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ADVANTAGES OF ANTERIOR RETROPERITONEAL APPROACH IN OSTEOSYNTHESIS OF PELVIC FRACTURES

COMPARISON OF TWO METHODS

Summary of the Doctoral Thesis
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Secretary of the Doctoral Committee of Medicine

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1. INTRODUCTION

1.1. Research facilities

Clinic of Traumatology and Orthopaedics of REUH "Gaiļezers", Department of Traumatology and Orthopaedics of Rīga Stradiņš University.

1.2. Topicality of research

Scientific and technical progress has conditioned the rise in the number of high energy traumas of the musculoskeletal system. Simultaneously, the number of pelvic fractures has proportionally risen, on average they constitute up to 3% of the total number of bone fractures (1; 2; 3; 4). The majority of pelvic fractures, i.e. approximately 75%, are considered to be severe and critical musculoskeletal injuries (5). Pelvic fractures are diagnosed in 18% of cases in the polytrauma patients. Open pelvic fractures constitute 1% of the total number (6) of pelvic fractures, in turn, according to the data provided by different authors, mortality rate in case of open pelvic fractures may reach 50% (7; 8; 3 ;4).

Pelvic fractures, intra-articular fractures in particular, relatively often (~ 10% cases) (7; 8) lead to permanent disability due to the development of posttraumatic osteoarthrosis in hip joints and the following endoprosthetic replacement of the hip joint.

Although the application of ilioinguinal approach has yielded good practical results (9), treatment results necessitate that new approaches in surgical treatment are sought. For example, extraperitoneal approach was first described by E. Hirvensalo (10) in 1992 and L.D. Cole (10).

This surgical treatment approach in case of pelvic ring and acetabular fractures is relatively widely used in the USA and Finland. In Latvia, this approach to the treatment of pelvic ring and acetabular fractures was introduced in 2008 by the author of the present Thesis at REUH Clinic of Traumatology

and Orthopaedics (the Head of the Department and scientific supervisor of the Doctoral Thesis Professor A. Jumtiņš, the Head of the Clinic *Dr. med.* G. Lācis). Using this surgical approach, 48 patients were operated in the period from October 2008 to May 2012. The treatment results of 35 patients out of 48 have been analysed in the present study. 34 patients from the control group were operated using conventional anterior ilioinguinal approach. The present study provides a comprehensive review of the opportunities offered by the application of the surgical treatment approach under discussion, its complications, results and advantages over other surgical approaches, using this approach in the treatment of the patients with unstable pelvic ring and acetabular fractures. Having summarised and analysed research results, the author has developed an algorithm for the application of various surgical approaches to be used in the treatment of pelvic fractures depending on the type of fracture.

1.3. Goal and objectives of the research

Goal of the research: to explore the anterior retroperitoneal and ilioingvinal surgical approach of operative and postoperative period of the clinical and radiological parameters as well as differences in postoperative functional outcomes in patients with complex pelvic fractures and based on the results obtained, to elaborate and develop recommendations for implementation in practical traumatology surgery.

1.3.1. Research objectives:

1. To conduct research on surgical indications for the application of retroperitoneal and iliongvinal approaches (surgery duration, intraoperative blood loss, hemotransfusion volume), used in the treatment of complex pelvic ring and acetabular fractures.

2. To conduct research on the postoperative radiological results (dislocation of fracture fragments) of the application of retro-peritoneal and iliongvinal approaches, used in the treatment of complex pelvic ring and acetabular fractures.
3. To conduct research on the postoperative functional results of the application of retroperitoneal and iliongvinal approaches, used in the treatment of complex pelvic ring and acetabular fractures, using Majeed scale.
4. According to research findings to develop the selection of a surgical approach to the treatment of pelvic fractures depending on the type of fracture.
5. To determine the advantages and disadvantages of the application of retroperitoneal approach in the treatment of complex pelvic ring and acetabular fractures.

1.4. Scientific hypothesis

Front retroperitoneal approach compared to ilioingvinal approach in cases of complex pelvic fracture allows shorter operative time, less intraoperative blood loss, smaller perioperative hemotransfusion amount , better postoperative radiological parameters of the pelvic bone fragments and late postoperative functional results.

1.5. Scientific novelty of treatment results

Clinical research data on the results of two surgical approaches (anterior retroperitoneal and ilioingvinal) used in the treatment of patients with complex pelvic fractures are integrated in the present research paper. On this basis of research findings, it has been performed statistically conclusions about advantages of the anterior retroperitoneal approach (see section 6).

1.6. Practical significance of the present thesis and application of research results

Anterior retroperitoneal laparotomy approach to pelvic fracture treatment has been developed and introduced for the first time in Latvia. For the first time providing indications and suggesting a developed algorithm for the selection of different surgical approaches to be used in case of traumatic pelvic fractures. The practical recommendations have determined (see section 7).

2. MATERIALS AND METHODS

2.1. Demographic characteristics of the study group

81 polytrauma patients with pelvic fractures were selected for the present research. Out of 81 patients, 22 were treated in a conservative way, but 59 patients were treated using surgical methods. 11 patients of those, who received surgical treatment, were treated using anterior fixation method, whereas 48 patients underwent open reposition and internal fixation. Having evaluated inclusion and exclusion criteria, 35 out of 48 patients, who were treated using anterior lower retroperitoneal approach, were included into the study group.

The study group included 21 male and 14 female patients. The age ranged from 17 to 70 years, average age was 44 years; ISS 9-48 with an average value of 20.5. Five patients had ISS < 16, but 30 were polytrauma patients with ISS ≥16. In 22 cases, pelvic fractures were caused by traffic accidents, but 13 patients suffered having fallen from height. Using retroperitoneal approach, study group patients were operated in the period from October 2008 to May 2012.

2.2. Demographic characteristics of the control group

Control group comprised 34 adult polytrauma patients, who received surgical treatment of pelvic fractures with the use of ilioinguinal approach. The group included 25 male and 9 female patients. The age ranged from 17 to 75 years, average age was 38 years. Mechanism of trauma: traffic accidents and falling from height, rates similar to the study group. ISS 9–48 with an average value of 20.5. Five patients had ISS < 16, but 29 were polytrauma patients with ISS ≥ 16. Using ilioingvinal approach, control group patients were operated in the period from 2005 to May 2009.

2.3. Research object

Adult patients with pelvic ring and acetabular fractures.

Inclusion criteria were systematised. The patients included in the study should have been hemodynamically stable, no inflammatory processes due to infection, which could increase postoperative infection risks, should have been diagnosed. The period between injury and surgical operation should not exceed three weeks, otherwise the formed scar tissue and primary callus increase intraoperative blood loss and extend surgery duration, and such blood loss cannot be objectively compared with other operation results.

Exclusion criteria:

- patients with repetitive pelvic fractures,
- patients with pathologic fractures,
- patients who have received other forms of surgical treatment of the pelvic facture site registered in anamnesis,
- patients treated using the combined surgical approach.

The patients included in the study were divided into two basic groups:

1. Study group – the patients who were operated using retroperitoneal lower laparotomy approach;
2. Control group – the patients who were operated using ilioinguinal approach.

2.4. Data collection methods

Operative treatment results were evaluated performing CT and taking a radiograph before and after the operation. The following projections were used for radiological examination of pelvic ring fractures: anterior – posterior (AP) projection of the pelvis, 'outlet' projection – X-rays in oblique projection angled 30° caudad in relation to patient's horizontal plane, and 'inlet' projection – X-rays in oblique projection angled at 30° cephalad in relation to

patient's horizontal plane. Majeed functional grading scale was used in evaluating the functional results.

In case of acetabular fractures, the remaining dislocation of bone fragments constituting 1 mm or less is evaluated as anatomic, ranging from 2–3 mm – as satisfactory, and larger than 3 mm – as unsatisfactory. Reposition of pelvic ring fractures is assessed using *Pohlemann* classification, according to which post-repositioning dislocation of bone fragments by 1 cm and less is considered to be satisfactory.

The study was conducted in the period of four years. On average, about 12 pelvic surgical operations were performed annually on the previously systematised patients. Based on the exclusion and inclusion criteria, out of 48 patients treated using anterior retroperitoneal method, treatment results of only 35 patients were analysed. In the control group, the data of 34 patients were systematised and their treatment results were analysed.

Intraoperative indicators (bold loss, operation time, surgical approach, hemotransfusion volume) were registered for all patients. After operative treatment, patient radiological control was performed in the following time periods – immediately after surgery, three, six and twelve months after surgery. Starting with the period of ten months after surgery, the patients were evaluated according to Majeed (14; 15; 16; 7) functional scoring scale. Finally, mathematical processing of all data obtained and integration of study results was performed. Research results were published.

2.5. Material and technical provisions of the research

All operations were performed on a specialised orthopaedic radiolucent surgical table. A mobile X-ray machine and a "Cell Saver" device for the reinfusion of the formed elements of blood were used in the operation process. Standard pelvic surgery instrument kit was used in operations, as well as osteosynthesis using screws with the opening diameter of 3.5 mm for

reconstruction plates and semi-tubular plates and cancellous or cortical screws with the diameter of 3.5 mm and 4.0 mm. In certain cases, cannulated screws with the diameter of 4.5 mm and 7.0 mm as well as interlocking pelvic osteosynthesis plates were used.

All operations were performed by one surgeon (author) and two assistants.

Processing of radiological examination data and the measurements were performed in the digital form using **Centricity PACS-IW software** and local intranet. Mathematical measuring scales were used in further processing of the obtained data.

2.6. Clinical examinations

Clinical examinations were performed upon patient checking into hospital and before the operation. Clinical symptoms were grouped as follows:

1. Limb shortening that can be caused by the dislocation of the pelvic fracture or the fracture of the extremity itself.
2. Bone crepitation and pathologic mobility, which are diagnosed palpating the pelvis in the fracture side.
3. Neurological symptoms – sensory and motor function dysfunctions associated with potential injuries of *n. ischiadicus* and *n. femoralis*.
4. Symptoms of blood circulation disorders – disturbance of peripheral pulse in the lower extremity in the fractured side of the pelvis.
5. Subcutaneous hematomas in perineum, genitals, or inguinal region.
6. Hematuria or anuria associated with urethra, bladder or kidney injury.

2.7. Radiological examinations

2.7.1. Computed tomography

All patients are examined using computed tomography upon checking into hospital, as CT is part of polytrauma patient examination protocol. CT is used to analyse the type of pelvic fracture, the extent of fracture fragment dislocation, a 3D image is created. Repeated CT is done after operation in order to ensure the adequacy of implant placement and extra-articular placement of osteosynthesis screw, as well as to measure the extent of the remaining fracture fragment dislocation.

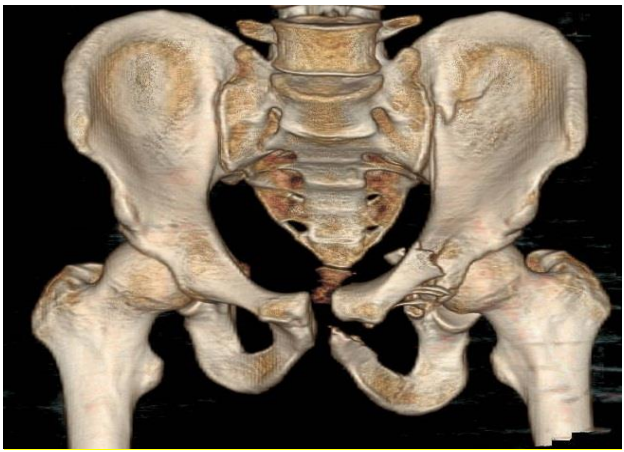


Fig. 2.4.1.1. **CT using a 3D reconstruction. Left anterior column fracture** (author photo)

In cases when the patients after high energy traumas had clinical signs indicating potential damages of large blood vessels and bleeding, computed tomography was combined with angiography.

2.7.2. Roentgenography

As a rule, X-ray examination of pelvic bones is done in three projections before the operation, immediately after the operation, and three, six and twelve months after the operation. Standard projections include an AP radiograph, when X-rays are directed perpendicular to the X-ray plate.

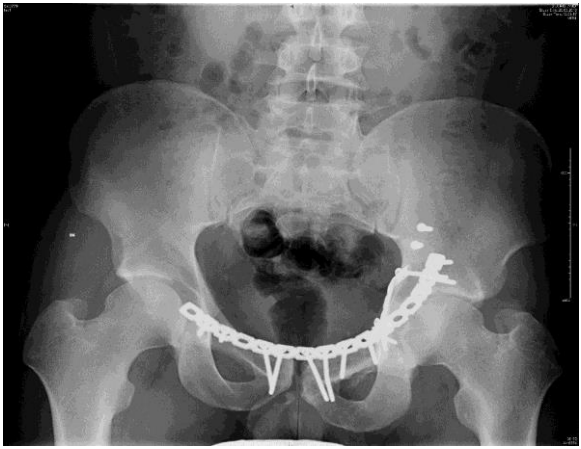


Fig. 2.4.2.1. **Postoperative pelvis radiograph in AP projection** (author′s photo)

The second projection is an *inlet* radiographic view, when X-rays are directed cephalad at 30° to the vertical axis. This radiographic projection most precisely of all shows pelvic bone dislocations in anterior and posterior parts. In addition, the inlet projection more precisely displays internal and external rotation dislocations in case of lateral compression or acetabular fracture.

Fig. 2.4.2.2. **Postoperative pelvis radiograph in INLET projection** (author′s photo)

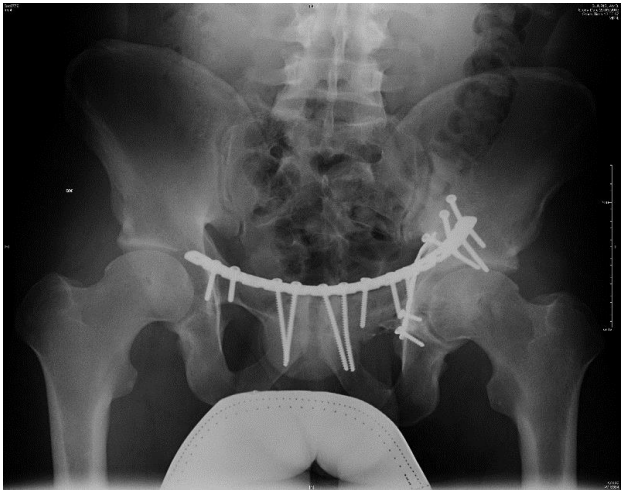


Fig. 2.4.2.3. **Postoperative pelvis radiograph in OUTLET projection** (author′s photo)

The third projection is an *outlet* radiographic view, when X-rays are directed caudad at 30° to the vertical axis, and directed towards symphysis. This projection provides information on the dislocation of posterior pelvic bone fragments in the cranial direction and the dislocation of splinters in the frontal part in the cranial or caudal direction.

In case of pelvic ring fractures, these examinations are sufficient, and other radiological examination are not necessary. In contrast, CT is indispensable in case of acetabular fractures.

2.8. Functional scoring scale of late results

Majeed functional scoring scale was applied to evaluate the late functional results. Starting with the period of 10 months after the operation, the patients were surveyed either by telephone or in person during ambulatory care visits (see Table 12.4.1 in Section 12.4).

Table 2.5.1.

Clinical result based on 100 point assessment grid for the employed and on 80 point assessment grid for the unemployed

Employed prior to injury	Unemployed prior to injury	Functional score
> 85	> 70	Excellent
70–84	55–69	Good
55–69	45–54	Adequate
< 55	<45	Poor

2.9. Statistical processing of research results

All demographic data on the patients in the study and control groups as well as the measurement data obtained in the course of research were systematised using Microsoft Excel data processing software. Statistical processing of clinical data was performed using SPSS 20 (Statistical Package

for the Social Sciences) – a software package for forecasting and statistical analysis.

Variations are expressed as mean ± standard deviation (SD) and compared with the independent T-test.

In all cases, the level of significance was used to test statistical hypotheses (whether to confirm $p \leq 0.05$ or reject $p > 0.05$ them).

3. SURGICAL TREATMENT USING ANTERIOR RETROPERITONEAL LAPAROTOMY APPROACH

The patients were evaluated as being fit for osteosynthesis, if they were hemodynamically stable and compensated (Hb ≥ 9.0 g/dl and Ht ≥ 28%), and if pelvic fractures met the following criteria:

- dislocation in case of pelvic ring fracture exceeded 1.0 cm;
- symphysis rupture, when diastasis exceeded 2.5 cm;
- subluxation or complete luxation of SI joint;
- intra-articular fracture of SI joint, if fracture fragment dislocation exceeded 3.0 mm;
- acetabular hip fracture, if fracture fragment dislocation exceeded 3.0 mm;
- pelvic fractures combined with the injuries of pelvic organs (rupture of bladder, rupture of urethra, injuries to major blood vessels).

The aims of the operation:

- to maximally restore the autonomy of pelvic bones; in case of pelvic ring fractures, dislocation, which would not exceed 1.0 cm, is considered acceptable, but in case of acetabular fractures – the dislocation, which would not exceed 1.0 mm;
- to perform stabilising osteosynthesis with plates and screws;
- to check hip joint area to remove detached bone and cartilage fragments;
- to check pelvic retroperitoneal space to remove hematoma remnants and loose splinters in order to avoid possible peritoneal damage.

3.1. Operation stages

3.1.1. Anaesthesia and patient positioning

During the general intubation anaesthesia, the patient lies on the back on a radiolucent orthopaedic surgical table. The surgical table should have an extension in caudal direction so that a mobile X-ray apparatus can be easily manipulated and make inlet, outlet and AP projection images. The patient's legs are flexed at about 20°−30° in both hip and knee joints, so that *m. iliopsoas* is relaxed. The lower extremity at the fractured side of the pelvis is positioned loosely, so that it can be manipulated in the course of operation.

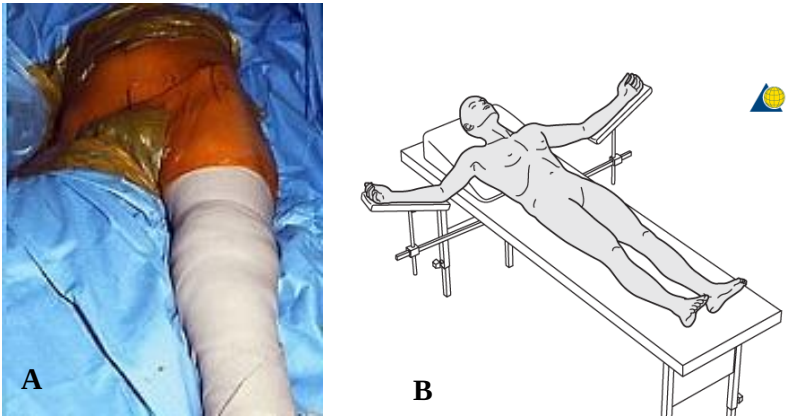


Fig. 4.1. **A – Preparation of the surgical site, the leg on the injured side is loosely laid, B – Patient positioning on the surgical table** (www.2.aofoundation.org)

3.1.2. Skin incision, fracture visualisation

When the surgical site is treated with disinfection, a linear ~ 15–20 cm long skin incision is made. The incision starts at about 2.0 cm from the nave down and continues along midline till the middle part of pelvic symphysis.

Having divided skin and subcutaneous tissues, *linea alba* is divided using the longitudinal incision. The spot where rectus abdominis muscles are attached to the pubis is left unaffected. Communicating blood vessels between *a.* and *v. iliaca externa* and *a.* and *v. obturatoria* ("*corona mortis*") are visualised.

After "*corona mortis*" is ligated and divided, large blood vessels *a.* and *v. iliaca externa* can be easier mobilised and the fracture site can be identified.

3.1.3. Reposition of bone fragments

Using an anterior retroperitoneal lower laparotomy approach, power tools are positioned in the direction from the healthy side to the damaged side, and the force is applied in the direction opposite to the force vector, which caused the fracture. It is very important to take that into consideration in case of pelvic acetabular anterior column fractures, transverse fractures, anterior column and posterior hemitransverse fractures, as well as in case of Type B lateral compression pelvic fractures.

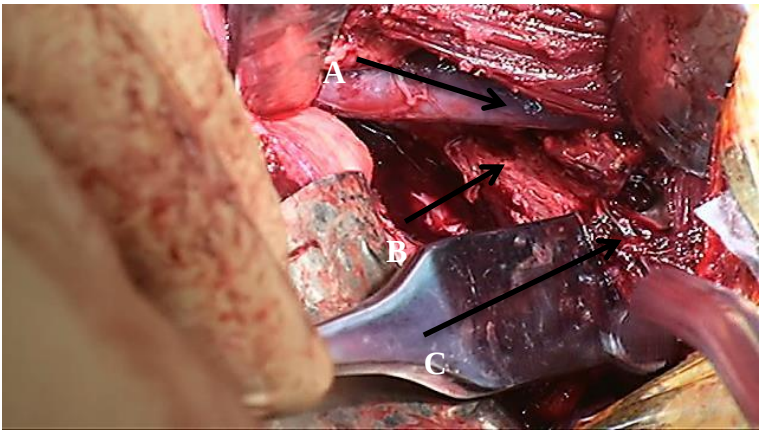


Fig. 3.1.3.1. **Fracture repositioning. A – *v. iliaca externa*, B – Fracture site, C – Repositioning device and direction of force application** (author′s photo)

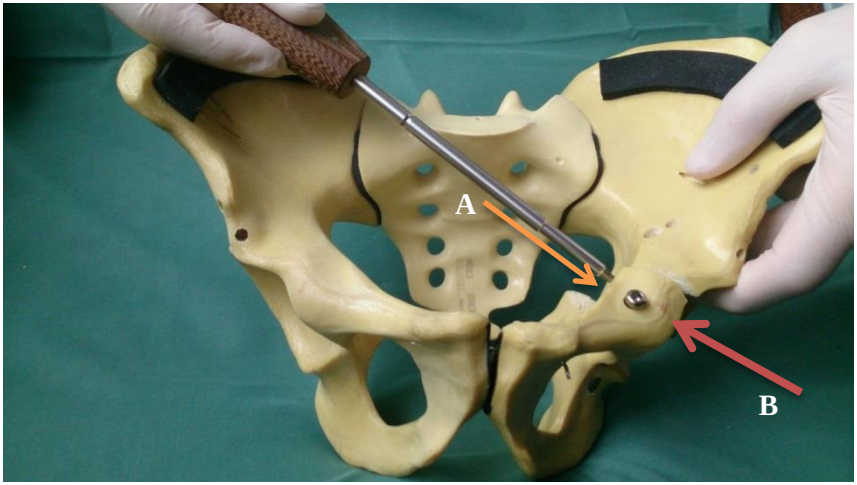


Fig. 3.1.3.2. **Representation of bone repositioning on a model. A – Repositioning force vector directly opposite to the force that caused the injury, B – Trauma force vector direction** (author′s photo)

In case of articular fractures of hip joints, when the repositioning of fracture fragments is not fully successful, in order to apply additional force from the abdominal side, traction of the hip joint should be performed using a 6.0 mm Steinmann pin, attaching a device with a T-shaped handle to its outer edge (Fig. 3.1.3.3.).

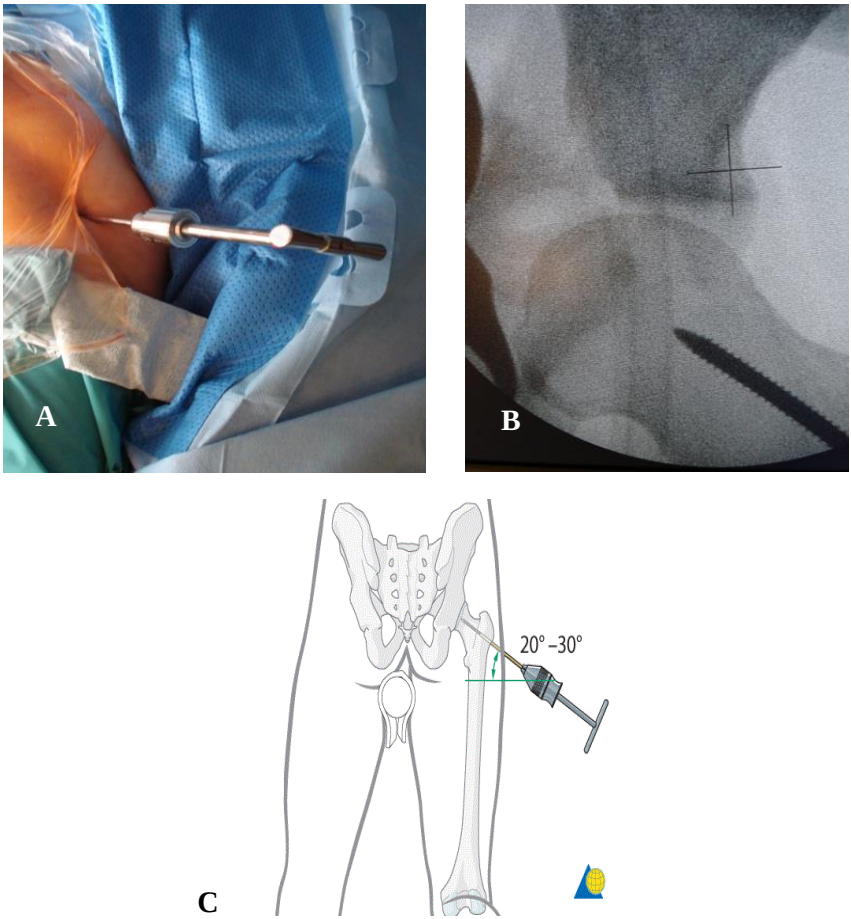


Fig. 3.1.3.3. **A – Insertion of a traction device into a left femoral neck, B – Traction in a radiograph, C – Schematic representation of the traction after AO** (A, B – author′s photo, C – www.aosurgery.org)

3.1.4. Temporary fixation of bone fragments

Temporary fixation was carried out with the 2.0 mm Kirshner wire, 7.0 mm or 4.0 mm cannulated screws or specialized holders of bone fragments. The advantage of wires: they can be inserted in different directions both percutaneously and directly through a surgical wound.

The advantage of screws over the wires: they provide a more stable fixation of bone fragments, and they can be left after performing permanent osteosynthesis. The drawback of screws: they pose a risk for iatrogenic tissue damage due to the use of an appropriate size drills and threading devices.

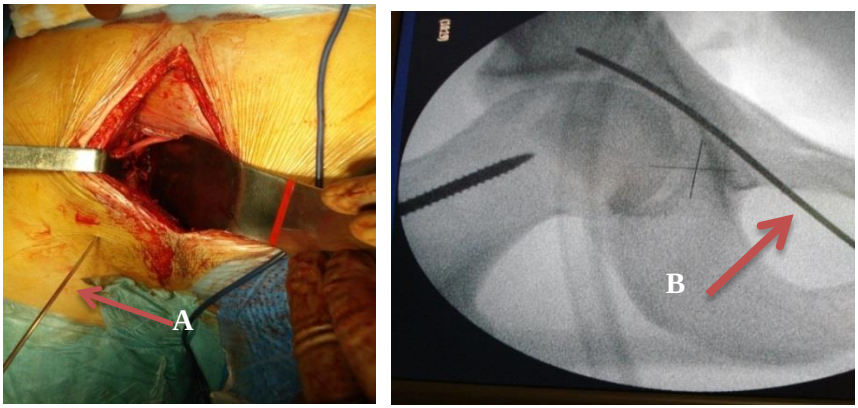


Fig. 3.1.4.1. **A – Temporary fixation wire inserted percutaneously in the right side of the pelvis, B – RTG control of the temporary fixation wire** (author′s photo)

Besides, the inserted screws may interfere with the next phase of surgery – basic osteosynthesis implant positioning.

Fig. 3.1.4.2. **A – T-type left-side acetabular fracture, B – Repositioning and temporary fixation with two para-articularly inserted cannulated screws** (author′s photo)

The third option of broken bone fragment fixation is the use of specialised bone holders / reponators. Their advantages are the opportunity to use considerable force and stable fixation, but disadvantages – difficult positioning, especially for adipose patients, and risk of iatrogenic bone structure damage.

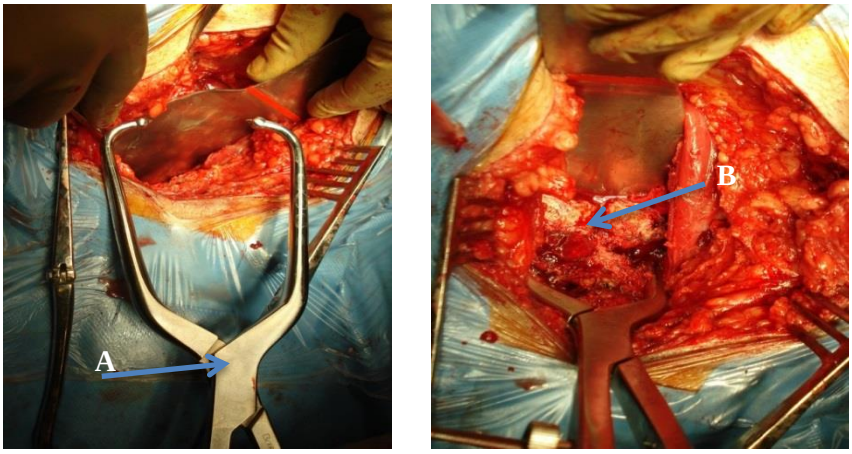


Fig. 3.1.4.3. **A – Pelvic bone reponator and fixator, B – Symphysis rupture repositioning and temporary fixation** (author photo)

3.1.5. Osteosynthesis

Osteosynthesis or fixation of bone fragments with implantable devices is the next step after performing the temporary fixation.

For permanent pelvic bone osteosynthesis, the author used the 3.5 mm screw opening reconstruction and semi-tubular plates, fixing them with the spongeous and cortical screws of 3.5 mm in diameter. In addition to plates, cannulated screws of 7.0 mm and 4.5 mm in diameter were used. 7.0 mm screws were used for sacroiliac joint and sacral fracture fixation, but 4.5 mm screws – for para-articular hip joint as well as transverse and anterior column fracture fixation, inserting them through the pubic bone in the direction of the upper branches from the symphysis to the hip joint.

For acetabular fracture osteosynthesis, a 3.5 mm screw opening reconstruction plate was used. Plate modelling was performed with specialised profiling instruments: benders and spinners. A plate profile is created on the basis of a template made of easily deformable and non-elastic material. Evenly pressing the template against the pelvic bone, it easily replicates the shape of bone surface; thus, an accurate model of a real plate can be obtained.

When the basic profile of osteosynthesis plate is created, it is positioned near the pelvic bone. In the process of positioning, one attempts to place the plate as close as possible to *linea arcuate*. The position and length of the plate are chosen so that it would be possible to place at least 4 osteosynthesis screws on each side of the fracture. The length of the plate can vary depending on the fracture type and the size of the patient.

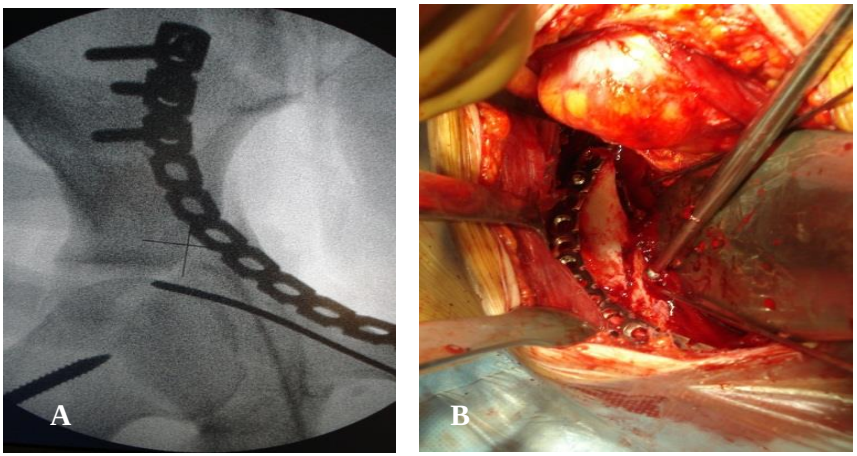


Fig. 3.1.5.1. **A – Intraoperative RTG control for plate positioning, B – Surgery phase involving plate positioning** (author′s photo)

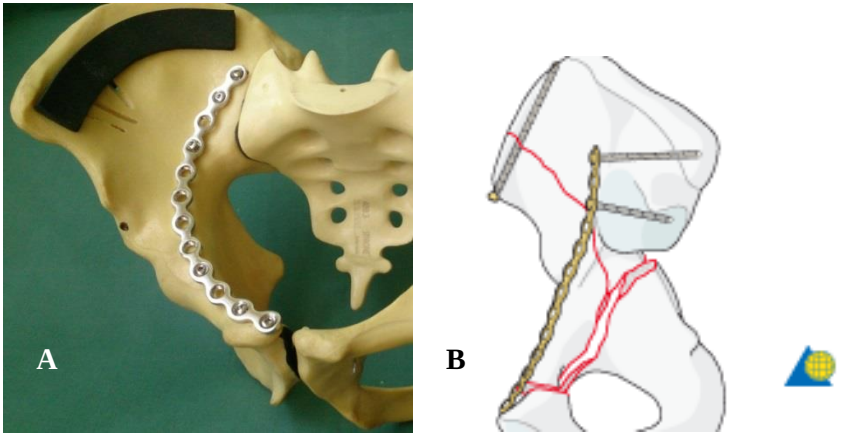


Fig. 3.1.5.2. **A – Position of the plate on a model, B – Schematic layout of the plate after AO** (A – author′s photo, B – www.aosurgery.org)

If any of the bone fragments is unstable, an additional semi-tubular plate is used (Fig. 3.1.5.3.), which enables one to fix a posterior column and separate bone fragments of quadrilateral surface (*facie quadrilaterum*).

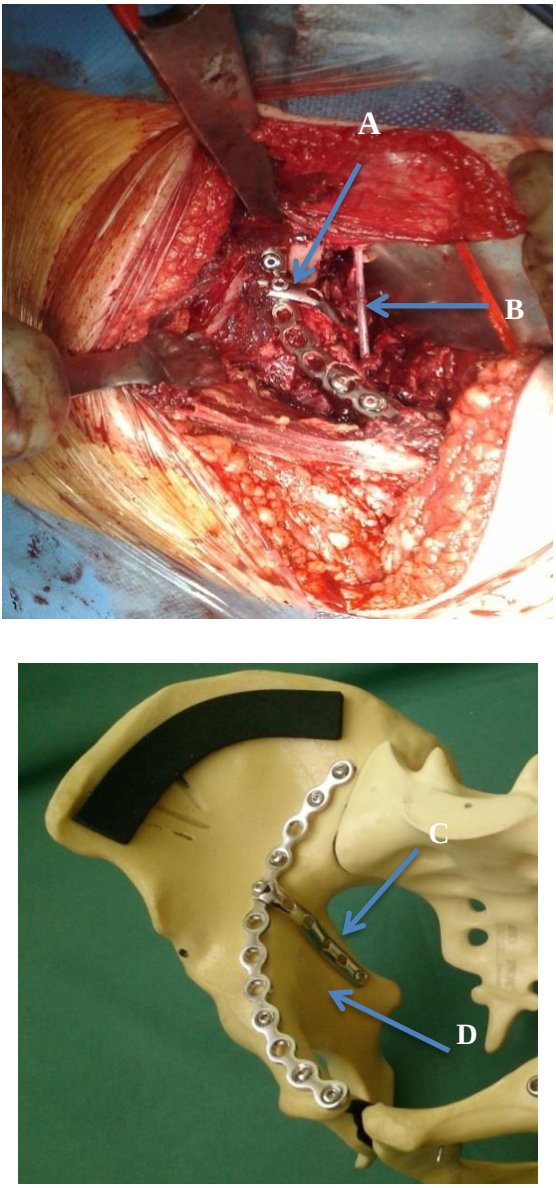


Fig. 3.1.5.3. **A – Surgery phase, an additional semi-tubular plate is inserted, B – *a. obturatoria*, C – Positioning of an additional plate on the model, D – Quadrilateral surface "*facie quadrilaterum*"** (author′s photo)

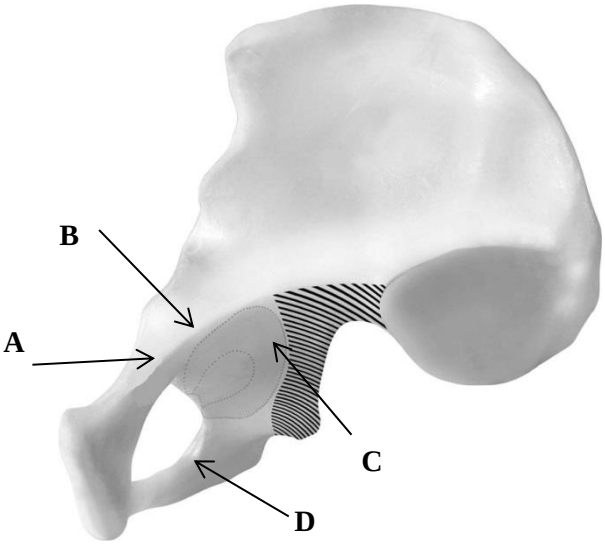


Fig. 3.1.5.4. **“Safe zone” for extra-articular screw placement, fixing the quadrilateral surface with the plate. A – Hip joint projection place, B – “safe zone”, C – *schiatic notch*, D – *schiatic notch minor***
(“Journal of orthopaedics and traumatology” No 5, Vol. 24, 2010)

When inserting an additional plate to fix the quadrilateral surface, a “safe zone” should be observed. It is the area on the quadrilateral surface, where it is relatively safe to insert osteosynthesis screws, not affecting the hip joint cavity. The safe zone is projected vertically in the back of quadrilateral surface and in front of *incisura ischiadicum majus*; the lower border is *incisura ischiadicum minus*, but the upper – *linea arcuate*, its average width is 11 mm.

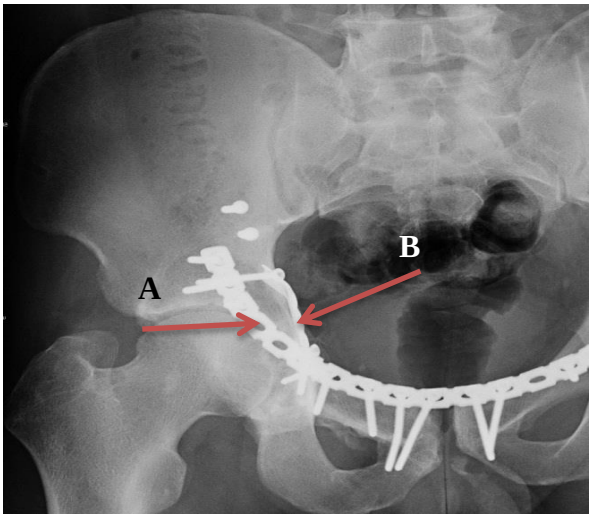


Fig. 3.1.5.5. **A – Acetabular and pelvic ring fracture fixation with the reconstruction plate, B – Quadrilateral surface and posterior column fixation with an additional plate in the "safe zone"** (author′s photo)

4. RESEARCH FINDINGS

4.1. Statistical results of the study groups patients with regard to age, gender and injury mechanism

Assessing the overall statistical data on the age and gender of the control group and the study group, it can be concluded that pelvic injuries most often happen to patients around the age of 40 years. The average age of participants in the control group was 37.8 years and the average age of participants in the study group was 44.0 years. This can be explained by the fact that the most common cause of the pelvic fractures is traffic accidents involving people of active age. The second most common cause of the injury is fall from a height that is also associated with the patients of active age.

The research involved 69 participants (35 in the study group and 34 in the control group), of which 46 men and 23 women. On the basis of independent samples T-test, it was found out that the average age of men and women did not differ statistically significantly ($p = 0.58$). Thus, the risk age to suffer a pelvic fracture did not differ for both gender groups.

Further, the age statistics of both groups was analysed.

On the basis of independent samples T-test, it was found out that the average age of the control group ± SD (37.82 ± 17.14) and the average age of the research group ± SD (44.09 ± 14.92) did not differ statistically significantly ($p = 0.11$). Thus, the overall average age should not affect the results of the research.

Evaluating gender statistical results, it can be concluded that male patients more often suffer traumatic pelvic fractures.

The control group comprised 25 men and 9 women, but the study group – 21 men and 14 women.

The results of chi-square statistical analysis demonstrated that there was no relationship between gender of the study group and that of the control group

(p = 0.23), and therefore gender in general could not affect the results of the research.

The statistical results of injury mechanism demonstrate that men experience falls from a height and traffic accidents in equal proportion; women, in turn, suffer most injuries as a result of traffic accidents.

On the basis of the chi-square statistical analysis, there was no statistically significant difference found between the gender and the type of injury (p = 0.12). However, fall-related injuries happen to men 3 times more often than to women.

The independent samples T-test demonstrated that the average age of the subject experiencing fall-related injury was 44.00 (SD ± 14.67), but suffering in traffic accidents – 38.72 (SD ± 17.20), and the age difference of 5.28 years was not statistically significant (p = 0.18). However, as it can be seen, fall-related injuries happen to older adults, but the population experiencing traffic accidents is slightly younger.

4.2. Results of intraoperative blood loss, hemotransfusion and duration of surgery of the study groups patients

Hemotransfusion protocol analysis demonstrates that the average total amount of transfused red blood cell mass is lower for the study group than for the control group. The hemotransfusion was performed in cases if Hb ≤ 8.5g/dl and Ht ≤ 25% (12).

The independent samples T-test showed that the average amount of transfused red blood cell mass comprised ± SD (547.52 ml) for the control group, but for the study group it was ± SD (324.93ml). These results make a statistically significant difference, where p < 0.01.

Within the framework of the research, blood loss was evaluated. On the basis of the independent samples T-test, it was found out that the average amount of blood loss was ± SD 647.65 ml for the control group and for the

study group it was ± SD 411.14 ml, and these results made a statistically significant difference (p = 0.05).

Blood reinfusion results also demonstrate that there are advantages of the methods used in the study group over those of the control group.

On the basis of the independent samples T-test, it was found out that the average amount of blood reinfusion was ± SD 547.52 ml for the control group and for the study group it was ± SD 281.20 ml, and the results made a statistically significant difference (p = 0.04).

Processing the independent samples T-test results, it was found out that the average duration of surgery was also statistically significantly different (p = 0.05); it accounted for ± SD 119.56 minutes for the control group and for the research group it was ± SD 102.7 minutes.

4.3. Postoperative radiological results

Postoperative radiological results were obtained from digital measurements of pelvis radiographs in standard projections (AP, outlet, inlet) with calibration and computed tomography scans. Such software as Centricity Web V2.1 and Centricity PACS-IW 3.7.3.9 was used to carry out the measurements.

4.3.1. Postoperative radiological results of acetabular fractures

Postoperative radiological results of acetabular fractures have been divided into three groups, which, according to literature data, are internatio nally recognised gradations depending on the size of fracture fragment dislocation.

Group 1 comprised patients with the dislocation of fracture fragments in the range of 0–1.0 mm; such a result was considered excellent.

Group 2 comprised patients with the dislocation size of fracture fragments in the range of 1.0–3.0 mm; and such a result was considered good.

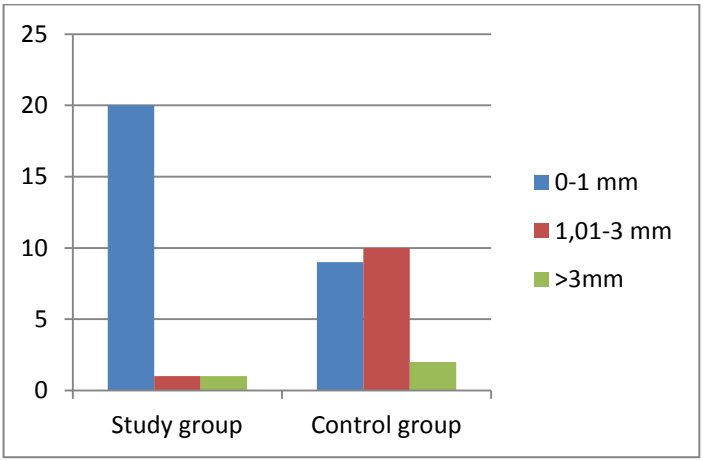
Group 3 comprised patients with the dislocation size of fracture fragments exceeding 3.0 mm; and such radiological result was considered poor.

Table 4.3.1.1.

Postoperative dislocation sizes of acetabular fractures

Groups	Postoperative dislocation size and number of bone fragments			Total
	0–1 mm	1.01–3.0 mm	> 3.0 mm	
Study group	20	1	1	22
Control group	9	10	2	21
Total	29	11	3	43

Table 4.3.1.1. and Histogram 11 demonstrate that the results of the study group are better; most patients received the assessment – excellent result. In the control group, the highest number of patients can be found in the row from 1.01–3.0 mm; therefore, the patients' results comply with the assessment – good result.



Histogram 11. **Grouping of patients depending on the dislocation size of postoperative acetabular fractures for the study group and the control group**

To evaluate the dislocation size of postoperative acetabular fracture, the chi-square statistical analysis was used. The results demonstrated that there was a relation between the method and dislocation of postoperative articular fractures, where $p < 0.01$. In the study group, the number of patients with a minimum degree of dislocation of 0–1 mm was more than twice that of the control group.

Table 4.3.1.2.

Average size of postoperative dislocation of articular fractures for the study and control groups, and calculated T-test P-value

Parameter under study	Groups	Number	Average size, mm	SD	SE of the mean	P
Postoperative dislocation, mm	Study group	22	0.823	0.8400	0.1791	0.001
	Control group	21	1.957	1.2762	0.2785	

Independent samples T-test was used to analyse the results and to find the correlation among average postoperative dislocation sizes of bone fragments for both groups. It can be concluded that the average dislocation size of acetabular fractures is ± SD (1.95 ± 1.27) for the control group, and it is ± SD (0.82 ± 0.84) for the study group, which is a statistically significant difference because $p < 0.01$ (see Table 4.3.1.2.).

4.3.2. Postoperative radiological results of pelvic ring fractures

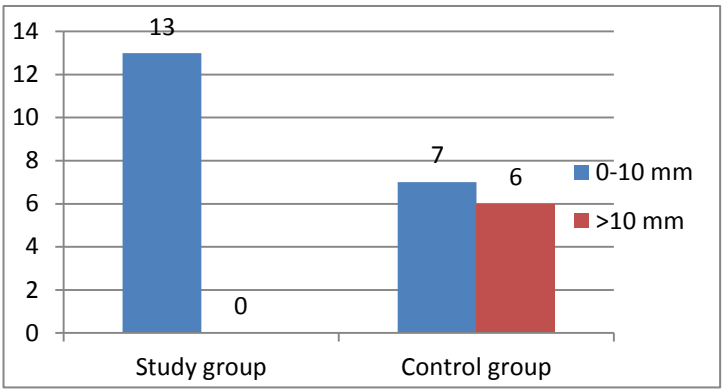
The study group comprised 13 patients with isolated pelvic ring fractures; all of these patients were involved in the postoperative result group with dislocation size not exceeding 10 mm, thus corresponding to the assessment ‘satisfactory result’.

Table 4.3.2.1.

Postoperative dislocation sizes of pelvic ring fractures for the study and control groups

	Dislocation of postoperative pelvic ring fragments		Total
	0–10 mm	>10 mm	
Study group	13	0	13
Control group	7	6	13
Total	20	6	26

The control group also comprised 13 patients with isolated pelvic ring fractures. Excellent result (dislocation of 0–10 mm) was shown by 7 patients, but unsatisfactory (dislocation of 10–30 mm) – by 6 patients. The results are depicted in Table 4.3.2.1. and Histogram 12.



Histogram 12. **Grouping of patients by postoperative dislocation sizes of pelvic ring fractures for the study and control groups**

Analysing pelvic ring fractures, it should be taken into account that both study and control groups comprised a small number of patients: 13 patients in each group. Therefore, using Fisher's test, it was found out that there was no relationship between the pelvic ring fracture dislocation and the surgical

method ($p = 0.08$). However, it should be noted that using a new method, all patients were included in the group with dislocation of 0–10 mm, and there was no one with unsatisfactory result. It should be concluded that it is necessary to conduct further research in this area. In contrast, using the independent samples T-test, the number of patients was sufficient, and it could be concluded that the average dislocation size of pelvic ring fractures was ± SD (7.33 ± 7.18 mm) for the control group, and for the study group it was ± SD (0.45 ± 0.37 mm), and there was a statistically significant difference ($p < 0.01$).

4.4. ISS and Majeed functional scoring scale results of the study groups patients

All results of Majeed functional scoring scale are shown in the tables below. First, the author summarised statistical results on the ISS (Injury Severity Score), Majeed scale and pelvic injury with or without neurotrauma.

Table 4.4.1.

Average values of ISS and Majeed scale for the control and study groups depending on a pelvic injury with or without neurotrauma

	Neuro-trauma	Number	Average value	SD	SE of the mean
ISS	Yes	16	22.813	9.8605	2.4651
	No	53	22.057	9.9950	1.3729
Majeed	Yes	16	68.313	6.4365	1.6091
	No	53	83.132	8.3414	1.1458

As seen from Table 4.4.1., a neurotrauma in combination with pelvic fractures does not significantly affect the ISS results; the average indicators are very close. However, the total result of Majeed functional scoring scale is affected. In case of neurotrauma, the total average value is lower. To process these results, the independent samples T-test was used.

As the independent samples T-test showed, there was a statistically significant difference ($p = 0.79$) in the average values of ISS for the patients with isolated pelvic fractures and for the patients with a pelvic injury combined with neurotrauma.

However, evaluating Majeed scale results on the basis of the independent samples T-test, it was found out that the average total value of Majeed functional scoring scale differed for the patients who had neurotrauma (68.31 ± 6.43) and the ones who did not have neurotrauma (83.13 ± 8.34); the difference of 14.81 points was statistically significant ($p < 0.001$).

Further, the ISS of the study group and that of the control group were compared. The average ISS was 20.60 for 35 patients of the study group, while for 34 patients of the control group the ISS was 23.91.

For 35 patients of the study group, the total average value of Majeed functional scoring scale was 85.20, while for 34 patients of the control group the result was 74.02.

Table 4.4.2.

Statistics of average values of Majeed functional scoring scale and the ISS for the study and control groups

	Group	Number	Average value	SD	SE of the mean
ISS	Study group	35	20.600	9.3438	1.5794
ISS	Control group	34	23.912	10.3026	1.7669
Majeed scale	Study group	35	85.200	8.8178	1.4905
Majeed scale	Control group	34	74.029	8.0584	1.3820

By analysing the obtained results with the independent samples T-test, it was found out that the average value of the ISS was not statistically significantly different ($p = 0.16$) for the study group and the control group; thus, the average severity of the injury, which could theoretically affect the belated results, was the same for both groups.

However, the total average indicator of Majeed functional scoring scale differed significantly (by 11.17 units), and after the independent samples T-test it was statistically significant, i.e., $p < 0.001$, which indicated that the belated results were related to the surgical method.

In the study group, the number of patients with neurotrauma gained in addition to the pelvic injury was 7, and in the control – 9. The average values of Majeed functional scoring scale for the study group and the control group were 73.57 and 64.22 points, respectively.

Table 4.4.3.

Average values of Majeed functional scoring scale for both groups' patients with neurotrauma in addition to pelvic injury

Group	Number of patients with neurotrauma	Average value of Majeed scale	SD	SE of the mean
Study group	7	73.571	3.0472	1.1518
Control group	9	64.222	5.2626	1.7542

The independent samples T-test showed that for the study group comprising patients who had also a neurotrauma in addition to pelvic injury, the average value of Majeed functional scoring scale was 9.34 points higher than that of the control group comprising patients with the analogous trauma, and this difference was statistically significant ($p < 0.001$).

Having performed calculations, we obtain that the average value of Majeed functional scoring scale for the patients with isolated pelvic fractures in the study group was 88.107 points for 28 patients, but in the control group – 77.560 points for 25 patients. The results are shown in Table 4.4.5.

Table 4.4.5.

Average value of Majeed functional scoring scale for patients from both groups with isolated pelvic fractures without neurotrauma

Group	Number	Majeed average value	SD	SE of the mean
Study group	28	88.107	7.2128	1.3631
Control group	25	77.560	5.5684	1.1137

As in the group of patients with isolated pelvic bone fractures the value of Majeed functional scoring scale was directly proportional to the results of treatment (the higher the number of points, the better the treatment outcome), a reliable result was obtained using the independent samples T-test.

The independent samples T-test shows that the average values of Majeed functional scoring scale differ by 10.54 points between patients from both groups with isolated pelvic injuries, and this difference is statistically significant ($p < 0.001$).

Further, values of Majeed functional scoring scale were separately analysed for the study group and the control group. The results were summarised in the same way as mentioned above, also evaluating the pelvic injuries in combination with neurotrauma.

Table 4.4.7.

Average values of Majeed functional scoring scale for the patients from the study group with and without neurotrauma

Neurotrauma	Number	Majeed average value	SD	SE of the mean
Yes	7	73.571	3.0472	1.1518
No	28	88.107	7.2128	1.3631

Table 4.4.7. demonstrates that the patients without neurotrauma have better average indicators. Within the group, the average indicator of Majeed scale varies from 73.571 to 88.107 points. To evaluate the reliability of

indicators, the author used the independent samples T-test, on the basis of which the following results were obtained: the average value of Majeed functional scoring scale differed by 14.53 points for the patients who had neurotrauma in addition to pelvic fracture within the research group, and this difference was statistically significant ($p < 0.001$).

Within the control group, the tendency of results is similar to that of the study group, i.e., patients who do not have neurotrauma in addition to pelvic fracture demonstrate better treatment results.

On the basis of independent samples T-test results, it can be concluded that within the control group the difference of average values of Majeed functional scoring scale is similar to that of the study group. Patients who suffered neurotrauma in addition to pelvic fracture had 64.22 ± 5.26 points, but patients without neurotrauma – 77.56 ± 5.56 points. The given difference of 13.33 points is statistically significant ($p < 0.001$).

Further, the nonparametric Spearman correlation coefficient analysis was performed. It was concluded that there was no statistically significant correlation ($p = 0.09$) between the average values of Majeed functional scoring scale and the numeric values of ISS.

Analysis of the results of patients after pelvic fractures enabled the author to conclude that the functional pelvic numerological Majeed scale depends on the fact whether a pelvic fracture is combined with neurotrauma or not; however, there is no correlation between the Majeed results and ISS.

5. DISCUSSION

In most cases (70–80%) fractures of pelvic ring and the acetabulum are treated surgically. Surgical treatment methods and techniques that have been improved during the last 50 years are mainly prescribed for cases of pelvic acetabular fractures. The development of treatment methods is still continuing, new and less traumatic surgical approaches are being sought for, the most appropriate treatment principles are being evaluated and controversial, unambiguously complex issues arise, especially concerning the treatment in cases of pelvic ring fractures (1). Many authors (2; 3; 4) still consider that fixation of the anterior part of the pelvic ring is not necessary, as the stability of pelvic ring up to 80% is ensured by the posterior part (5).

Surgical treatment is developing along with the technical progress, for example, nowadays it is hard to imagine surgical treatment of pelvis without portable X-ray machines in the operating theatre, which has been also highlighted in several sources, for example, in Norris and Carmack (6; 7).

A range of special surgical instruments and implants have been developed for the supporters of minimally invasive surgery. Jakob and Droeser (8) describe the advantages and significance of minimally invasive surgery, but at the same time other authors (9; 10) consider that minimally invasive approach is permissible only in cases of non-dislocated fractures, which might as well be treated conventionally.

At the time of rapid technological development many publications about the use of computer-assisted navigation system for osteosynthesis of pelvis appear. Osterhoff, Zwingmann and other authors (9; 11) emphasise that it is a future technology with already proven good results to be further developed. In contrast, Hirvensalo, Cimmermanis and the author of the Thesis consider that navigation equipment, the same as minimally invasive surgery, must be used

only in cases of non-dislocated fractures, and high cost of this equipment will limit its use in surgical clinics.

In the author's point of view, the ilioinguinal approach (12; 13; 14) that has been used till now can be considered as too broad and traumatic (10; 15). Dissection and preparation of nerves, blood vessels, lymphatic vessels and sperm ducts is usually a time-consuming and labour-consuming process, and almost always it causes intensive formation of scar tissues around these significant organs. Using this approach, the obtained recognition of the nature and character of the fracture, as well as its visualisation, is rather relative.

An issue concerning skin incision is also controversial. Is it better to make lower midline abdominal incision or horizontal Pfannenstiel incision, as D. Cole and R. Bolhofner described (16)? By using Pfannenstiel incision and cutting straight abdominal muscles along the midline, i.e. the so called modified Stoppa approach, cannot sufficiently move the straight abdominal muscles aside and ensure optimal visualization of the inner surface of the pelvic ring (17).

In the author's opinion, the only benefit of the use of Pfannenstiel incision is the cosmetic effect, although it is also rather relative.

In the course of research, several important conditions for preoperative period have been established and that helped and facilitated successful implementation of this surgical technique. Initially, the lower extremity of patient's injured side was fixed on the extension table with a view that it could simplify and facilitate the repositioning of the fracture, but in reality it proved wrong, it caused stretching of psoas muscle and iliopsoas muscle (*m. iliopsoas*), and that caused difficulties to move it and reach fracture fragments, as well as their repositioning. The other complexity caused by the extension equipment was the support of pelvis that is positioned in the region of patient's perinaeum with counter-pressure against the region of symphysis and pubic bone. As a result of such traction counter-pressure, the dislocation of the pelvic fracture

could be adjusted only in cases of acetabular fractures, whereas in cases of pelvic ring fractures the dislocation even increased, especially in cases of B and C type fractures.

Thus henceforward when placing the patient on the surgical table the lower extremity of the injured side was slightly bent in knee and hip joint, thus achieving relaxation of psoas muscle and ilicus muscle / iliopsoas muscle and providing the possibility for manipulation, but in cases when there is a need for traction counter-pressure during surgery, a manual force is used, prior to fixing the iliac wings with external fixation apparatus.

It must be also emphasised that during preoperational period it was not possible to predict the possible blood loss during the operation, therefore, after the surgery of the first two patients, during which the used cell saver or accumulation system allowed to compensate approximately 750 ml of autogenous blood, this method was used as a standard algorithm in all subsequent surgeries.

The length of the surgery can affect the overall condition of the patient and increase the risk of infection. The average surgery duration was 103 minutes, which can be considered an excellent result and this corresponds to or is very close to the data mentioned in the relevant literature – 100–195 minutes (18; 16; 19).

Reposition of fractures and bone fragments by using anterior retro-peritoneal lower laparotomy approach caused comparatively less difficulties than the classically adopted ilioinguinal approach. This can be explained by the fact that by using anterior retroperitoneal approach it is possible to direct the force vector of reposition instruments directly opposite to the force vector that causes trauma (see Fig. 3.1.3.1. and 3.1.3.2.).

We faced problematic reposition of bone fragments in cases when due to different objective reasons the patient could not be operated earlier than 3 weeks after the trauma. Problems were not directly related to the chosen

method of surgery, but formation of primary scar tissues around the fractures. However, we consider that also in these cases anterior retroperitoneal approach has more advantages in comparison with ilioinguinal approach. There is still one controversial question – whether it is necessary to expose the patient to high risk and perform an open reposition with major blood loss in case of partially consolidated fractures? There is no definite answer to this question, because on the one hand, a traumatologist who deals with acute traumatology, will always try to maximally restore the anatomic structure of pelvic ring and acetabulum in order to maximally prevent secondary complications (20), but on the other hand, an orthopaedist who mainly deals with prosthetics, considers that the main task of the traumatologist is to prepare the pelvic structure for future athroplasty. Although according to our research results, anterior retroperitoneal approach offers greater opportunities and better results in comparison to the conventional surgical approach, we consider that it also is not an ideal and universal surgical method suitable for all pelvic fractures. This surgical approach had to be combined with additional lateral or posterior approaches to patients with Type C pelvic ring fractures, in cases of several two-column acetabular fractures with dislocations in iliac wing, as well as in cases of dislocated sacrum fractures and cases of SI joint subluxations or even total luxations. In order to get objective results, the patients, who were treated using combined surgical approaches, were not included in the research. Example is shown in Fig. 5.1.

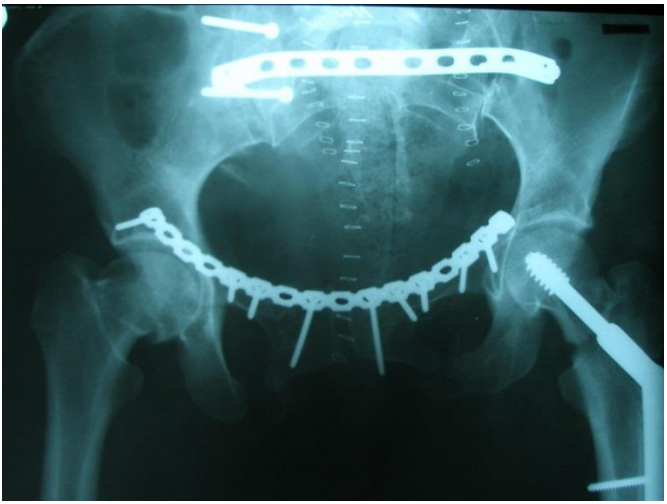
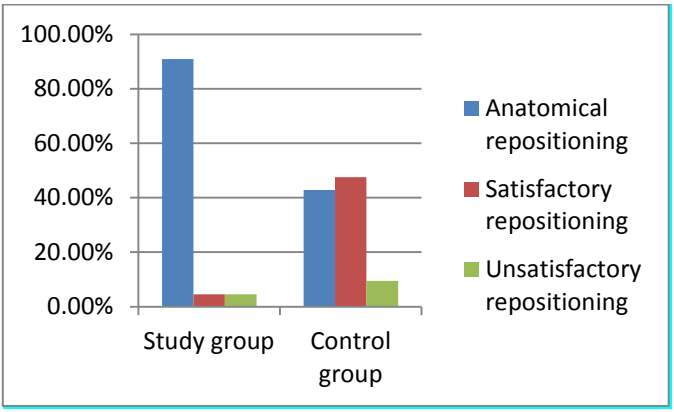


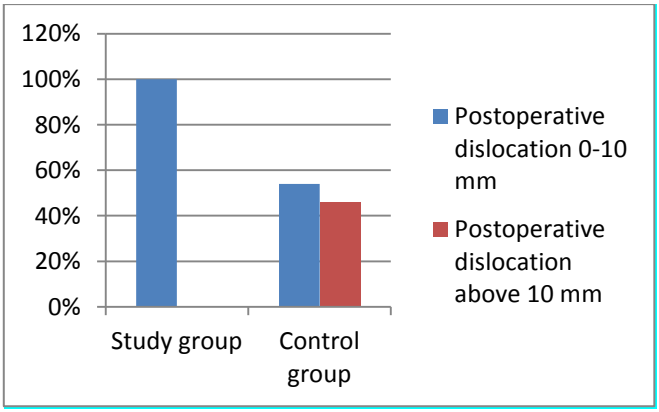
Fig. 5.1. **Polytrauma patient with Type C pelvic ring fracture that has been surgically treated with anterior retroperitoneal lower laparotomy approach in combination with two posterior parasacral approaches** (author′s photo)

Postoperative radiological examinations demonstrated acceptable results in 95.4% of cases of acetabular fractures, in 90.9% of cases an anatomical repositioning of fractures was achieved, in 4.5% of cases satisfactory repositioning of fractures and in 4.5% of cases unsatisfactory repositioning was observed. For the control group, correspondingly, anatomical repositioning was achieved in 42.8% cases, satisfactory repositioning – 47.6%, and 9.5% were evaluated as poor result (see Histogram 13). Concerning anterior retro-peritoneal approach, the acquired radiological results practically correspond to the data mentioned in the literature, where anatomical repositioning is achieved in 58–90% of cases, satisfactory repositioning – in 4–37% of cases (21; 22).



Histogram 13. **Comparison of surgical repositioning of pelvic acetabular fractures in the study group and control group**

When treating pelvic ring fractures with anterior retroperitoneal approach, satisfactory repositioning of bone fragments (from 0 to 10 mm) was achieved in 100% of cases. In the control group, repositioning till 10 mm was achieved in 54% of cases, but in all other cases postoperative dislocation was above 10.0 mm.



Histogram 14. **Comparison of postoperative repositioning of pelvic ring fractures in the study group and control group**

One of the advantages of anterior retroperitoneal surgical approach is that this approach can be successfully used in cases of bilateral pelvic ring and pelvic acetabular fractures, because it provides access to both sides of pelvis, which is not possible using other surgical approaches. Therefore, according to the author, this could be an optimal method to be used in cases of bilateral pelvic ring and pelvic acetabular fractures, because rather small lower midline abdominal incision and cutting straight abdominal muscles along the midline can be considered less traumatic.

Another advantage of this surgical approach is that it can be successfully used in polytrauma patients, because pelvic fractures are combined with injuries of internal organs. An example of traumatic peritoneal sac injury on the level of SI joint with subsequent hemoperitoneum is illustrated below (Fig. 5.2.).

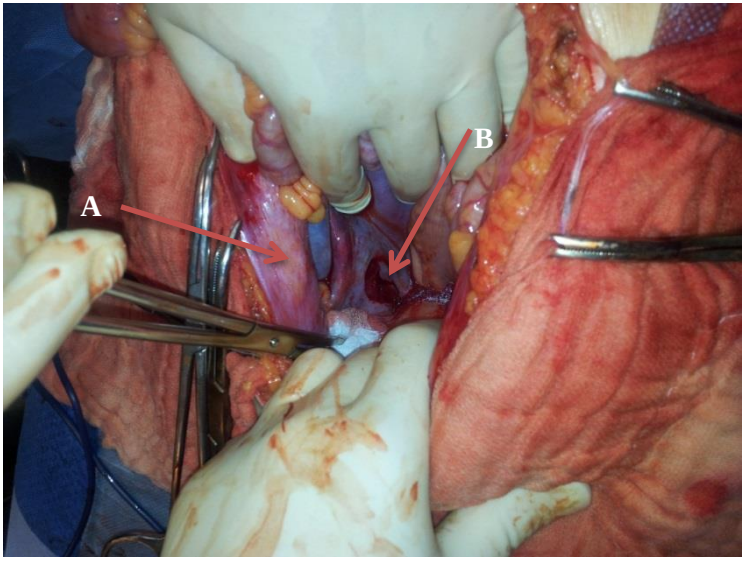


Fig. 6.2. **Rupture of peritoneal sac caused by dislocated fracture of posterior part of pelvis detected during laparotomy, A – Peritoneum, B – Rupture of peritoneum** (author′s photo)

Iatrogenic damages of peritoneum that were observed in two cases (5.7%) were stitched with continuous stitch and did not cause any gastro-intestinal tract complications (intestinal perforation, postoperative constipation or peritonitis). According to the literature, using this surgical technique peritoneum may be damaged on average in 32% of cases (21).

Functional result has been evaluated by using Majeed functional scoring system (23). The results have been evaluated in the long term, by telephone interviews with patients or by filling in questionnaires, when the patients attended the clinic in person.

The parameters that were used in Majeed functional scoring system reflect the main problems that could appear after pelvic trauma, as observed in 69 cases of surgically treated fractures. Pain is a significant problem and it is comparatively easy to evaluate it. Inconvenient sitting was mentioned more often than expected, and most frequently difficulties were caused by sitting on one gluteal side due to pseudarthrosis of ischium or hypertrophic callus (19; 22).

Sexual intercourse is a complicated activity that has not been sufficiently evaluated in the previous reports. Some male patients had severe pain due to internal fixation of pubic bone symphysis, others had pain in sacrum region. For women, pain during sexual intercourse was more often related to side compression injuries, as well as to bending of pubic branches towards perinaeum (23). Evaluation of sexual intercourse with a four point system is probably too basic. This evaluation should be revised.

Movement of hip joints can be influenced by pain or stiffness when pelvic fracture lines cross hip joint's acetabulum. This fact was not categorised as an individual unit, because it is implicitly included in the evaluation of gait, walking ability, sexual intercourse and sitting. In cases that significantly involve hip joint's acetabulum, evaluation should be aimed at pelvis by using the acknowledged methods that have been described by Merle d'Aubigne and

Postel (17) (1954), Salvati (11), Harris (12), Charnley (13), Parkers and Palmers (14) and others. An attempt to evaluate or classify pelvis stability was also not made, because it was also included in other evaluations. It was often difficult to evaluate performance efficiency, because it could change over time.

Numerical scouring system also allows comparing different treatment methods and can help in rationalising surgical treatment of severe pelvic fractures.

6. CONCLUSIONS

1. The analysis of surgical parameters (duration of surgery, blood loss during surgery, hemotransfusion amount) in patients with complex pelvic fractures, in cases of the anterior retroperitoneal approach are statistically significantly better than in cases of ilioingvinal approach.
2. The analysis of surgical correction of postoperative radiological parameters in patients with complex pelvic fractures, in cases of the anterior retroperitoneal approach are statistically significantly better than in cases of ilioingvinal approach.
3. The analysis of late postoperative functional results, using Majeed scale, in patients with complex pelvic fractures, in cases of the anterior retroperitoneal approach are statistically significantly better than in cases of ilioingvinal approach.
4. Anterior retroperitoneal approach in cases of complex pelvic fracture is safe and provides qualitative pelvic bone fragments for osteosynthesis.

7. PRACTICAL RECOMMENDATIONS

1. Pelvic ring and acetabular fracture surgical approach algorithms in order of type of pelvic fracture (see Sections 12.1, 12.2.).
2. Anterior retroperitoneal approach has the following advantages in comparison with the ilioinguinal approach:
    a. it is possible to direct the force vector of reposition instruments directly opposite to the force vector that caused trauma;
    b. skin incision in the surgical site using anterior retroperitoneal approach is substantially lesser;
    c. using anterior retroperitoneal approach, it is easier to position and fix osteosynthesis implants, because the wound is monolithic;
    d. neurovascular structures are better visualised – *a*. and *v.iliaca, a*. and *v. obturatoria,* "*corona mortis*", *n. femoralis* and *n. obturatorius*;
    e. in cases of complex pelvic fracture and injury of pelvic organs is safe approach and provides to perform examination of pelvic organs in polytrauma patients and switch from retroperitoneal approach to intraperitoneal approach simultaneously;
    f. anterior retroperitoneal approach in cases of complex bilateral pelvic fracture is safe and provides to access both sides of pelvis through one incision.
3. In the course of research, the drawbacks of the method investigated have been established:
    a. possible iatrogenic damages of peritoneum while working with power tools or repositioning bone fragments;
    b. if there is no penetration of the femur head in the pelvis minor, it is not possible to examine hip joints.

8. BIBLIOGRAPHY

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9. POSTER PRESENTATIONS

- Poster presentation *Sparing of Vital Resources while Treating Pelvic Fractures with the Modified Stoppa Approach*. RSU 10th (15) Scientific Conference, 2011, Riga.
- Poster presentation *Sparing of Vital Resources while Treating Pelvic Fractures with the Modified Stoppa Approach*. RSU 11th Scientific Conference, 2012, Riga.
- Poster presentation on the topic at the European Emergency Surgery and Polytrauma (ECTES) Congress, 2012, Basel, Switzerland.

10. REPORTS ON RESEARCH RESULTS

- Report on the topic *Stoppa Surgical Approach in Treatment of Pelvic Fractures,* Latvian Association of Surgeons meeting of 25 February 2009.
- Report on the topic *First Results of Pelvic Fracture Treatment with the Modified Stoppa Approach.* L*atvian Association of Traumatology and Orthopaedics* meeting of 3 July 2009.
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- Report on the topic "The Failure of Pelvic Osteosynthesis" Baltic Congress of Traumatology and Orthopaedics, Riga, Latvia, May 2013.
- Report on the topic "Medium-term Outcome of Patients with Pelvic Ring and Acetabular Fractures Operated by the Modified Stoppa Approach" 33rd Annual Meeting of the *Israel Orthopaedic* Association, Tel Aviv, Israel, 2013.

- Report on the topic “Outcome of Polytrauma Patients with Pelvic Fractures Operated by the Modified Stoppa Approach” 3rd Scientific International Congress of Traumatology and Orthopaedics, Tel Aviv, Israel, 26–28 June 2014.

11. SCIENTIFIC PUBLICATIONS

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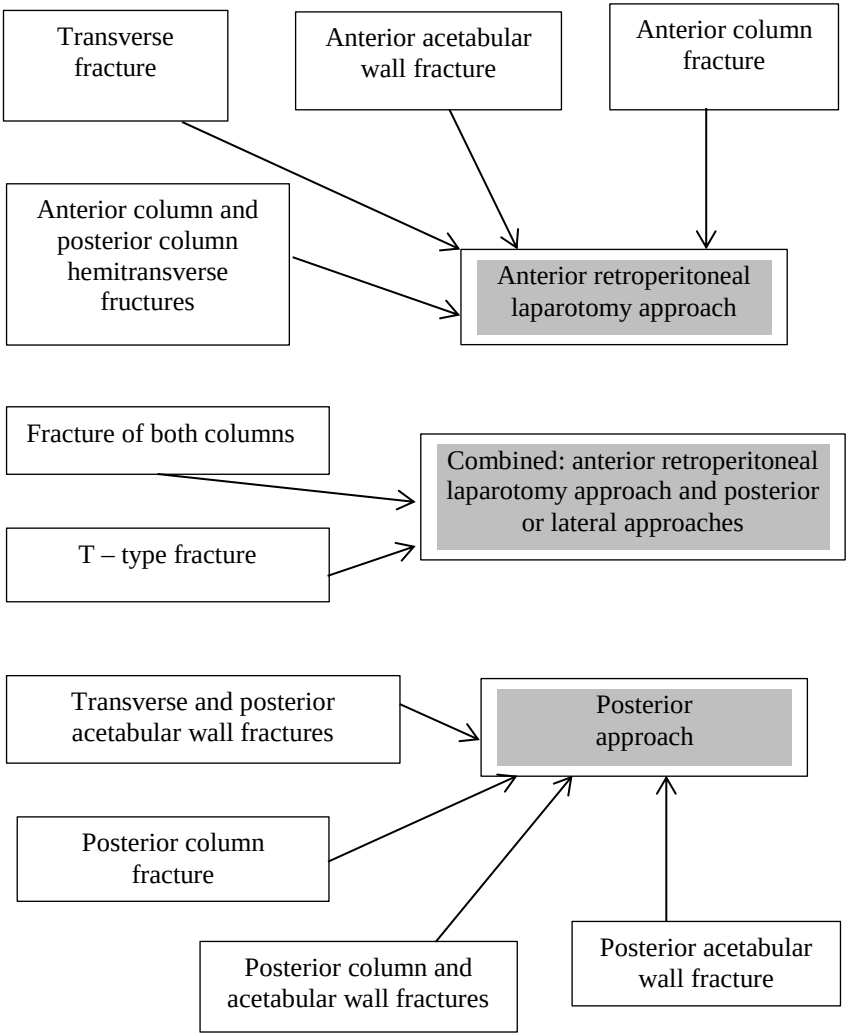
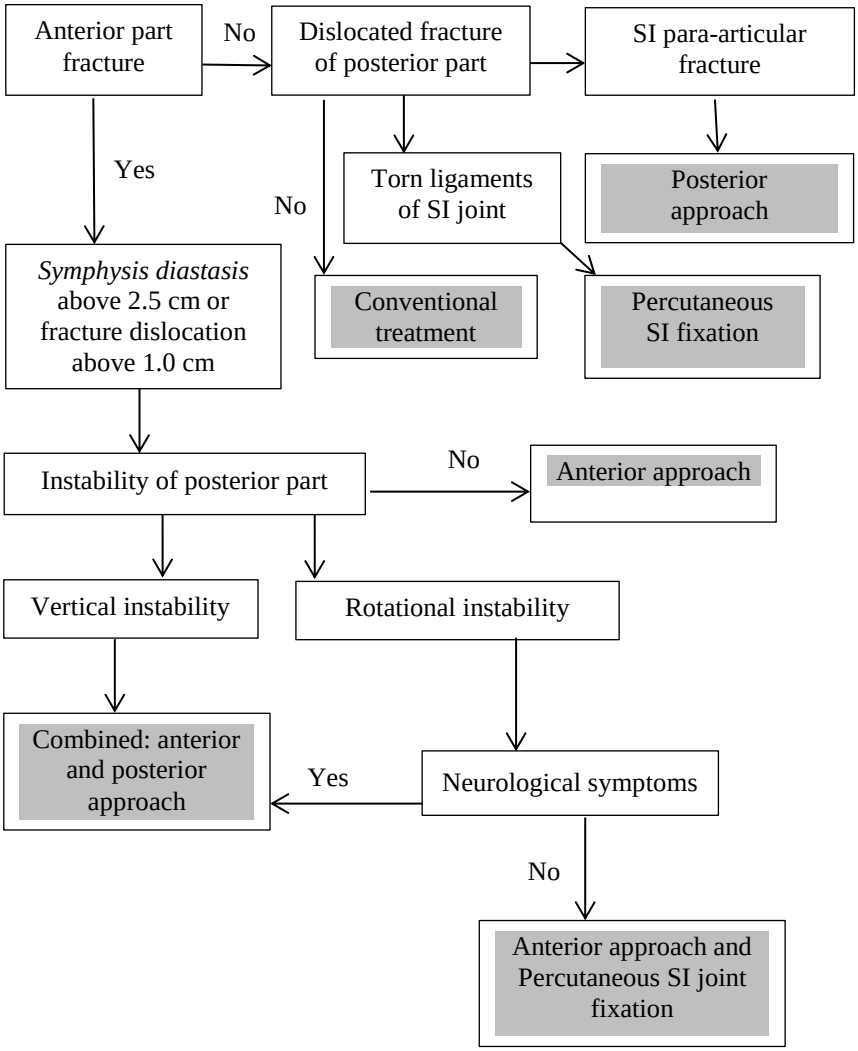
12. APPENDICES

12.1. Algorithm for selection of a surgical approach to acetabular fracture of pelvis



12.2. Algorithm for selection of a surgical approach to pelvic ring fractures:



12.3. Majeed functional scoring system questionnaire

Table 11.4.1.

Majeed functional score calculation table

Pain – maximum 30 points	**Number of points**
Intense, continuous at rest	0–5
Intense with activity	10
Tolerable, but limits activity	15
With moderate activity, abolished by rest	20
Mild, intermittent, normal activity	25
Slight, occasional or no pain	30
Work – 20 points	–
No regular work	0–4
Light work	8
Change of job	12
Same job, reduced performance	16
Same job, same performance	20
Sitting – 10 points	–
Painful	0–4
Painful if prolonged or awkward	6
Uncomfortable	8
Free	10
Sexual intercourse – 4 points	–
Painful	0–1
Painful if prolonged or awkward	2
Uncomfortable	3
Free	4
Standing – 36 points	–
A Walking aids (12)	–
Bedridden of almost	0–2
Wheelchair	4
Two crutches	6
Two sticks	8
One stick	10
No stick	12
B Gait unaided (12)	–
Cannot walk or almost	0–2

Table 11.4.1. (continued)

Pain – maximum 30 points	**Number of points**
Shuffling small steps	4
Gross limb	6
Moderate limb	8
Slight limb	10
Normal	12
C Walking distance (12)	–
Bedridden of few meters	0–2
Very limited time and distance	4
Limited with sticks, difficult without, prolonged standing	6
One hour with a stick, limited without	8
One hour without sticks, slight pain or limb	10
Normal for age and general condition	12