column fractures, anterior wall fractures, anterior column with posterior hemitransverse fractures, certain fractures of both columns, partial transverse fractures, and partial T-type fractures. The value of this approach has been established in numerous reports.\textsuperscript{5,6}

In 1994, Cole and Bolhofner\textsuperscript{6} described the modified Stoppa intrapelvic approach for the treatment of acetabular fractures. This approach provides direct access to the pubic bones, the posterior surface of the ramus, the quadrilateral surface, the pubic eminence, and the infrapectineal surface, as well as the sciatic buttress, sciatic notch, and anterior sacroiliac joint.\textsuperscript{6-8} Reported advantages of this approach include less surgical trauma and an improved mechanical advantage in the reduction and fixation of medially displaced fractures.\textsuperscript{6-9}

Generally speaking, the modified Stoppa approach can be adopted to treat all fractures that can be managed through the ilioinguinal approach.\textsuperscript{6-10}

This prospective, randomized study compared the results of the modified Stoppa approach and the ilioinguinal approach in treating patients with acetabular fractures. The purpose of the study was to evaluate which surgical approach is more favorable in the treatment of acetabular fractures.

**MATERIALS AND METHODS**

Between April 2007 and May 2010, sixty consecutive patients with acetabular fractures were included in a randomized trial to compare the results of 2 different surgical approaches. The ethics committee of the hospital approved the study. Informed consent was obtained from the patients or from their relatives if they were incapable of consent. Inclusion criteria were patients with acetabular fractures that were considered preoperatively to be fully treated through an anterior intrapelvic approach, such as anterior column fractures, anterior wall fractures, anterior column with posterior hemitransverse fractures, some fractures associated with both columns, partial transverse fractures, and partial T-type fractures. Exclusion criteria were patients with preexisting ipsilateral hip disease, which could interfere with the clinical and radiological evaluation of the results, and patients with only a displaced posterior column or posterior wall fracture that needed fixation via the Kocher-Langenbeck approach. The iliac crest approach can be adopted as an additional incision when anterior column fractures exit the iliac crest and partial T-type fractures or transverse fractures with a fracture line cross the iliopectineal line and cannot be adequately reduced or stabilized using only the modified Stoppa approach.

Patients were randomly divided into 1 of 2 groups—the modified Stoppa group or the ilioinguinal group—using consecutively numbered and sealed envelopes based on a computer-generated list. Sealed envelopes were opened when the surgeon was going to conduct the open reduction of the fracture.

Preoperative data from the 2 groups, including patient demographics, injury history, fracture patterns, and associated inju-
ries, were compared. Fracture diagnosis and classification were completed with pelvic computerized tomography (CT) scans, 3-dimensional CT reconstruction images of pelvis, and 3 pelvic plain radiographic views in accordance with Judet et al. Preoperative variables included patients’ demographics, injury history, fracture patterns, associated injuries, time to surgery, and Injury Severity Score. Intraoperative variables included operative time, blood loss, wound drainage, blood transfusion, and intraoperative complications. Postoperative variables included early complications, late complications, quality reduction, imaging results, and clinical outcomes. All fractures were treated within the acute time frame of less than 3 weeks from the original injury.

Indications for surgery, according to Guyton and Perez, included an acetabular fracture with 2 mm or more of displacement in the dome of the acetabulum as defined by any roof arc measurements of less than 45°, posterior wall fractures with more than 50% of the wall involved, and hip instability and incongruence. All polytrauma patients had full clinical and neurological examinations initially as a part of the management protocol. Evaluation of the soft tissue around the pelvis was mandatory. Preoperative skeletal traction was used to aid in the management of femoral head instability and avoid pressure necrosis on the femoral head articular cartilage. All patients were administered antibiotics prophylactically with a second-generation cephalosporin for 48 hours and anticoagulant prophylaxis with low-molecular-weight heparin for 72 hours. Patients underwent surgery as soon as their physiological status permitted and the operating room was available.

All surgeries were performed by a senior surgeon (Y.F.) who was experienced in acetabular surgery and familiar with both approaches. The goal of the surgery was to obtain the reduction of the innominate bone and the articular surface of the acetabulum. Wound closure was achieved using a suction drain, with intensive care to the inguinal canal repair. Patients with closed degloving had a separate incision for drainage of the collecting hematoma with the closed suction drain application. Low-molecular-weight heparin was restarted 6 hours postoperatively, and antibiotic was stopped 48 hours postoperatively unless another systemic or local indication was found for its continuation.

Postoperatively, anteroposterior pelvic radiographs, Judet radiographs, and pelvic CT scans were obtained routinely. Reduction was graded on all 3 radiographic views using the scoring system published by Matta in 1996 (Figures 5, 6). Displacement greater than 3 mm on any plain radiographic view indicated an unsatisfactory reduction. Displacement of 3 mm or less was defined as a satisfactory reduction, and an anatomic reduction had 1 mm or less of displacement.

Physical therapy usually began at 48 hours postoperatively with passive mobilization of the hip. The postoperative rehabilitation primarily aimed to recover the muscle strength around the hip. Hip abductor and extension exercises were encouraged throughout the follow-up period. A limitation in weight bearing on the involved extremity was maintained for the first 8 weeks postoperatively, after which progressive weight bearing as tolerated was encouraged.

Clinical and radiographic evaluations were obtained at 6-week, 3- and 6-month, and 1-year follow-ups. Thereafter, patients were examined at 1-year intervals.
Clinical outcomes at 1 year postoperatively were scored using the system published by Merle D’Aubigne,14 with 4 grades possible: excellent (18 points), good (15-17 points), fair (12-14 points), and poor (3-11 points). A physical examination for range of motion and neurovascular status was performed at each clinical visit by a research nurse and an orthopedic resident who were not directly associated with the study. The final radiological results were also classified according to Matta15 into 4 grades: excellent, indicating a normal appearance of the hip; good, indicating mild changes, small osteophytes, moderate (1 mm) narrowing of the joint, and minimum sclerosis; fair, indicating intermediate changes, moderate osteophytes, moderate (less than 50%) narrowing of the joint, and moderate sclerosis; and poor, indicating advanced changes, large osteophytes, severe (more than 50%) narrowing of the joint, collapse or wear of the femoral head, and acetabular wear. Heterotopic ossification was evaluated and graded according to the Brooker classification.16 Hip osteoarthritis was evaluated and graded according to the Index of Severity for Osteoarthritis introduced by Lequesne.17

**Statistical Analyses**

Statistical analyses of the data were performed using SPSS version 13.0 statistical software (SPSS, Inc, Chicago, Illinois). The authors tested the assumption of normality by a 1-sample Kolmogorov-Smirnov test. Student’s t test was used for quantitative variables. Categorical variables were analyzed by Pearson’s chi-
square test or Fisher’s exact test where appropriate. The level of statistic significance was set at a 2-sided \( P \) value of .05.

**RESULTS**

No patient refused to participate in the study, and all patients were followed up for an average of 34 months (range, 24-48 months). Preoperative data from the 2 groups were compared, and the study showed no significant differences in all measured preoperative variables between 2 groups (all \( P > .05 \)) (Table 1).

**Modified Stoppa Group**

In the modified Stoppa group, 8 (27%) patients had the modified Stoppa approach used in isolation. The injuries included 1 anterior wall fracture, 1 anterior column fracture, 1 T-shaped fracture, 2 transverse fractures with fracture line crossing the cotyloid fossa, and 3 fractures of both columns. The remaining 22 (73%) patients required exposure of the lateral window for fracture reduction or fixation placement. Average operative time was 183 minutes (range, 125-275 minutes), average blood loss was 776 mL (range, 350-1500 mL), average wound drainage was 103 mL (range, 55-200 mL), and average blood transfusion was 330 mL (range, 200-900 mL) (Table 2).

Complications included 1 (3.3%) patient with obturator artery injury and 1 (3.3%) with a corona mortis injury, both of which were caused by careless dissection and required packing and ligating. One (3.3%) patient had delayed healing of the incision caused by fat liquefaction, but the patient healed within 3 weeks with the aid of an infrared heat lamp treatment. Two (6.7%) patients had atrophy of the rectus abdominis without hernia. One (3.3%) patient developed a deep vein thrombosis in the ipsilateral leg, but it did not lead to pulmonary embolization, and chemical prophylaxis was extended for 3 months postoperatively with medical and laboratory control. Two (6.7%) patients had an obturator nerve injury due to excessive traction or careless dissection. They were notified that they had weakness of the hip adductors at the first postoperative visit. One patient recovered remarkably, with a significant improvement of the hip adductors after taking methycobal orally for 6 months postoperatively, whereas the other patient only recovered slightly. Four (13.3%) patients had hip osteoarthritis, 2 mild cases and 2 moderate cases. No patient had heterotopic ossification.

Sixteen (53.3%) reductions were graded as excellent, 10 (33.3%) as good, and 4 (13.3%) as poor. In particular, 75% of poor

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**Table 1**

| Variable                              | Modified Stoppa Group (n=30) | Ilioinguinal Group (n=30) | \( P \)  
|---------------------------------------|------------------------------|--------------------------|---------
| Mean age (range), y                   | 41 (33-65)                   | 42 (31-62)               | .206*   
| Sex, No. (%)                          |                              |                          |         
| Male                                  | 20 (67)                      | 17 (57)                  | .325*   
| Female                                | 10 (33)                      | 13 (43)                  |         
| Associated injuries, No. (%)          |                              |                          |         
| None                                  | 5 (16.7)                     | 6 (20)                   |         
| Head                                  | 2 (6.7)                      | 3 (10)                   |         
| Chest                                 | 2 (6.7)                      | 2 (6.7)                  |         
| Abdominal                             | 1 (3.3)                      | 2 (6.7)                  |         
| Genitourinary                         | 2 (6.7)                      | 1 (3.3)                  |         
| Upper limb                            | 4 (13.3)                     | 4 (13.3)                 |         
| Lower limb                            | 7 (23.3)                     | 6 (20)                   |         
| Spine                                 | 2 (6.7)                      | 1 (3.3)                  |         
| Sciatic nerve                         | 2 (6.7)                      | 3 (10)                   |         
| Combined                              | 3 (10)                       | 2 (6.7)                  |         
| Injury history, No. (%)               |                              |                          | .629*   
| Road traffic accident                 | 21 (70)                      | 23 (76.7)                |         
| Fall from height                      | 6 (20)                       | 4 (13.3)                 |         
| Crush injury                          | 3 (10)                       | 3 (10)                   |         
| Fracture pattern, No. (%)             |                              |                          | .929*   
| Anterior wall                         | 1 (3.3)                      | 1 (3.3)                  |         
| Anterior column                       | 2 (6.7)                      | 1 (3.3)                  |         
| Both column                           | 13 (43.3)                    | 11 (36.7)                |         
| T-shaped                              | 3 (10)                       | 3 (10)                   |         
| Transverse                            | 3 (10)                       | 4 (13.3)                 |         
| Anterior column with posterior hemitransverse | 8 (26.7)  | 8 (26.7)                  |         
| Mean (range) time to surgery, d       | 8.1 (4-19)                   | 8.3 (5-21)               | .778b   
| Mean (range) Injury Severity Score    | 24.6 (10-52)                 | 26.0 (12-57)             | .649b   
| Mean (range) length of stay, d        | 17.1 (11-31)                 | 18 (12-34)               | .283b   

*Pearson’s chi-square test.  
Student’s \( t \) test.
reductions resulted from fractures of both columns. Radiologic results at 2-year follow-up were excellent in 13 (43.3%) patients, good in 11 (36.7%), fair in 3 (10%), and poor in 3 (10%). Clinical outcome results at 2-year follow-up were excellent in 13 (43.3%) patients, good in 12 (40%), fair in 3 (10%), and poor in 2 (6.7%).

Ilioinguinal Group

Average operative time in the ilioinguinal group was 256 minutes (range, 160-350 minutes), average blood loss was 1107 mL (range, 600-1820 mL), average wound drainage was 154 mL (range, 70-305 mL), and average blood transfusion was 550 mL (range, 200-1200 mL) (Table 2).

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Intraoperative complications included 1 (3.3%) patient with external iliac vein injury, 2 (6.7%) with corona mortis injury due to careless dissection, and 3 (10%) with a nerve injury (Table 3). The 2 patients with a corona mortis injury were ligated timely before massive bleeding. However, the 1 patient with an external iliac vein injury had approximately 300 mL of blood loss because of careless dissection and untimely hemostasis. This patient was sent to the authors’ hospital approximately 2 weeks after injury and underwent surgery 4 days after admission. Serious adhesion of the soft tissue was found around the fracture site, which had an adverse effect on fracture reduction. This might be a factor in the external iliac vein injury. Of the 3 patients with a nerve injury, 1 patient who had fractures of both columns had a sciatic nerve injury (possibly due to excessive traction intraoperatively) and 2 had a lateral femoral cutaneous nerve injury (1 due to excessive traction and the other with transection injury). The 2 patients with nerve damage (sciatic nerve and lateral femoral cutaneous nerve injury) due to excessive traction recovered, but the patient with a transection injury did not recover, despite taking methycobal orally for 6 months.

Four (13.3%) patients had wound complications. Two developed delayed healing, and 2 developed an infection. The 2 patients with delayed healing were healed within 3 weeks postoperatively with the aid of an infrared heat lamp treatment. The 2 patients with a wound infection were cured through debridement and regular use of a second-generation cephalosporin for approximately 1 week postoperatively. Two (6.7%) patients developed a lung infection, and 1 (3.3%) had deep vein thrombosis in the ipsilateral leg. The 2 patients with lung infections were successfully treated within 15 days postoperatively with second-generation cephalosporin, and the patient with a deep vein thrombosis was cured using chemical prophylaxis for approximately 3 months while under medical and laboratory control. Six (20%) patients had hip osteoarthritis: 1 (3.3%) mild, 3 (10%) moderate, and 2 (6.7%) severe cases. In addition, 4 (13.3%) patients had heterotopic ossification: 1 (3.3%) mild and 3 (10%) moderate cases.

Table 2

<table>
<thead>
<tr>
<th>Variable</th>
<th>Modified Stoppa Group (n=30)</th>
<th>Ilioinguinal Group (n=30)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operative time, min</td>
<td>183 (125-275)</td>
<td>256 (160-350)</td>
<td>.032</td>
</tr>
<tr>
<td>Blood loss, mL</td>
<td>776 (350-1500)</td>
<td>1107 (600-1820)</td>
<td>.035</td>
</tr>
<tr>
<td>Wound drainage, mL</td>
<td>103 (55-200)</td>
<td>154 (70-305)</td>
<td>.029</td>
</tr>
<tr>
<td>Blood transfusion, mL</td>
<td>330 (200-900)</td>
<td>550 (200-1200)</td>
<td>.012</td>
</tr>
</tbody>
</table>

Student’s t test.

Table 3

<table>
<thead>
<tr>
<th>Complication</th>
<th>Modified Stoppa Group (n=30)</th>
<th>Ilioinguinal Group (n=30)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intraoperative</td>
<td>4 (13.3)</td>
<td>6 (20)</td>
<td>.731a</td>
</tr>
<tr>
<td>Vascular injury</td>
<td>2 (6.7)</td>
<td>3 (10)</td>
<td>1.000b</td>
</tr>
<tr>
<td>Nerve injury</td>
<td>2 (6.7)</td>
<td>3 (10)</td>
<td>1.000b</td>
</tr>
<tr>
<td>Early</td>
<td>2 (6.7)</td>
<td>7 (23.3)</td>
<td>.145b</td>
</tr>
<tr>
<td>Wound infection</td>
<td>0</td>
<td>2 (6.7)</td>
<td></td>
</tr>
<tr>
<td>Delayed healing</td>
<td>1 (3.3)</td>
<td>2 (6.7)</td>
<td></td>
</tr>
<tr>
<td>Lung infection</td>
<td>0</td>
<td>2 (6.7)</td>
<td></td>
</tr>
<tr>
<td>Deep vein thrombosis</td>
<td>1 (3.3)</td>
<td>1 (3.3)</td>
<td></td>
</tr>
<tr>
<td>Late</td>
<td>6 (20)</td>
<td>10 (33.3)</td>
<td>.243a</td>
</tr>
<tr>
<td>Hip osteoarthritis</td>
<td>4 (13.3)</td>
<td>6 (20)</td>
<td>.488a</td>
</tr>
<tr>
<td>Heterotopic ossification</td>
<td>0</td>
<td>4 (13.3)</td>
<td>.112b</td>
</tr>
<tr>
<td>Atrophy of rectus abdominis</td>
<td>2 (6.7)</td>
<td>0</td>
<td>.492b</td>
</tr>
</tbody>
</table>

Pearson’s chi-square test. Fisher’s exact test.
Thirteen (43.3%) of the reductions were graded as excellent, 12 (40%) as good, and 5 (16.7%) as poor (Tables 4-6). Similarly, poor reductions occurred most frequently, and 80% of them were caused by fractures of both column. Radiologic results at 2-year follow-up were excellent in 10 (33.3%) patients, good in 12 (40%), fair in 5 (16.7%), and poor in 3 (10%). Clinical outcome results at 2-year follow-up were excellent in 11 (36.7%) patients, good in 13 (43.3%), fair in 2 (6.7%), and poor in 4 (13.3%).

A shorter operative time ($P = .032$) and less blood loss ($P = .035$) were observed in the modified Stoppa group compared with the ilioinguinal group. Similarly, the number of blood transfusions ($P = .012$) and the amount of wound drainage ($P = .029$) were significantly lower in the modified Stoppa group compared with the ilioinguinal group. No significant differences were found between the 2 groups in overall intraoperative complications ($P = .731$), early complications ($P = .145$), or late complications ($P = .243$) (Table 3). In Tables 4-6, no significant differences could be seen between the 2 groups in reduction quality ($P = .740$), radiologic results ($P = .817$), or clinical outcomes ($P = .784$).

**Discussion**

It is well known that the ilioinguinal approach is time consuming\(^1\) and likely to cause blood loss\(^8\). However, recent articles have reported that the modified Stoppa approach has relatively less blood loss\(^8\) and less operative time than the ilioinguinal approach.\(^1\) Indeed, in the current study, the ilioinguinal approach took more operative time, caused more blood loss, and resulted in more patients who required blood transfusions and wound drainage than did the Stoppa approach for the treatment of acetabular fractures. The authors believe that all of these results are largely associated with the considerable surgical trauma caused by the ilioinguinal approach with the combination of the lateral, middle, and medial windows.

No statistically significant differences were found between the 2 groups in intraoperative, early, and late complications. The modified Stoppa approach was not superior to the ilioinguinal approach in reducing the complication rate. Despite a relatively high rate of early complications in the ilioinguinal group, the authors believe that early complications are not completely related to the surgical approach. Wound complications are not only related to the surgical incision but are also associated with local soft tissue conditions or morbus internus, such as diabetes mellitus and other individual differences. However, lung infection or deep vein
thrombosis has almost nothing to do with the surgical approach. In the current study, 1 incidence of a lung infection might be associated with preoperative pulmonary contusion, whereas 3 incidences of deep vein thrombosis were likely related to the quadrilateral plate and posterior column components of these fractures. Because the modified Stoppa approach can provide direct access to the quadrilateral surface, intraarticular surface, sciatic buttress, sciatic notch, and anterior sacroiliac joint, it is conducive to the reduction and fixation of fractures involving the quadrilateral plate and the posterior column. In addition, with the modified Stoppa approach, the so-called middle window of the ilioinguinal approach can frequently be avoided, resulting in a shorter operative time, less blood loss, less wound drainage, and less blood transfusion.

No statistical differences were found in the radiologic results and clinical outcomes between the 2 groups, and both groups achieved a good prognosis, which roughly corresponds with previous reports. Therefore, the current authors believe that both surgical approaches can result in a good prognosis for patients with acetabular fractures. The current study also has some limitations. First, the study included a small sample size with a relatively short follow-up. In addition, in the modified Stoppa group, 22 fractures were fixed with the lateral window of the ilioinguinal approach, which may be an unfavorable factor to the accuracy of the study. However, this prospective, randomized clinical study had a cohort without a preoperative statistical difference (Table 1), and the interference of selection bias was ruled out. Furthermore, the preoperative data from patients in the 2 groups proved to be basically consistent, which enhanced the comparability of the results of this study. Average follow-up period in the study was 3 years, with all patients having at least 2 years of follow-up. Therefore, the clinical results for both groups could reflect the prognosis for all patients.

**Conclusions**

This study showed no significant differences in the reduction quality, imaging follow-up results, clinical outcomes, and complications between the modified Stoppa approach and the ilioinguinal approach for the treatment of acetabular fractures. However, the modified Stoppa approach was significantly superior to the ilioinguinal approach in limiting operative time, blood loss, wound drainage, and blood transfusion. Thus, the authors recommend using the modified Stoppa approach rather than the ilioinguinal approach when anterior exposure of the acetabulum is required, especially for fractures involving the quadrilateral plate. Nevertheless, the exact extent of these beneficial results has not yet been clearly defined. More randomized, controlled trials are needed to compare the modified Stoppa approach and the ilioinguinal approach to improve clinical decision making.
REFERENCES


