The Pararectus approach for anterior intrapelvic management of acetabular fractures

AN ANATOMICAL STUDY AND CLINICAL EVALUATION

A new anterior intrapelvic approach for the surgical management of displaced acetabular fractures involving predominantly the anterior column and the quadrilateral plate is described. In order to establish five ‘windows’ for instrumentation, the extraperitoneal space is entered along the lateral border of the rectus abdominis muscle. This is the so-called ‘Pararectus’ approach. The feasibility of safe dissection and optimal instrumentation of the pelvis was assessed in five cadavers (ten hemipelves) before implementation in a series of 20 patients with a mean age of 59 years (17 to 90), of whom 17 were male. The clinical evaluation was undertaken between December 2009 and December 2010. The quality of reduction was assessed with post-operative CT scans and the occurrence of intraoperative complications was noted. In cadavers, sufficient extraperitoneal access and safe instrumentation of the pelvis were accomplished. In the patients, there was a statistically significant improvement in the reduction of the fracture (pre- versus post-operative: mean step-off 3.3 mm (SD 2.6) vs 0.1 mm (SD 0.3), p < 0.001; and mean gap 11.5 mm (SD 6.5) vs 0.8 mm (SD 1.3), p < 0.001). Lesions to the peritoneum were noted in two patients and minor vascular damage was noted in a further two patients. Multi-directional screw placement and various plate configurations were feasible in cadavers without significant retraction of soft tissues.

In the treatment of acetabular fractures predominantly involving the anterior column and the quadrilateral plate, the Pararectus approach allowed anatomical restoration with minimal morbidity related to the surgical access.

It is accepted that the quality of reduction of an acetabular fracture, as observed radiologically, affects the outcome.1-3 In order to preserve a functional, mobile, painless hip joint that continues to function for the rest of the patient’s life,4 the operative treatment of these fractures aims to achieve anatomical restoration of the articular surface.2,5 About 50 years ago, Judet, Judet and Letournel5 described a classification and treatment algorithm for acetabular fractures. The ilioinguinal approach was introduced as an anterior approach for those fractures involving the anterior column.

Management of acetabular fractures involving the anterior column has become more challenging as complex fracture patterns with involvement of the quadrilateral plate, medial displacement of the femoral head and significant impaction of the superomedial joint surface (‘gull sign’)6 have increased in incidence.2,7,8

For the visualisation, disimpaction and fixation of a fracture of the dome of the acetabulum with less surgical morbidity than has been associated with the ilioinguinal approach, other surgical approaches or refinements of standard approaches have been described.9-16 However, an inadequate view and/or difficulty with access with these approaches remains a concern, with residual articular incongruities detected more frequently on post-operative CT scans.17 Therefore, we describe a new anterior, single-incision intrapelvic anatomical approach with extraperitoneal access for treatment of fractures involving predominantly the anterior column and quadrilateral plate. We hypothesised that the approach described provides: 1) sufficient access to potential fracture sites; 2) adequate visualisation of essential neurovascular structures; 3) feasibility for anatomical restoration even in cases with impaction of the superomedial joint surface; and 4) less invasive soft-tissue dissection.

Materials and Methods
Anatomical examination. Anatomical examinations were conducted on five human cadaver specimens (four male, mean age 84 years (72 to 90)) from Inselspital, Bern 3010, Switzerland.

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Cadavers were embalmed using a technique described elsewhere. Dissection and instrumentation were performed by the first author (MJBK).

Cadavers were placed in the supine position with the surgeon on the opposite side to the hip which was to be dissected. Landmarks for the incision were the umbilicus, the anterior superior iliac spine (ASIS) and the symphysis pubis, which together form a triangle (Fig. 1). The incision starts cranially at the junction of the lateral and middle thirds of the line connecting the umbilicus with the ASIS. The incision is curved and directed towards the border between the middle and medial thirds of the line connecting the ASIS with the symphysis. An extension of the incision is possible as presented (dotted lines).

The dissection continues with identification of the external iliac artery and vein (Figs 3 to 5). The vascular bundle is mobilised and encircled with a silastic sling, in order to allow safe retraction. The dissection proceeds laterally with circumferential mobilisation of the iliacus and psoas muscles, whilst protecting the ilioinguinal, femoral, lateral femoral cutaneous and genitofemoral nerves and the internal gonadal blood vessels. The iliopsoas muscle and the neurovascular structures are also tagged using silastic slings. For exposure of the inner surface of the iliac wing, the iliacus muscle is detached from the innominate bone. In the cephalad–caudad dissection the inferior epigastric vessels and vas deferens in the male or the round ligament in the female are identified. The ilipectineal fascia is incised and the pectineus muscle partially released and mobilised laterally.
The crest and the superior ramus of the pubis and the iliopsoas muscle are exposed. The vascular anastomosis between the epigastric or external iliac and obturator vessels is identified, ligation and divided to allow safe placement of a plate on the pubic rami. The exposure of the false pelvis is then complete.

Dissection within the true pelvis starts anteriorly with visualisation of the obturator nerve and vessels. The bladder and the obturator neurovascular structures are retracted medially using a blunt retractor placed over the bundle into the sciatic notch. The obturator internus muscle is detached from the quadrilateral plate down to the ischial spine. Dissection is safely completed along the pelvic brim to the anterior aspect of the sacroiliac (SI) joint. The bifurcation of the internal iliac vessels and lumbar plexus can be exposed medially and caudal to the SI joint. Additionally, reduction clamps can be placed for reduction of the quadrilateral fragments under direct vision and also with an intra-articular view in cases with impacted fragments.

For instrumentation, 3.5 mm reconstruction plates (with six to 12 holes) and cortical screws were used (Fig. 6). In order to avoid the possibility of screws penetrating the hip joint, they were inserted according to recommendations based on the determination of safe zones or absolutely and relatively hazardous regions for screw placement. On the left hemipelvis a lag screw was inserted, directed from anterior to posterior at the level of the ASIS. On the right hemipelvis a bridging plate was placed along the iliac crest.

Radiological analysis. CT data were acquired on a 64-slice MDCT Unit (Somatom Sensation Cardiac 64; Siemens, Erlangen, Germany). A spiral scan (anteroposterior scanogram image) of the pelvis was performed (collimation 64 x 0.6 mm; pitch 0.5; tube rotation time 0.5 s; tube voltage 140 kV; current 450 mA).
Clinical implementation study. Those fracture patterns as described by Judet et al\(^5\) that would have been treated previously at our institution using a combination of the modified Stoppa\(^9,21\) and the first window of the ilioinguinal approach\(^22\) without the need for an additional posterior approach were selected for open reduction and internal fixation using the approach described above. Between December 2009 and December 2010, 20 patients with a mean age of 59 years (17 to 90), of whom 17 were male, were included in a prospective evaluation protocol. Their mean body mass index was 23.15 kg/m\(^2\) (18 to 27) and the mean American Society of Anesthesiologists’ (ASA) physical status classification\(^23\) grade was 2.14 (1 to 3). Their mean Injury Severity Score\(^24\) was 13.3 (9 to 27). There were nine fractures involving both columns, two involving the anterior column only, eight anterior column and hemitransverse fractures and one of the anterior column with involvement of the anterior wall.\(^5\) All patients were operated on by the first author (MJBK).

The delay to surgery, operative time, blood loss, length of incision and intra-operative complications were documented. Anteroposterior radiographs of the pelvis and CT scans were used pre-operatively to classify the fractures. CT scans were used for the assessment of persistent displacement post-operatively, focusing on ‘step-offs’ and ‘gaps’ in the articular surface.\(^12\)

The ‘step-off’ was defined as the most significant displacement of an intra-articular fragment and the ‘gap’ was defined as the largest separation of the intra-articular fracture. In order to assess the mediolateral displacement of the femoral head (‘medialisation’), a sagittal plane through the symphysis anteriorly and the body of the sacrum posteriorly was defined on the CT scan using 3D reconstruction. The medial displacement of the femoral head was measured in the axial view as the perpendicular distance from the centre of the femoral head to this sagittal plane. In order to assess the cranio-caudal displacement of the femoral head (‘cranialisation’), an axial plane through the L5/S1 disc space was defined. The displacement of the femoral head superiorly was measured in the coronal plane as the perpendicular distance of the centre of the femoral head to this axial plane. In order to describe the persistent displacement, these parameters were also measured in the undamaged contralateral hemipelvis and differences between the two sides were calculated. The reduction of the fracture was graded as anatomical (< 1 mm persistent displacement), imperfect (1 to 3 mm) or poor (> 3 mm). The ‘gap’ or ‘step-off’ measurements were based on the CT classification\(^25\) according to the modification of rating by Matta.\(^4\)

CT scans were performed on either a 16- or a 64-slice scanner (Somatom Sensation 16 or Somatom Sensation Cardiac 64, Siemens, Erlangen, Germany). Slices were acquired with a thickness of 1 mm or less, with a voltage of 120 or 140 kV in large patients and a variation of current according to the care–dose algorithm. The radiological evaluation was performed by an experienced independent radiologist (HMB).

Statistical analysis. Wilcoxon’s signed ranks test for paired groups was used to compare pre- and post-operative measurements of displacement of the fracture on CT scans, with the level of significance set at a p-value < 0.05.
internal bony surface of the innominate bone. The second window was between the iliopsoas muscle and the external iliac vessels. The sacroiliac joint was exposed posteriorly by medial retraction of this muscle provided access to the superior pubic rami, the iliopectineal eminence and the pelvic brim. The fourth window was opened by lateral retraction of the vas deferens and provided access to the pubic symphysis. The fifth window contained the femoral branch of the genitofemoral nerve in one and the cutaneous branch of the obturator nerve in one patient, the femoral branch of the genitofemoral nerve in one and the cutaneous branch of the obturator nerve in the third, due to trauma or traction during surgery. In all cases neurological symptoms resolved fully.

Calculations were done with StatXact 8 software (Cytel Inc., Cambridge, Massachusetts). Statistical analysis was performed by an originally uninvolved statistician (DD).

Results

Anatomical examination. The approach described facilitates the extraperitoneal exposure of the inner surface of the hemipelvis. Neurovascular structures at risk during exposure were clearly visualised in all specimens (Figs 4 and 5). In four of the five specimens an anastomosis between the epigastric and obturator vessels was present on both sides. We were able to establish five ‘surgical windows’ as a modification of the description by Letournel. The first window was comparable to that provided by the modified Stoppa approach, rather than to the description of Letournel.

The dissection and manipulation during instrumentation of the pelvis was quite demanding. All instrumentations accomplished from the first to the fourth anatomical windows were as follows: through the first window a six-hole bridging plate was placed on the iliac wing of the right hemipelvis. A small incision on the iliac crest was necessary on the left hemipelvis for a lag screw, directed from anterior to posterior at the level of the ASIS. Through the second, third and fourth windows, 10- or 12-hole bridging plates could be placed on both pelvic brims. For fixation of the bridging plate on the pelvic brim from anterior to posterior, screws were placed as follows: one or two parsymphyseal screws, one screw through the teardrop in an anteroposterior direction into the ischial tuberosity, one into the ischial spine, one or two into the posterior inferior iliac spine. Through the fifth window, an 8-hole bridging plate was placed on the proximal part of the quadrilateral plate, parallel to the pelvic brim or arcuate line and perpendicular to the previously mentioned bridging plate on the left hemipelvis. On the right hemipelvis a six-hole buttress plate was placed – more caudal and posterior and closer to the ischial spine – instead of a bridging plate through the fifth window. The direction for screw placement was angled laterally, except for the plates on the quadrilateral plate, and the screws were directed into the ischial tuberosity. No significant retraction of the soft tissues was required to accomplish these instrumentations and radiological analysis confirmed extra-articular screw placement.

Clinical implementation. This new approach enabled clear visualisation, reduction and fixation of displaced acetabular fractures (Figs 7 and 8). The mean delay to surgery was four days (standard deviation (SD) 2; 0 to 9), the mean operating time was 197 minutes (SD 51; 130 to 312) and mean blood loss was 1700 ml (SD 1500; 250 to 6000). The mean length of the incision was 11 cm (SD 4; 7 to 20). In four patients there were intra-operative complications, with minor vascular damage in two cases (branch of external iliac vein and inferior epigastric artery, respectively) and small perforations of the peritoneum in two. These were repaired intra-operatively.

Post-operatively, 19 patients were followed up for a mean of nine months (SD 3); one was lost to follow-up. In the 19 patients that were followed up, the wounds healed uneventfully in all cases, the fractures united and full weight-bearing was achieved after a mean of 72 days (SD 22). No inguinal or abdominal wall hernias occurred. Post-operative neurological symptoms were noted in three patients. The lateral femoral cutaneous nerve was injured in one patient, the femoral branch of the genitofemoral nerve in one and the cutaneous branch of the obturator nerve in the third, due to trauma or traction during surgery. In all cases neurological symptoms resolved fully.
which has been reported using the ilioinguinal approach. These include avoidance of an inguinal hernia, which may offer additional benefits over the ilioinguinal approach. We also believe that this ‘Pararectus’ approach along the pelvic brim and orthogonal to the fracture displacement so that reduction forces can be better applied that the approach described here allows for a more medial view of the impacted acetabular dome fragments, resulting in a suboptimal reduction of the fracture. We have found that the approach described here allows for a more medial approach so that the mesh can easily be detached at its cranial border instead of being dissected.

The fasciae of the rectus and externus abdominis muscles in our approach there is no dissection of the inguinal canal. The ilioinguinal approach was described for the management of acetabular fractures involving predominantly the anterior column but in our hands does not allow a good view of the impacted acetabular dome fragments, resulting in a suboptimal reduction of the fracture. We have found that the approach described here allows for a more medial approach so that reduction forces can be better applied along the pelvic brim and orthogonal to the fracture displacement. We also believe that this ‘Pararectus’ approach may offer additional benefits over the ilioinguinal approach. These include avoidance of an inguinal hernia, which has been reported using the ilioinguinal approach. In our approach there is no dissection of the inguinal canal. The fasciae of the rectus and externus abdominis muscles only need to be sutured to complete closure of the approach. We also believe that in cases where an inguinal hernia has previously been repaired or reinforced with a mesh, this new approach facilitates dissection in this area.

Within the first post-operative year. An 81-year-old patient with various medical comorbidities died ten months post-operatively of an unrelated cause.

Radiological analysis confirmed statistically significant surgical reduction of the fracture, using Wilcoxon’s signed ranks test for paired groups. The mean pre- and post-operative step-off within the fracture was 3.3 mm (SD 2.6) and 0.1 mm (SD 0.3), respectively (p < 0.001). The mean pre- and post-operative fracture gap was 11.5 mm (SD 6.5) and 0.8 mm (SD 1.3), respectively (p < 0.001). Details of measurements in various CT planes are shown in Table I. Surgical treatment provided statistically significant correction of medialisation and cranialisation of the femoral head (p < 0.001).

The pre-operative fracture displacement was > 3 mm in all patients. Post-operatively, the quality of reduction was classified as ‘anatomical’ in eight patients, ‘imperfect’ in nine and ‘poor’ in three, with the persistent displacement in at least one of three CT planes. Using the ‘step-off-analysis’ alone, 19 patients had an anatomical reduction, with one imperfect reduction.

Discussion

The ilioinguinal approach was described for the management of acetabular fractures involving predominantly the anterior column but in our hands does not allow a good view of the impacted acetabular dome fragments, resulting in a suboptimal reduction of the fracture. We have found that the approach described here allows for a more medial approach so that reduction forces can be better applied along the pelvic brim and orthogonal to the fracture displacement. We also believe that this ‘Pararectus’ approach may offer additional benefits over the ilioinguinal approach. These include avoidance of an inguinal hernia, which has been reported using the ilioinguinal approach. In our approach there is no dissection of the inguinal canal.

The intrapelvic space is entered from a more cranial position so that the mesh can easily be detached at its cranial border instead of being dissected.

Traction injuries to local nerves, especially the lateral cutaneous nerve, have been reported in up to 18% of cases using the ilioinguinal approach. With our approach, prolonged or excessive traction is not necessary, and only mild and transient neurological symptoms were observed in three of our patients with the lateral cutaneous nerve involved in only one.

As most complications with use of the ilioinguinal approach were considered to be related to the soft tissue structures in the ‘middle’ window of the approach, new approaches avoiding dissection in this area have been described. These involve less invasive dissection without exposure of the inguinal canal, visualisation of the entire pelvic brim, access to the quadrilateral plate and to the posterior column. However, the limited exposure of these approaches sometimes requires intra-operative conversion to a standard ilioinguinal approach or the addition of a ‘lateral’ window but at best only satisfactory or even unsatisfactory radiological results have been reported when applying the classification of Matta.

Significant weakness of adduction of the hip in the use of the other approaches has been noted in 26% of patients, which may be due either to the injury or the iatrogenic stretching of the obturator nerve during exposure of the quadrilateral plate. Traction injuries of the lateral femoral cutaneous nerve have been reported in 5% of patients and of the femoral nerve in 4% of patients. Finally, postoperative hernia formation has been described in 2% (one in 55) to 3.5% of cases (two of 57). Although these alternative approaches might be less invasive, they are not as satisfactory as the ilioinguinal approach in exposing the acetabular fracture. The Pararectus approach requires a relatively short incision with good exposure to allow correct placement of screws. Finally, compared with the ilioinguinal and the Stoppa approach, our Pararectus approach allows clear visualisation of the fracture without the need to change either the surgical window or the position of

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<th>Parameter</th>
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<th>Post-operative</th>
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<td>Mean (SD) femoral head displacement</td>
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<td>Cranialisation</td>
<td>7.9 (5.6)</td>
<td>2.0 (1.2)</td>
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* Wilcoxon’s signed ranks test for paired groups
retractors. A potential disadvantage of this approach might be the risk of entering the peritoneum, as previously observed for other intrapelvic approaches, with peritoneal perforations during exposure in about 32% of cases. The Pararectus approach might be unsuitable for obese patients or those presenting with abdominal distension, ileus or bowel obstruction.

As demonstrated in cadavers, the Pararectus approach provides sufficient intrapelvic access to acetabular fractures involving the anterior column and the quadrilateral plate and gives exposure of neurovascular structures at risk from iatrogenic injury.

This approach has become the standard approach in selected cases at our department in these patients.

Supplementary material
Two tables detailing i) the demographics and ii) the fracture pattern for all 20 patients are available with the electronic version of this article on our website www.jbjs.org.uk

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References