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# Pelvic Ring Injuries and Acetabular Fractures

*Quality of Life Following Surgical Treatment*

TOMAS BORG



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### **Abstract**

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The overall aim was to study outcome following surgery of the injured pelvis with focus on assessment from the patient's perspective. All adult patients operatively treated for pelvic ring injuries or acetabular fractures at the Department of Orthopaedics, Uppsala University, starting 2003 were prospectively included and followed with quality of life (QoL) instruments for 2 years. The most common trauma mechanism was motor vehicle accident (MVA). Study I included 54 patients with pelvic ring injuries during the three-year period 2003-2005. The two instruments, SF-36 and LiSat-11, were used. In 45 responders lower than normative QoL and life satisfaction prevailed at two years after the injury. Study II included 12 patients with pelvic ring injuries or acetabular fractures sustained following a jump from height in an attempt to commit suicide. At four years all patients were still alive and SCID-interviews performed by a psychiatrist revealed low recurrence of self-destructive behaviour and high QoL in the younger patients. Study III included 136 patients with acetabular fractures where 52 had elementary and 84 associated fracture patterns. Fracture reduction was 0-1 mm in 106 patients and 2 mm or more in 30. QoL was significantly higher in patients with anatomically reduced fractures. Physical SF-36 domains improved with time, albeit QoL was lower than norm. Study IV had the aim to construct a condition-specific outcome instrument for patients with acetabular fractures. Closed and open questions were sent to 127 consecutive acetabular fracture patients at 6, 12 and 24 months following surgery. Responses were validated through factor analysis, scree tests, item reduction and principal component analysis which resulted in a multi-item verbal descriptive scale (VDS) with six condition-specific questions related to "Pain", "Walking", "Hip motion", "Leg numbness", "Sexual life", "Operation scar" and a global question concerning impact on daily life activities for acetabular fracture assessment.

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*To*

*Maria, Jessica, Sofie*



# List of Papers

This thesis is based on the following papers, which are referred to in the text by their Roman numerals.

- I Borg, T., Berg, P., Fugl-Meyer, K., Larsson, S. (2010) Health-related quality of life and life satisfaction in patients following surgically treated pelvic ring fractures. A prospective observational study with two years follow-up. *Injury*, 41(4):400-404
- II Borg, T., Holstad, M., Larsson, S. (2010) Quality of life in patients operated for pelvic fractures caused by suicide attempt by jumping. *Scand J Surg*, 99:180-186
- III Borg, T., Berg, P., Larsson, S. (2010) Quality of life and life satisfaction following acetabular fractures. A prospective study with two years follow-up. *Submitted*
- IV Borg, T., Carlsson, M., Larsson, S. On the construction of a questionnaire for assessment of outcome following surgical treatment of acetabular fractures. *Manuscript*

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# Abbreviations

AO	AO Foundation (Arbeitsgemeinschaft für Osteosynthesefragen)
HHS	Harris hip score
HRQOL	Health related quality of life
MVA	Motor vehicle accident
ORIF	Open reduction internal fixation
OTA	Orthopaedic Trauma Association
PCA	Principal component analysis
PRO	Patient reported outcome
QoL	Quality of life
THA	Total hip arthroplasty
VDS	Verbal descriptive scale

# Introduction

In orthopaedic trauma surgery an injured pelvis is a distinctive challenge. Pelvic ring injuries and acetabular fractures, or a combination of both, resulting from high-energy trauma are often displaced to such an extent that surgery is the inevitable treatment method<sup>1-13</sup>. The most common injury mechanisms producing these fractures and disruptions are motor vehicle accidents (MVA), and associated injuries are common. Sometimes even low-energy trauma, especially in the elderly, can lead to displacement of the joint surfaces of the acetabulum in particular, requiring operative treatment<sup>14-16</sup>. This scenario is increasingly common and as a result typical fracture patterns need to be addressed. The pelvis is a central part of the skeleton consisting of the two innominate bones and the sacrum firmly joined together front and back shaping a ring-structure, where each innominate bone holds its acetabulum with the articulating cups of the hip joints. It is a massive construction that can withstand great forces, but if the energy transmitted through the pelvis exceeds the holding power a fracture or disruption of the pelvic ring or an acetabular fracture may result.

Surgical reconstruction in both fracture groups is technically demanding and patients are often referred to units specialized in treatment of these injuries<sup>12, 17-19</sup>. Pelvic ring injuries are reconstructed with the goal of achieving a realigned and stable situation allowing bone and soft-tissues to heal properly, so the patient in the future will be able to bear weight on the lower extremities without pelvic pain or limp due to shortening. Acetabular fractures on the other hand constitute a challenging joint-reconstruction problem to be solved, with the goal of recreating the concave articulating surface through precise fracture reduction and stable fixation to achieve a hip function as close as possible to preinjury level<sup>20-22</sup>.

Radiological and clinical results in both fracture groups have been described in numerous retrospective and some prospective studies<sup>17, 21, 23, 24</sup>. Contemporary studies of various medical conditions increasingly include patient-reported outcome (PRO) assessment. Numerous validated evaluation instruments for self-assessment exist, from the general quality of life perspective to the specifically health-related. One the most widely used health-related quality of life (HRQOL) instruments is SF-36<sup>25, 26</sup>. In orthopaedics not so many PRO studies had been presented following surgery of pelvic ring injuries and acetabular fractures when this project commenced.

An initiative of this work was to prospectively evaluate all patients treated surgically at my home institution for pelvic ring injuries and acetabular fractures, with special emphasis on PRO.

The majority of pelvic ring injuries and acetabular fractures with displacement or instability requiring surgery are as mentioned caused by high-energy trauma. In addition to MVA, another pelvic injury mechanism is jump from height during suicide attempt. In a study comparing survival jumpers and fallers Teh *et al.*<sup>27</sup> reported a higher proportion of pelvic injuries in jumpers when compared to fallers. Pelvic or acetabular fracture are not uncommon in survivors following suicide attempt by jumping. Several studies<sup>28-30</sup> have shown that a high proportion of patients committing suicide by jumping have mental disorders. The combination of severe somatic injury and psychiatric disorder puts extra strain on orthopedic ward staff. After acute somatic treatment patients are often transferred to psychiatric supervision and feedback to somatic colleagues regarding patient outcomes can be limited. There was a paucity of information regarding QoL in this group of patients in medical literature. Recurrence of self-destructive behaviour following serious suicide attempts had been reported to be high. One of the studies specifically addresses suicide jump survivors with an injured pelvis.

## Pelvic ring injuries

Pelvic ring fractures and disruptions requiring surgery are severe injuries often caused by high-energy trauma, and frequently associated with other injuries. There is considerable morbidity not only due to the pelvic injury itself but also due to, for instance, associated vascular, neurological and urological injuries. Common indications for surgery are instability and/or displacement, with the goal being restoration of stability within an anatomic or near anatomic position of the pelvic ring. It has been shown that an adequate reduction of posterior displacement is associated with less pain compared with pelvic fractures or disruptions with persistent malreduction of the posterior part, leading to a malunion.

Studies of various injuries and diseases that include PRO assessment have provided an inclusive understanding of the patient post-treatment. For patients surgically treated for pelvic fracture available information on patient outcome using PRO instruments is limited<sup>17, 31-35</sup>. Pelvic fractures are typically severe injuries, often occurring in younger people and commonly associated with other injuries. These injuries might consequently have long-term effect on HRQOL. The purpose of this study I was to prospectively evaluate PRO in patients surgically treated for acute pelvic fractures and disruptions, using general HRQOL instruments.

The pelvic ring consists of the sacrum, the two SI-joints, the two innominate bones on each side built from os ileum – os pubis – os ischium joined together and the symphysis pubis. The posterior iliosacral ligaments are the strongest in the body. The pelvic cavity contains a variety of soft-tissues and can be divided into the greater or false pelvis, comprised by the lower part of the abdomen, and the lesser or true pelvis inferior to the pelvic brim. In addition to providing skeletal support, the pelvic ring protects important structures in both these cavities including great vessels, nerves, gastrointestinal system and reproductive organs. Sufficient trauma energy directed directly or indirectly towards the pelvic ring will lead to fractures of bone structures and/or disruptions of the SI-joint or symphysis pubis.

### **Radiology**

Pelvic ring injuries can be evaluated with plain radiographs taken in three views. In addition to the antero-posterior view, the inlet view is taken at a 45 degree angle cephalad and the outlet view at a 45 degree angle caudal (*Figure 6*). Comprehension of these views is helpful in the use of the C-arm intraoperatively.

CT images yield additional information. 2-D reconstructions (*Figure 1*) are particularly useful in visualising fractures and disruptions of the posterior parts of the pelvis, the sacrum and the SI-joints. 3-D reconstructions (*Figure 2*) are useful in visualising the relation in space between the bony parts of the pelvis.



*Figure 1. CT 2D-reconstruction of transforaminal sacral fracture, left side*

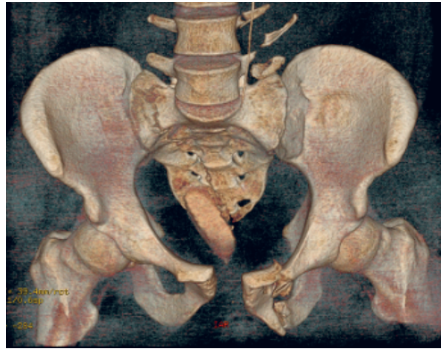


Figure 2. CT 3D reconstruction of SI-joint dislocation, symphyseolysis; and rami fractures

### Fracture classification

There are several classification systems for pelvic ring injuries<sup>36-38</sup>; from the work of Buchholz, Pennal and Tile evolved a division in three main types: A-, B- and C-type with emphasis on posterior stability. Another classification system is the Young-Burgess<sup>39</sup>, based on the injury mechanism, in which there are four main types: lateral compression, antero-posterior compression, vertical shear and combined mechanical. The most comprehensive classification system of pelvic ring injuries is the AO/OTA-classification<sup>40, 41</sup>, and is employed in the studies contained in the present work. The first classification was published in 1996 and the latest version published in 2007, a result of the cooperation between the AO-foundation in Europe and the OTA in the US.

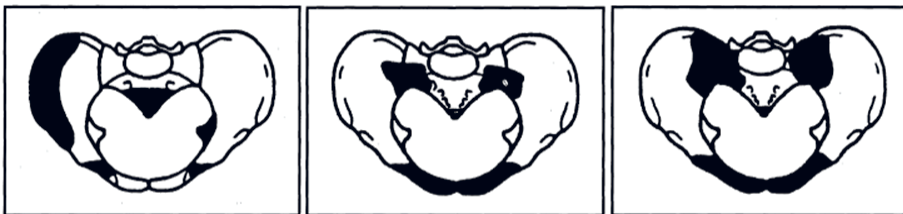
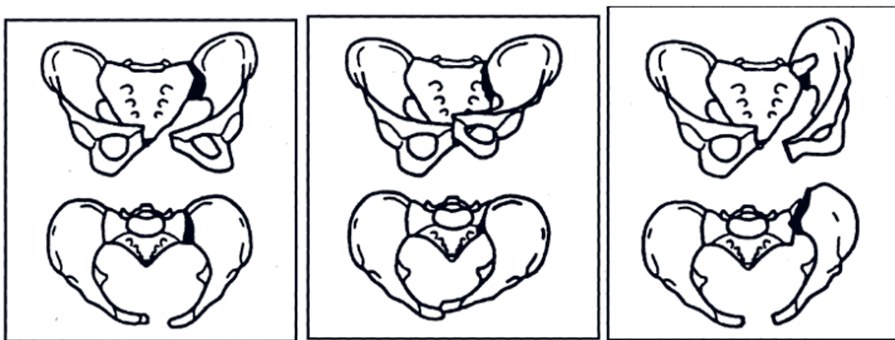


Figure 3. Pelvic ring injuries: Type A sparing the posterior arch (left), type B incomplete disruption of posterior arch (middle) and type C complete disruption of posterior arch (right). Injury sites demarcated in black. © Lippincott Williams & Wilkins

A-type fractures occur in the periphery of the pelvis (Figure 3) leaving the pelvic ring stable, so the patient is mobilised without surgical treatment. A-type fractures are not part of the studies presented here.

B-type injuries are posteriorly partially unstable, horizontally unstable but vertically stable. There are 3 different subgroups (B1-B3) and 8 sub-subgroups. B1-types (*Figure 4*) are “open book” injuries resulting from a diverging force, anteriorly resulting in a symphyseolysis and posteriorly in SI-joint anterior disruption or sacral fracture. These are commonly associated with nerve and vascular injuries, but all other types can be as well. B2-types (*Figure 4*) are “lateral compression” injuries resulting from a force from the side. Anteriorly the symphysis or rami can be compressed, while posteriorly there is usually a sacral fracture, alternatively a partial SI-joint lesion or iliac fracture. B2 injuries are the most common pelvic ring injuries. B3-types are bilateral partially stable B-injuries, either “open book” bilateral, “open” one side and “compressed” one side or “lateral compression” bilateral.



*Figure 4. Three common groups of pelvic ring injuries: B1 “open book” (left), B2 “lateral compression” (middle) and C1 unilateral posterior complete instability (right). © Lippincott Williams & Wilkins*

C-type injuries are posteriorly completely unstable injuries. There are 3 different subgroups (C1-C3) and 9 sub-subgroups. C1-types (*Figure 4*) are unilateral complete disruptions through either the ilium, the SI-joint or the sacrum. C2-types are bilateral, with one side consisting of one of the three C1-types and the other side is of B-type. C3-types are bilateral C-type injuries; either extrasacral on both sides, sacral one side and extrasacral other side, or sacral both sides.

## Surgical treatment

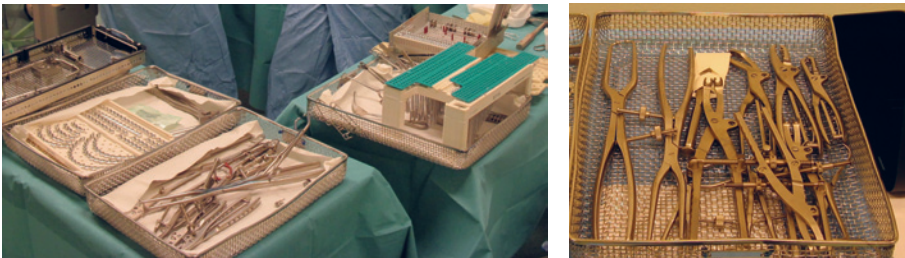
Pelvic ring injuries with displacement or instability are treated surgically. Conservative treatment in these instances has historically yielded poor results<sup>42, 43</sup>. Surgery can be performed open, percutaneously or as a combination of both. Open surgery has the benefit of better visualization for the sur-

geon. The drawbacks for the patient are risk for infection, blood loss, soft tissue damage and scar.

Percutaneous procedures are becoming more and more utilized<sup>44-46</sup>. The main benefit for the patient is limited surgical traumatization, less risk for infection and blood loss. One of the drawbacks is the more time-consuming use of the C-arm with increased radiation exposure for the patient and surgical staff. Surgical stabilization of one or both SI-joints is a common percutaneous procedure. A combined open and percutaneous approach is judicious if the injury is to be addressed at multiple locations of the pelvic ring. The open technique is used for some of the fractures or disruptions and the percutaneous technique is also used where appropriate.

### **Reduction and fixation**

Special tools are used in pelvic surgery in order to achieve reduction of fractures and disruptions. Pelvic clamps (*Figure 5*) are highly useful in sacral fractures or SI-joint dislocations that are approached openly, even if the subsequent fixation is percutaneous, and clamps are also used anteriorly for symphyseal disruptions. Careful handling of the soft tissues is paramount.



*Figure 5. Reduction tools and plates used for surgery of the injured pelvis*

Secure fixation can be achieved with screws alone, or accompanied by plates. Posteriorly one frequent procedure at my institution is the use of two 7.0 cannulated screws from the ilium anchored into the S1-body. In the case of sacral dysmorphism there might only be room for one S1-screw, which has to be placed under meticulous fluoroscopic guidance and with thorough understanding of the anatomy. The risk of nerve injury is otherwise high, especially to the L5 nerve root riding on the slanting sacrum where it can be hit by a screw. This mistake is easy to make, since the position of the screw may look deceptively correct in the S1-body, but the passage of fluoroscopic landmarks has to be made with careful precision with respect to the individual patient's anatomical characteristics.

There are numerous retrospective studies describing the outcome following surgical treatment of pelvic ring injuries, conversely prospective studies are few<sup>17</sup>.

## Acetabular fractures

Surgical intervention with open reduction and internal fixation (ORIF) is the treatment of choice for displaced acetabular fractures. Conservative treatment leads to an unacceptably high frequency of secondary arthritis. The clinical and radiological outcome have been described by a number of authors following the classic papers of Letournel and Judet<sup>3, 4, 13</sup>. Associated fracture type, damage to the femoral head, associated injuries, age, inadequate fracture reduction and development of heterotopic ossification are important prognostic factors that correlate with a less favourable clinical outcome. Few publications have described outcome following acetabular fractures using QoL instruments. For other orthopaedic diseases and conditions, studies describing outcome from the patient's view have added new insight that have improved the parts of the treatment algorithms that add real value to the patient and contributed to a better global understanding of the diagnosis. A study assessed 15 consecutive surgically treated acetabular fracture patients with MFA, gait analysis and muscle strength measurement on average 24 months following surgery<sup>47</sup>. Functional outcome as determined by MFA scores was considerably poorer compared with norms. Another retrospective study of patients 60 years of age or older surgically treated for displaced acetabular fracture showed that SF-36 scores were within one standard deviation of the mean for an age-matched reference group<sup>14</sup>.

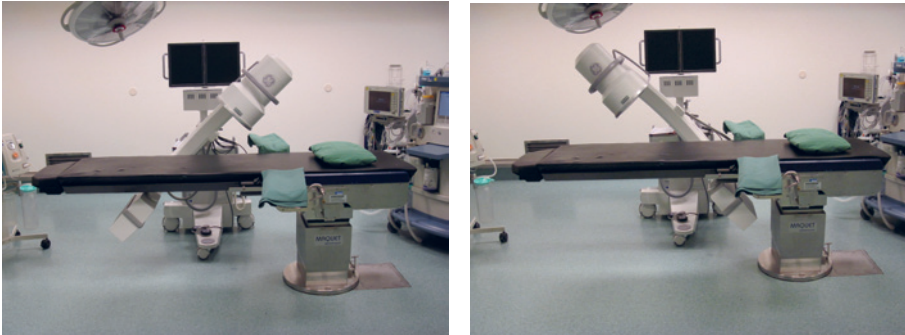
The acetabulum is the part of the pelvis holding the cartilage of the hip joints in sockets articulating with the femoral head. Its construction is composed of two columns, the posterior and the anterior column. These two columns have been described as forming an upside-down letter Y when viewed from the side. Trauma to the acetabulum is indirect, induced by forces transferred from the femur via the femoral head into the hip joint. Depending on the position of the hip joint in flexion-extension and abduction-adduction at the time of injury, various typical fracture patterns occur<sup>3</sup>.

There is very little tolerance for deviation in this spherical joint compared to other more resistant joints in the body, and untreated displaced injuries have a high risk of arthrosis. Surgery is recommended if trauma leads to an acetabular joint step or gap  $> 2$  mm.

Hip dislocation is frequently associated with acetabular fractures. Complicating factors are nerve injuries, femoral head damage, impaction of joint surfaces as well as intraarticular joint fragments requiring removal. Avascular necrosis of the femoral head can be seen as early as well as a late complication.

## Radiology

Acetabular fractures can be evaluated with plain radiographs taken in the three views attributed to Judet. In addition to the antero-posterior view, the iliac oblique view is taken with a 45-degree tilt of the uninjured side up and the obturator oblique view with a 45-degree tilt of the injured side up - intraoperatively the C-arm is turned instead. Distinct landmarks are analysed on the plain radiographs: the iliopubic line, ilioischial line, posterior wall, anterior wall, roof and tear drop. Knowledge of these landmarks is vital when interpreting images intraoperatively, as the C-arm is turned (*Figure 7*).

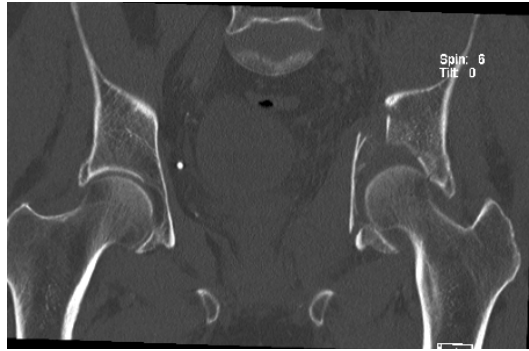


*Figure 6. Inlet (left) and outlet (right) views - imaging facilitated via maximum sliding of a completely radiolucent carbon table.*

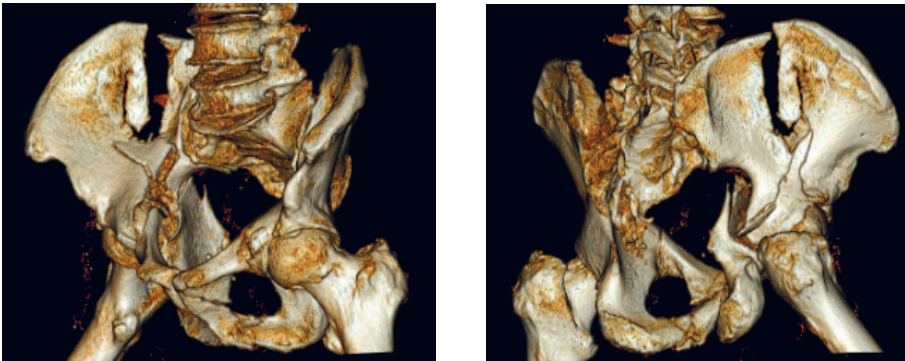


*Figure 7. Oblique views, obturator and iliac, depending on affected side - by tilting the table extra obliquity can be achieved despite C-arm limitations.*

CT images yield invaluable additional information. 2-D reconstructions (*Figure 8*) can expose intra-articular fragments needing removal, femoral head damage and acetabular impaction not seen on plain radiographs. 3-D reconstructions (*Figure 9*) visualize the relation in space between fracture fragments and the two columns of the acetabulum.



*Figure 8. CT 2D-reconstruction of associated anterior – posterior hemitransverse acetabular fracture; central dislocation of the hip and acetabular impaction.*



*Figure 9. CT 3-D reconstruction of associated both column acetabular fracture*

## Fracture classification

The classification system of acetabular fractures most widely used internationally is the Letournel system, originated in the work by Judet and Judet. The AO/OTA classification of acetabular fractures is based on the Letournel system.

The Letournel classification system consists of ten fracture types divided in two groups, elementary and associated fractures, five in each group. One of the reasons for using this classification system is to help out in choosing the surgical approach that will provide best access to the technically most demanding parts of a complex fracture.

## Elementary fractures

There are five kinds of elementary fracture types: two involve the posterior structures, either column or wall; two involve the anterior structures, column or wall; and one involves both columns – namely the transverse fracture.

Posterior wall fracture (*Figure 10*) is the most common fracture type, often associated with hip dislocation. It is also notorious for poor outcome, although whether this is related to the injury only or the fact that they sometimes are operated on centres with few fractures per surgeon per year is debated. Acetabular impaction, femoral head damage and intra-articular fragment needing removal are often-encountered complicating factors.

Posterior column fracture is an unusual fracture type more common in younger patients. Anterior wall fracture is a very unusual fracture type. Anterior column fracture (*Figure 10*) is on the other hand a quite common fracture type. The anterior column is extensive, and this fracture type can easily be misclassified. Transverse fracture (*Figure 10*) is a not uncommon fracture type. It is the only elementary fracture type involving both columns. Due to their pure fracture-configuration Letournel chose to put transverse fractures in the elementary group, but this does not mean that they are easy to treat, however. They are subdivided into infratectal, juxtatectal and transtectal transverse fractures, the latter in particular demanding a meticulous reduction effort in order to successfully avoid leaving the patient with an intra-articular step or gap in the primary weight bearing area, leading to detrimental early wear and rapid loss of hip function.

## Associated fracture patterns

There are five kinds of associated fracture patterns. Associated posterior wall – posterior column fractures (*Figure 11*) and associated posterior wall – transverse fractures are not uncommon fracture patterns. Associated anterior – posterior hemitransverse fractures (*Figure 11*) are common, increasing with patients age. T-shaped fracture is an unusual fracture pattern.

Associated both column fracture (*Figure 11*) is a very common fracture pattern. It is easy to misclassify other fracture types into this category. Both columns can be affected but still not in the way “true” associated both column fractures are. There are in fact five fracture types involving both the anterior and the posterior column, one elementary and four associated. Transverse fracture, associated transverse – posterior wall, T-shaped, associated anterior – posterior hemitransverse and associated both column fracture all involve both columns. To be classified as a true both column fracture no articular cartilage remains attached to the innominate bone. This is the only fracture type that can have secondary congruence, where the articular surface is congruent but the whole joint complex is displaced, typically medially.

Numerous publications use this classification system. In a metaanalysis of acetabular fractures by Giannoudis and co-workers (2005)<sup>48</sup> one of the inclusion criteria was that the study used the Letournel classification.



Figure 10. Three common elementary acetabular fracture types: posterior wall (left), anterior column (middle) and transverse fracture (right). © Lippincott Williams & Wilkins



Figure 11. Three common associated acetabular fracture patterns: posterior column – posterior wall (left), anterior – posterior hemitransverse (middle) and both column fracture (right). © Lippincott Williams & Wilkins

## Surgical treatment

Acetabular fractures with displacement are treated surgically. Conservative treatment in these instances has historically yielded poor results<sup>49</sup>.

Surgery is in the vast majority of cases performed through the use of one of two approaches: Kocher-Langenbeck posteriorly, or the ilioinguinal approach anteriorly. The choice of approach depends on the fracture configura-

tion. The use of a single, the most suitable, approach for the individual case is normally preferred even if it makes some part of the fracture reduction procedure difficult and indirect, in order to minimize extensive soft tissue impact on the patient. There are extensive approaches described such as the extended iliofemoral and the triradiate but they have been associated with risk of morbidity<sup>50, 51</sup> and were practically not used in the studies in the present work. Trochanteric flip is another possible approach<sup>52</sup>; however in my institution one preferred extension is a trochanter osteotomy added to the Kocher-Langenbeck approach when necessary.

The Kocher-Langenbeck approach (*Figure 12*) is used to obtain access to posterior structures directly, while anterior structures are addressed indirectly. The ilioinguinal approach (*Figure 13*) is used to obtain access to anterior structures directly, and posterior structures are addressed indirectly.



*Figure 12. Patient in lateral position for Kocher-Langenbeck approach*



*Figure 13. Ilioinguinal approach, the patient supine with free-draped leg on triangular support, reduction clamps in first and second window, cannulated screw fixation from lateral.,*

## Reduction and fixation

Several special tools are routinely used in acetabular fracture surgery in order to achieve fracture reduction. In addition to the standard set of pelvic clamps, the collinear retractor can be useful and an asymmetric large pelvic clamp is also handy. Traction can be accomplished with a Schantz pin and T-handle in the proximal femur (*Figure 14*). The careful handling of the soft tissues cannot be overemphasized. Reduction tools can put stress on the sciatic nerve in the Kocher-Langenbeck approach, and on the femoral and obturator nerve in the ilioinguinal approach. Blood vessels can also be overstretched by reduction devices, that can lead to rupture, especially in the elderly in case of arteriosclerosis.



*Figure 14. A percutaneous Schantz pin with T-handle in the lateral proximal femur enables traction on medially displaced femoral head*

The preferred method of fixation at my institution is by the use of the Matta plating system. In this system, there are two sets of pre-contoured curved plates for the anterior column with radius to fit men and women respectively. There are also straight plates of two kinds, pelvic plates and acetabular plates that are less rigid for use mainly in the fixation of posterior wall and posterior column.

Secondary arthritis can develop after injury to the acetabulum. The reported frequency of THA is between 5 and 20 percent following surgery<sup>48</sup>. In the standard protocol for the present work, patients even with severe risk factors for secondary arthritis were surgically treated with internal fixation, primarily in order to achieve a bony healing of the fractured acetabulum, after which the secondary procedure with THA could be performed at the

referring hospital in a timely manner. An increase in the number of elderly patients with displaced acetabular fractures will lead to a corresponding increase in the number of primary THA.

There are numerous retrospective studies describing the outcome following surgical treatment of acetabular fractures, and a few prospective studies <sup>1, 23, 51</sup>. In the studies by Matta he showed that anatomical reduction gave better functional results. Whether there is a correlation or not between anatomical reduction and QoL outcome was not well established when the studies in this work were designed.

# Quality of life

Patient reported outcome has been shown to be important in the evaluation of medical treatments. Assessment is often conducted with general instruments and, if available, combined with condition-specific instruments. Various generic instruments exist to evaluate patients from a health related quality of life (HRQOL)<sup>25, 53</sup> perspective and other instruments can be used to evaluate life satisfaction<sup>54</sup>.

## **Generic instruments**

Generic instruments are not specific to a certain disease or injury. We chose to use SF-36 as HRQOL instrument and LiSat-11 for evaluation of life satisfaction.

### *SF-36 Health related quality of life assessment*

Outcome following fracture surgery has been successfully assessed using HRQOL-instruments, one of the most frequently used being SF-36<sup>25, 55</sup>. This instrument was developed by Ware *et al.* as part of the Medical Outcomes Study. It consists of 36 questions (Table 1), responded to by the use of a VDS, 35 of them used to calculate scores summed into eight domains. Only question 2, which addresses health transition in time where patients compare their present health status compared to one year earlier, is not used in the calculation of the eight domain scores. Transformation of responses into these domain scores (from 0 to 100 for respective domain) permits quantitative interpretation, where higher scores are associated with better QoL and state of health.

SF-36 ([www.sf-36.org](http://www.sf-36.org)) has been used in various medical conditions spanning the entire field of medicine. The instrument has been translated into Swedish and validated, with a corresponding Swedish normative population for comparison<sup>56</sup>. SF-36 has been used to assess QoL in a number of different orthopaedic conditions, including joint replacement surgery and spine surgery. In pelvic ring injuries and acetabular fractures it had been used in relatively few studies when this work was commenced.

The SF-36 VDS, in the original version for which Swedish norm values could be retrieved ([www.hrql.se](http://www.hrql.se)), has answering alternatives ranging from 2 (Role Physical and Role Emotional) to 6 (Bodily Pain, Vitality and Mental Health).

Table 1. *Thirty-six questions in order of appearance in SF-36*

	Item	Counts in domain	Short
1	EVGFP rating	General health	GH
2	Health transition	Not counted	
3a	Vigorous activities	Physical function	PF
3b	Moderate activities	Physical function	PF
3c	Lift, carry groceries	Physical function	PF
3d	Climb several flights	Physical function	PF
3e	Climb one flight	Physical function	PF
3f	Bend, kneel	Physical function	PF
3g	Walk mile	Physical function	PF
3h	Walk several blocks	Physical function	PF
3i	Walk one block	Physical function	PF
3j	Bathe, dress	Physical function	PF
4a	Cut down time	Role physical	RP
4b	Accomplished less	Role physical	RP
4c	Limited in kind	Role physical	RP
4d	Had difficulty	Role physical	RP
5a	Cut down time	Role emotional	RE
5b	Accomplished less	Role emotional	RE
5c	Not careful	Role emotional	RE
6	Social – extent	Social function	SF
7	Pain – magnitude	Bodily pain	BP
8	Pain – interfere	Bodily pain	BP
9a	Pep/life	Vitality	VT
9b	Nervous	Mental health	MH
9c	Down in dumps	Mental health	MH
9d	Peaceful	Mental health	MH
9e	Energy	Vitality	VT
9f	Blue/sad	Mental health	MH
9g	Worn out	Vitality	VT
9h	Happy	Mental health	MH
9i	Tired	Vitality	VT
10	Social – time	Social function	SF
11a	Sick easier	General health	GH
11b	As healthy	General health	GH
11c	Health to get worse	General health	GH
11d	Health excellent	General health	GH

In the version we used PF has 10 questions with 3 alternatives; RP has 4 questions with 2 alternatives; BP has 2 questions with 6 and 5 alternatives respectively; GH has 5 questions with 5 alternatives; VT has 4 questions with 6 alternatives; SF has 2 questions with 6 alternatives; RE has 3 questions with 2 alternatives; and MH has 5 questions with 6 alternatives. The results are transformed into scales with the following number of levels from 0-100: PF 21 levels, RP 5 levels, BP 11 levels, GH 21 levels, VT 21 levels, SF 9 levels, RE 4 levels and MH 26 levels. Additional in-between levels can be assigned to some of the scales, for example if the patient leaves blanks.

Scale scores cannot be calculated if the respondent leaves too many unanswered questions in the respective domains. In SF-36v2<sup>TM</sup> (version 2) RP and RE have 5-level response choices in place of dichotomous to discriminate better; VT and MH have 5-level in place of 6-level response categories. This version, as previously mentioned, did not have available norm values for the Swedish population to compare with when the studies in this work started.

The distribution of norm values is skewed and ceiling effects can occur; standard deviations are large (Figure 21). Physical Function and Mental Health are regarded as the two most robust domains of the eight <sup>26</sup>. PF has been shown to discriminate physical function well, and MH is fruitful for assessing mental aspects; a value of <52 is regarded as indicative of depression. Two summary scores have been proposed, where all the domain scores are weighed and put into specific calculation algorithms, the physical component summary (PCS) and the mental component summary (MCS). They both have some drawbacks, however. For example, when a strictly physical parameter such as PF increases in a patient's response, the PCS will increase but the MCS will decrease even if there are no other changes. This patient's MCS is lowered without mental parameters having changed. The reciprocal situation exists: if a patient's response in a strictly mental parameter such as MH increases and no other changes occur, i.e. physical parameters are unchanged, the MCS will increase but the PCS will decrease. It has been described as a seesaw effect <sup>57</sup> and the summary scores have not been used in our studies.

#### *LiSat-11 Life satisfaction assessment*

Another important aspect of QoL is life satisfaction <sup>54</sup>. Many different aspects of the patient's life can be affected by injury apart from the strictly health related.

The LiSat-11 instrument was constructed by Fugl-Meyer and colleagues (1991)<sup>58</sup>. It is a one-page, generic 11-item questionnaire addressing life satisfaction, in which each item has six-graded response alternatives in a VDS (Table 2). The instrument has been validated in a representative sample of Swedish men and women aged 18–74 years. It has adequate test–retest reliability, discriminate and specificity validities. The scale can safely be dichotomised into “not satisfied” (answer alternatives 1-4) and “satisfied” (answer alternatives 5-6) even though the distribution of norm values is skewed. The instrument has been used in the assessment of trauma patients in a retrospective study by Anke *et al.* (2003)<sup>59</sup> in a rehabilitation hospital, and in a prospective follow-up study by Snekkevik *et al.* (2003)<sup>60</sup>, among others.

Table 2. *Eleven questions in order of appearance in LiSat-11.*

Item	Very dissatisfied	Dissatisfied	Rather dissatisfied	Rather satisfied	Satisfied	Very satisfied
Life as a whole	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Work	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Financial situation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Spare time	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Friends/acquaintances	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sexual life	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ADL	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Family	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Partner	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Physical	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Psychological	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

The originators of the instrument have established that being satisfied indicates an individual well adapted with little or no gap between aspirations and goal achievement. Conversely, being not satisfied means that the individual experiences an aspiration–achievement gap.

### **Condition-specific instruments**

The variation in important symptoms in different medical conditions has led to the development of numerous condition-specific outcome instruments to assess functional status. In orthopaedic surgery some of the most common are used for shoulder, knee or hip assessment. Some are physician-rated, others are self-assessment tools.

#### *Pelvic ring injuries*

The Majeed score<sup>24, 61</sup> was developed in Kuwait, and results are presented for 42 patients all treated by external fixation during a 6-year period. Sequential assessments were made for 22 of these patients up to 2 years postinjury.. The Iowa Pelvic Score<sup>32, 33</sup> evaluates activities of daily living, work history, pain, limp, visual pain line and cosmesis. In the retrospective studies by Miranda and Nepola patients were treated with external fixation or nonoperatively. The German pelvic study group<sup>34</sup> has developed a scoring system as a summary of radiological result, clinical result and social reintegration.

#### *Acetabular fractures*

For acetabular fracture patients there was no validated condition-specific assessment tool. Functional status is commonly evaluated using three hip instruments: the original Merle d'Aubigné-Postel<sup>62</sup>, the modified Merle d'Aubigné-Postel<sup>23</sup> and the Harris Hip Score (HHS)<sup>63</sup>.

The original Merle d'Aubigné-Postel score (1954) was established for use in hip arthroplasty treatment with acrylic prostheses. It assesses pain, walk-

ing, hip motion and deformity where the first three items are rated from 0 to 6. In the calculation of change for a patient a painless hip and the ability to walk is regarded as more important than mobility and these two items are weighted by a factor of 2. The instrument has not been validated.

The HHS (1969) was developed from the results of 38 patients treated between 1945 and 1965 with mold arthroplasty due to traumatic arthritis of the hip secondary to acetabular fracture or hip dislocation. There are four areas with maximum possible scores concerning pain (44), function (47), range of motion (5) and absence of deformity (4) for a maximum sum of 100 points. This instrument has not been validated either, and has been shown to have marked ceiling effects<sup>64</sup>.

The modified Merle d'Aubigné-Postel score was proposed by Matta in 1986<sup>23</sup>. It is based on 102 patients with a total of 105 fractures, where 88 fractures were treated with ORIF and 17 by skeletal traction. Forty-nine patients with a total of 50 fractures were available for one- or two-year follow-up examination. The assessment includes the three items pain, walking and hip motion with an alteration of calculating scores compared with the original Merle d'Aubigné-Postel score. Each item is rated from 1 to 6 and added into a total score without weighting, yielding a score ranging from 3 to 18.

Ceiling effects in the hip scores had been described when the work in this thesis was begun. The aim was therefore the development of an instrument for evaluation of specific outcome following surgical treatment of acetabular fractures with internal fixation.

# Aims

- Evaluate quality of life in patients with pelvic ring injuries following surgical treatment
- Evaluate quality of life, survival and recurrence of self-destructive behaviour in patients with pelvic ring injuries and acetabular fractures sustained from attempted suicide by jumping
- Evaluate quality of life in patients with acetabular fractures following surgical treatment
- Develop a condition-specific outcome evaluation instrument for patients with acetabular fractures

# Patients and methods

## Study populations

The studies in this thesis are based upon a population of patients surgically treated for pelvic ring injuries and acetabular fractures between 2003 and 2008 at the Department of Orthopaedics, Uppsala University Hospital, Sweden.

In all four studies patients aged 16 years and older were prospectively included following surgical treatment. Paper I included 54 patients with pelvic ring injuries operated between 2003 and 2005 and were followed for 2 years post-surgery. Paper II included 12 patients with pelvic ring injuries or acetabular fractures sustained from suicide attempt by jumping from height during 2003 and 2004. Patients were followed for 4 years post-surgery. Paper III included 136 patients with acetabular fractures surgically treated between 2004-2008 and followed for 2 years post-surgery. Paper IV is based on the chronologically initial 127 acetabular fracture patients in Paper III. (Figure 15).

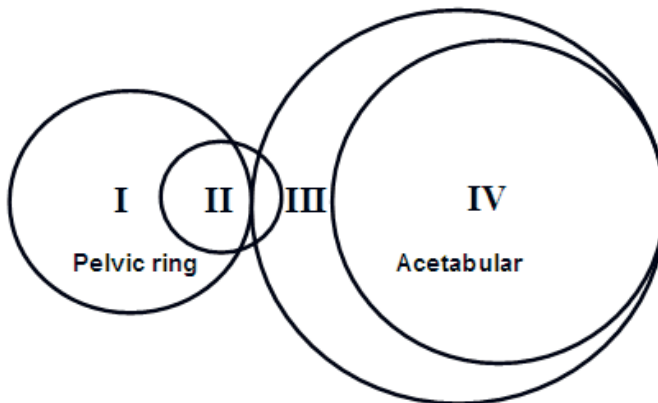


Figure 15. Study I pelvic ring injuries, study II suicide jump survivors, study III and IV acetabular fractures.

In total thirty hospitals referred patients after providing initial care. Inclusion criteria were displacement of the pelvic ring or the acetabulum with surgical indication of internal fixation. Initial radiographs and trauma CT scans were complemented with CT pelvis followed by image reconstruction.

Surgery was performed 1–21 (median 6) days after the trauma. Anti-thrombotic treatment was given from the day of injury until the patient was sufficiently mobilised, while systemic antibiotics were given perioperatively for 24 hours. Radiographs were taken on day 1 post-surgery and patients were returned to referring hospitals when in a stable transferrable condition, normally day 1 or 2 post-surgery. They were followed with QoL questionnaires and radiographs were taken at local hospital at 2 years post-surgery. Age- and gender-matched SF-36 normative values were retrieved for respective fracture groups. The LiSat-11 reference sample was selected from 1898 individuals (1014 men, 884 women) ages 18–74 that had perceived their health as good, with no history of long-lasting (more than one month) disease/disability restricting their life situation and had not been medically/surgically treated during the preceding 12 months.

#### *Follow-up questionnaires, radiographs and medical records*

In order to achieve a high response rate, certain measures common for all studies were taken.

The current address of patients was verified in the online national database immediately preceding questionnaire distribution by post, and the address was rechecked at subsequent mail-outs. An accompanying explanatory letter was attached, appealing to patients to answer in a relaxed home environment, with specific instructions clarifying that: a) the questions were part of fixed instruments and could not be altered, b) that they try to answer all questions, with one mark for each, and c) provision of a telephone number to a specific nurse at OPD for queries concerning the questionnaires. If no response was received, a single additional reminder with a new questionnaire was mailed out.

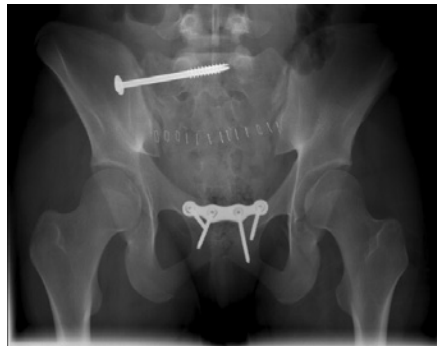
In order to obtain x-rays, requests were sent to the heads of the orthopaedic departments corresponding to patient address. Precise descriptions for inlet-outlet or Judet-views were provided. Receipt of digital images was monitored, and if receipt was not confirmed the x-ray departments at the respective hospitals were contacted and if necessary the heads of the orthopaedic departments were approached again.

Orthopaedic medical records were also sent from the referring hospitals. A dedicated part-time research secretary was employed to handle administrative tasks for the studies.

## Paper I

All 54 patients (28 male, 26 female) with a mean age of 34 (range 16–68 years) surgically treated for pelvic ring injuries with internal fixation between the years 2003 and 2005 were prospectively included. Indications for surgery included instability and/or displacement exceeding 5 mm. The most

common trauma mechanism was MVA in 21 patients (39 %). Additional injuries were seen in 40 (74 %) of the patients, most commonly a lower extremity fracture. Seventeen patients (31 %) had polytrauma corresponding to an ISS  $\geq$  16. The surgical approach was open in 20, percutaneous in 14 and combined in 20 patients. One re-operation was performed due to inadequate reduction. Post-operative radiographs included AP pelvis and inlet–outlet views (*Figure 16*).



*Figure 16. Pelvic ring injury type B: postop AP view (top), inlet view (left) and outlet view (right).*

Fractures were classified according to AO/OTA (*Figure 17*). The most common fracture types were B2 and C1. Post-operative fracture reduction was measured according to the German pelvic study group<sup>65</sup>. Posterior components were anatomic or within 5 mm residual displacement in 46 patients and  $>5$  mm in 8 patients. Reduction of the symphysis was  $<5$  mm in 23 patients, 6–10 mm in 6 patients and  $>10$  mm in 2 patients. Rami fractures residual displacement was  $<10$  mm in 27 and  $>10$  mm in 11 patients. Patients were followed with SF-36 and LiSat-11 at two years post-surgery.



*Figure 17. Pelvic ring injury type C postop*

## Paper II

Twelve patients (11 female/1 male, aged 17–51 years) surviving suicide attempt by jumping from height and sustaining pelvic ring injuries or acetabular fractures requiring surgical treatment 2003-2004 were prospectively included. There were 10 pelvic and 2 acetabular fractures. Jump height, fracture type and associated injuries are described in Table 3. ISS was  $> 16$  in 5 patients. In-house acute psychiatric consultation was completed in tandem with surgical treatment and further psychiatric treatment was conducted at the referring hospital. Patients were followed with SF-36 and LiSat-11 at two years post-surgery.

At four years post-surgery a psychiatrist cooperating with our unit examined the patients medical records for information regarding earlier suicide attempts, substance abuse and history of mental illness. Patients were approached respectfully and semi-structured SCID-I clinical version telephone interviews, used to diagnose depression and personality disorders, were performed. The structured forms composed of 24 pre-printed variables were filled out. Psychiatric consultation or medication after the trauma was documented, as well as sick leave. Treating psychiatrists were contacted. Seven patients were interviewed out of which one could not provide reliable answers. Additionally five patients could not be interviewed, of which two were too mentally unstable and three could not be contacted.

Table 3. *Twelve patients surviving suicide attempt by jumping*

Age	Sex	Jump	Injury	Associated injuries
17	F	Bridge 11 m	SI right, sacrum left	Pnths, lung, liver
17	F	Bridge 10 m	SI-bilat, ilium left	Pnths, orbit, extremities
18	M	Building 20 m	Sacrum bilat	Spine, paraplegia, extremities
19	F	Building 10 m	Anterior column	None
19	F	Building 12 m	Sacrum	Calcaneus
28	F	Building 7 m	Sacrum	Femur, tibia
29	F	Building 10 m	Assoc transv post wall	Brain, pnths, heart, liver, burn
29	F	Building unknown	Sacrum bilat	Ribs, extremities
43	F	Building 7 m	Sacrum, rami	None
46	F	Building 10 m	Sacrum, rami	Spine, sternum, estremities
47	F	Building 12 m	Sacrum bilat, symphysis	Spine, paresis, spleen, elbow
51	F	Building 10 m	SI fracture-dislocation	Extremities

### Paper III

All 136 patients (108 men, 28 women) with surgically treated acetabular fractures between September 2004 and August 2008 were prospectively included. SF-36 and LiSat-11 questionnaires were sent at 6, 12 and 24 months after surgery. Patients were operated 1-17 (median 6) days after the trauma. Indication for surgery was intra-articular fracture displacement >2 mm. Patient mean age was 49 years (range 17-83), and the two most common trauma mechanisms were MVA and fall from height. and the two most common trauma mechanisms were MVA and fall from height. Additional injuries were seen in 54 patients, most commonly a lower extremity fracture. Thirty-one patients had ISS >16. Radiographs and trauma CT scans were supplemented with CT pelvis and standard reconstructions.

Fractures were classified according to Letournel. Postoperative radiographs included AP pelvis, obturator oblique and iliac oblique views (*Figure 18*). Radiographic assessment was conducted according to Matta, with fracture reduction described as 0-1 mm, 2-3 mm or > 3mm and final radiological outcome graded in the four steps excellent, good, fair or poor. Complex fracture patterns were more frequent (52 elementary/84 associated), and the three most common types were posterior wall, associated anterior-posterior hemitransverse and associated both column fractures. Femoral head damage was present in 17 patients, acetabular impaction in 9, posterior hip dislocation in 26 and sciatic nerve injury in 14 (12 spontaneously recovered/2 persistent L5 palsy).



*Figure 18. Associated both column acetabular fracture postop. AP view (top), obturator oblique, (left) and iliac oblique (right).*

Surgical approach was Kocher-Langenbeck in 51 patients, ilioinguinal in 82, a combination of both in 1, the extended iliofemoral in 1 and Smith-Petersen in 1. Post-operative complications included 3 deep vein thromboses, 3 non-lethal pulmonary emboli, 11 superficial infections and 5 deep infections.

In particularly the anterior – posterior hemitransverse fracture patterns multiple measures to address the medialisation of the femoral head and displaced quadrilateral plate were taken. In order to achieve long-standing retention of reduction, for example cannulated screws from the lateral side augmented with nuts medially, instick-plate into the true pelvis to buttress the quadrilateral plate, instick-plate combined with a cannulated screw and nut (*Figure 19*).



*Figure 19. Contoured T-plate in “the first window”; augmented with percutaneous cannulated screw through plate hole and nut in the true pelvis; to secure quadrilateral surface in associated anterior – posterior hemitransverse acetabular fracture*

## Paper IV

One hundred twenty-seven acetabular fracture patients (27 women/100 men) with a mean age of 50 (SD= 17), surgically treated between September 2004 and June 2008 were included in the analysis. They reported outcomes at three postoperative time points: 6 months, 1 year and 2 years.

An expert group initially defined topics that were considered relevant, based on clinical experience, for assessing patients following acetabular fractures. Eleven closed questions were constructed, and a six-graded VDS with alternatives ranging from “No discomfort” to “Very severe discomfort” was chosen. Three open questions were also presented for additional patient input (Table 4). Principal component analyses (PCA) with varimax rotation was employed to estimate content validity, with scree tests to determine the number of factors involved. Bartlett’s test of sphericity and Kaiser-Meyer-Olkin’s (KMO) measure of sampling sufficiency were employed to assess factorability of the correlation matrix. Factor loadings greater than 0.50 were considered acceptable. The reliability in terms of internal consistency was expressed as Cronbach’s alpha coefficients. The responses to the open questions were thoroughly analysed and categorised. SF-36 was used for comparison.

Table 4. *Initial questionnaire*

Discomfort	None	Very little	Little	Moderate	Severe	Very severe
Pain	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Walking	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Hip motion	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Leg sensation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Leg weakness	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sitting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sexual life	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Operation scars	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Sleeping	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Voiding urine	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Voiding bowels	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other discomforts:	No	Yes		Describe	.....	.....
Things can no longer do:	No	Yes		Describe	.....	.....
Major sources of discomfort:				Describe.	.....	.....

*Statistics*

For variables with normal distribution a parametric test was used, the student's t-test. Nonparametric methods were used when assumptions for parametric methods were not met. A p-value <0.05 was considered representing a statistically significant difference.

# Results

## Paper I

Of the 54 fractures all except one remained in position at 2 years post-surgery and implants also remained in position except in one patient where one of two SI-screws backed out.

Forty-five patients responded to the questionnaire at 2 years post-surgery. Fracture patients scored significantly lower than the reference population in all eight domains of SF-36, with highest scores in Social Function and lowest scores in Role Physical. Scores in General Health were closest to the reference population and there were significant differences between B-type and C-type fractures in this domain only, with B-types scoring higher.

LiSat-11 scores were lower than the reference population in all 11 items, with the highest proportion of satisfaction reported with “family life” and the lowest with “physical health”. Satisfaction with “financial situation” was closest to the reference population, and the global item “life as a whole” showed comparable configuration to the reference population but somewhat shifted towards lower values (*Figure 20*). Satisfaction with “life as a whole” correlated to all other 10 items, and also correlated to 7 out of 8 SF-36 domains, all except Role Physical. We found no difference in LiSat-11 outcome between patients with fracture type B or C, nor any differences in QoL outcome related to the presence of associated injuries or achieved posterior fracture reduction.

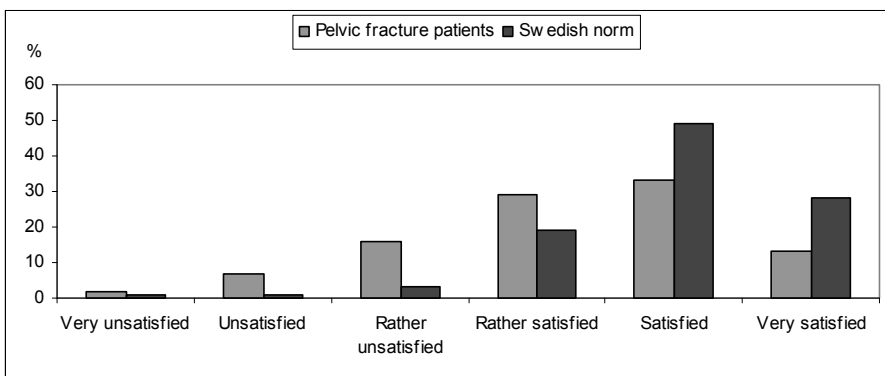


Figure 20. Life satisfaction at 2 years post-surgery

## Paper II

At two years post-surgery 8 out of 12 patients responded to QoL questionnaires; 4 could not due to their psychiatric condition. Patients scored lower than the reference population in all SF-36 domains with the most pronounced differences in Physical Function, Role Physical and Vitality. The 5 patients at or below age 29 scored higher than the 3 patients at the age of 46 or above. LiSat-11 scores showed that in ten items, all except “friends and acquaintances”, there were more satisfied patients than unsatisfied. The younger patients were more satisfied with “life as a whole”.

At four years post-surgery all 12 patients were still alive. Seven patients gave informed consent to be interviewed but one could not give reliable answers. Three patients had a history of previous suicide attempts and 2 had other self-destructive behaviour. Six of the patients had a diagnosed psychosis, 4 patients suffered from affective disorders, 5 patients were substance abusers, 2 patients had a personality disorder and 1 patient had posttraumatic stress disorder. For one patient the medical records were insufficient for a diagnosis.

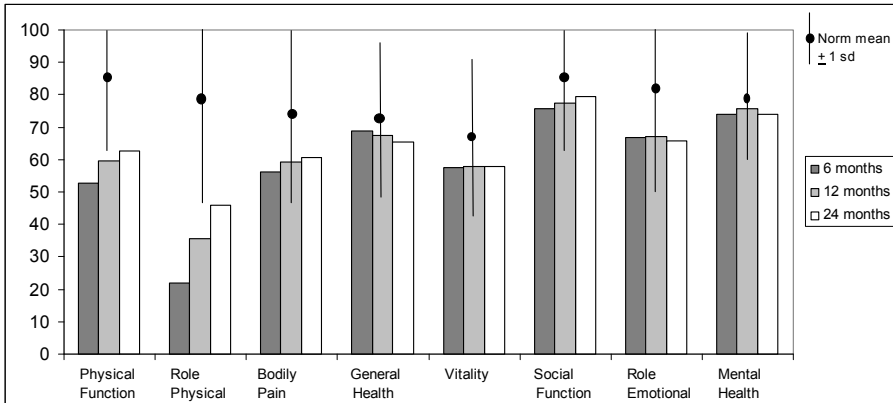
Psychiatric evaluation and SCID-interviews revealed that in all patients except one the suicide attempt was very serious. All 12 patients were known by psychiatric and/or primary health care providers before they jumped. Six patients had ongoing treatment with medication for a psychiatric disorder at the time of the jump, but 3 of these had not taken their prescription. Only one patient made a new suicide attempt during the follow-up period. In four patients the jump resulted in the start of a proper psychiatric investigation and rehabilitation plan.

## Paper III

Acetabular fracture reduction by 0-1 mm in 106 patients, 2-3 mm in 23 patients and >3 mm in 7 patients was accomplished. Elementary fractures showed 92 % anatomical reduction (0-1 mm) and associated fracture patterns 72 %. At 2 years post-surgery the radiological outcome was excellent or good in 93 % and fair or poor in 7 % of patients. Nineteen patients had been operated with a THA during the follow-up period, of which 13 had associated fracture patterns. Half of the 23 patients with femoral head and/or acetabular chondral lesion or impaction lost their normal hip joint.

In total, 129 patients responded to the questionnaires, 1 patient could not be located, 3 did not respond and 3 had died from unrelated causes. Over time patients improved significantly in the two domains Physical Function and Role Physical, while we found no change in the other six domains. At 2 years post-surgery fracture patients scored lower than the reference population in all eight domains of SF-36 (Figure 21). However, patients with anat-

omic reduction scored better in all domains ( $p < 0.001 - 0.039$ ) except Vitality ( $p = 0.07$ ) when compared with patients with residual displacement of 2 mm or more. The distribution of Physical Function scores in the anatomically-reduced patients was skewed towards good outcome, similar to reference, but in contrast to the other group (*Figure 22*). We found no difference in SF-36 outcome between patients with elementary or associated fracture patterns. Physical Function was better in the group of patients with a Matta radiological grading excellent compared to good, whereas the other two groups grading fair and poor had too few patients for analysis.



*Figure 21. SF-36 results in acetabular fracture patients (n=129) at three time-points compared with reference.*

LiSat-11 scores showed no change over time in life satisfaction. At two years post-surgery, patients were lower than reference in 9 items but similar to reference in “friends/acquaintances” and “financial situation. Satisfaction with “life as a whole” correlated to all other ten LiSat-11 items, as well as to all eight SF-36 domains (Spearman rho 0.01 level, 2-sided).

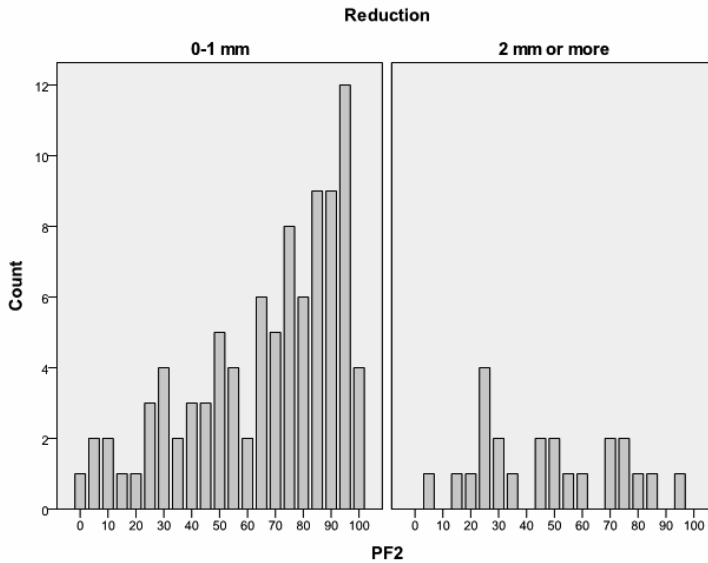


Figure 22. SF-36 Physical Function scores in acetabular fracture patients at 2 years post-surgery, in relation to post-operative reduction.

## Paper IV

One-hundred and twenty patients (94 %) completed the questionnaires at one or several post-surgery follow-ups, and 92 (72 %) completed the questionnaires at all three follow-ups.

### *Closed questions*

The initial 11 closed questions were used in a correlation analysis of the answers at 6 months post-surgery. There were significant inter-correlations between all questions (Spearman rho 0.17-0.80) so the number of questions could be reduced. The two questions regarding voiding of bladder or bowels were taken out due to low frequency of reported discomfort. The other 9 questions were used in a PCA to reduce the number of questions and test the content validity. The scree-test revealed that four factors could explain 76 % of the variance. Bartlett's test of sphericity was significant ( $X^2(2)=301.368$ ,  $df=36$ ,  $p<0.0001$ ) and KMO was 0.827 indicating that data were appropriate for proceeding with the PCA. This solution allowed for logical interpretation. The choice of questions to remain was based on the outcome of the PCA in combination with the responses in the open questions. The question concerning sleeping discomfort was removed due to low frequency of reported problems and because sleeping problems could have other origins than the acetabular fracture, as well as the fact that it was difficult to inter-

pret since it loaded in two of the factors. Questions concerning leg weakness and sitting were also removed due to loadings in two different factors and were deemed difficult to interpret. The question concerning operation scar was kept, as it loaded in a separate factor, as well as the fact that the analysis of answers to the open questions revealed that patients described various discomforts from the cicatrix. The remaining questions were discomfort from pain, walking, hip motion, leg numbness, sexual life and operation scar (*Figure 23*).

An additional PCA with the reduced questionnaire with 6 questions was performed with data from the follow up at 24 months post-surgery. The scree-test revealed that four factors explained 92 % of the variance. Bartlett's test of sphericity was significant ( $X^2(2)=258.792$ ,  $df=15$ ,  $p<0.0001$ ) and KMO was 0.837 indicating that data were appropriate for proceeding with the PCA.

The three questions concerning pain, walking and hip motion loaded in one factor - a "Hip score" - while the questions concerning peripheral neurology, sexual life and operation scar loaded in separate factors. Reliability expressed as Cronbach alpha coefficient was estimated to  $\alpha=0.89$  for the six questions and  $\alpha=0.95$  for the first factor "Hip score" including three questions. Comparisons with SF-36 were used to estimate the criterion validity. The three SF-36 domains Physical Function, Bodily Pain and General Health were considered most relevant to this study, as well as SF-36 total, yielding strong correlations (Spearman 0.56-0.80). Construct validity was considered adequate as the outcome of the PCA gave the four factors mentioned above. Reliability expressed as ICC for the different data collection times was 0.75 (6 months), 0.84 (12 months), and 0.85 (24 months). Patients reported better clinical outcome regarding peripheral neurology over time, as well as improving scores for the question leg sensation/numbness over time ( $p=0.016$ ). Another observation was that the group with fracture reduction 2 mm or more reported worsening pain over time ( $p=0.026$ ) while the group with fracture reduction 0-1 mm did not ( $p=0.573$ ).

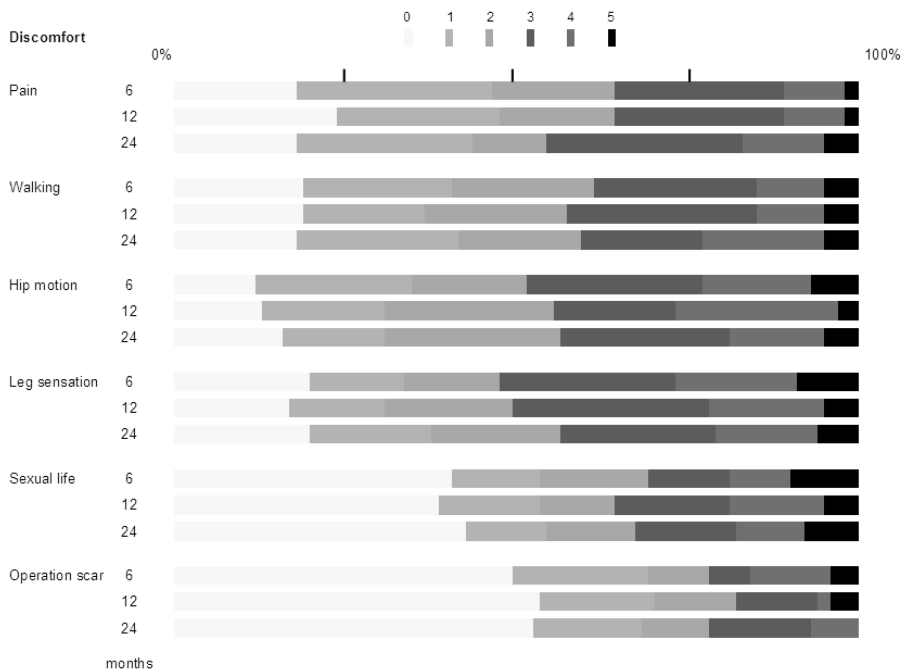


Figure 23. Acetabular fracture patients reported discomfort at three time points post-surgery; a six-graded VDS from “No discomfort” (0) to “Very severe discomfort” (5).

### Open questions

The analysis of responses to the open questions illustrated that patients had certain problems with daily activities. The problems were expressed as the following inabilities: inability to work, engage in sport activities, perform house work, engage in leisure activities, run, dance, walk in the forest or on irregular ground, lift heavy loads, put on stockings or other clothes due to stiffness in the back, walk without aid, get in or out of a car due to limited mobility, climb stairs, sit on one’s heels, bend forwards, and inability to sit for a long time. Two other kinds of problems were explicitly described by patients, namely suffering from neurological discomfort in the lower extremities and discomfort from the operation scar.

The result was the construction of a global question concerning the impact on daily life activities from the pelvic injury (Figure 24).

We would like you to answer the following questions regarding discomfort you experience following the pelvic injury

---

How much discomfort do you presently have

	None	Very little	Little	Moderate	Severe	Very severe
from pain in the pelvis ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
from the pelvis when walking ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
with decreased mobility of the hips ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
from loss of sensation or numbness in the legs ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
in your sexual life ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
from operation scars ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

	Not at all	Very little	Little	Moderately	Severely	Very severely
How much are you affected in your daily life from the pelvic injury ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

---

Figure 24. Acetabular trauma questionnaire

The “Discomfort index”, calculated as the sum of scores from 0 (No discomfort) to 5 (Very severe discomfort) in each of the 6 questions, thus with a possible range of 0 (best) to 30 (worst) is presented in Figure 25.

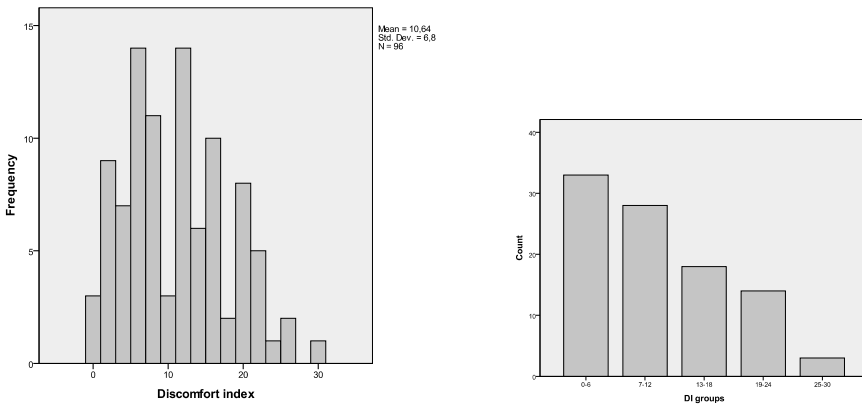


Figure 25. “Discomfort index” from 0 (best) to 30 (worst) at 2 years post-surgery in acetabular fracture patients; presented in intervals on the right.

The “Hip score”, calculated as the sum of scores from 0 (No discomfort) to 5 (Very severe discomfort) in the three questions regarding Pain, Walking, Hip motion; thus with a possible range of 0 (best) to 15 (worst), is presented in Figure 26 and Figure 27. The group with anatomic reduction had better scores ( $p=0.004$ ).

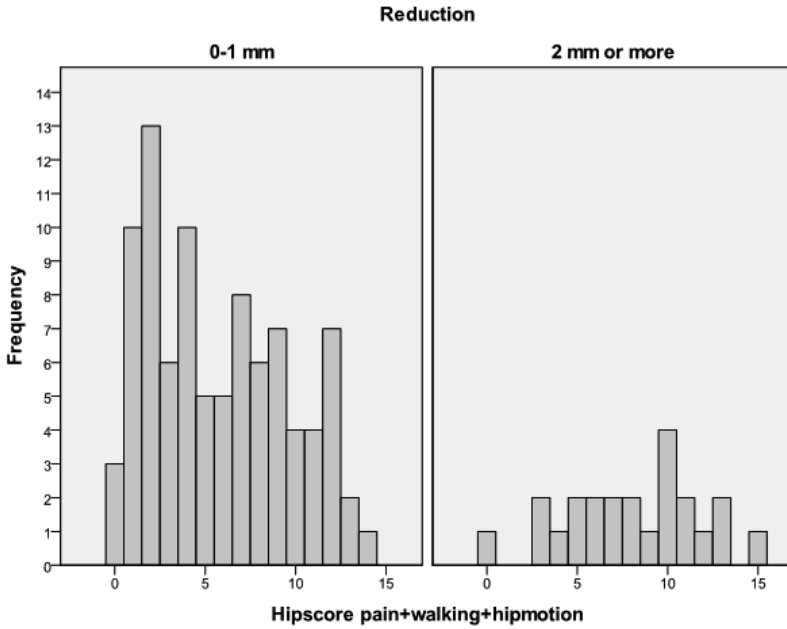


Figure 26. “Hip score” as a summary of discomfort from Pain (0-5), Walking(0-5) and Hip motion.(0-5), resulting in a score ranging from 0 (best) to 15 (worst); acetabular fracture patients at 2 years post-surgery in two reduction groups.

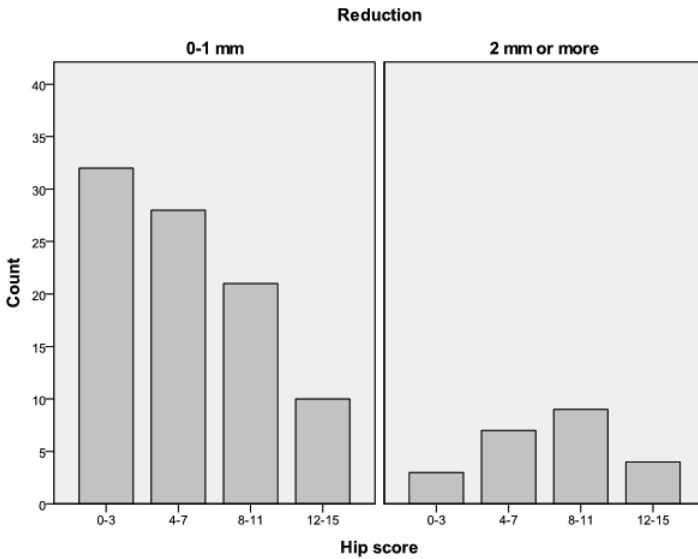
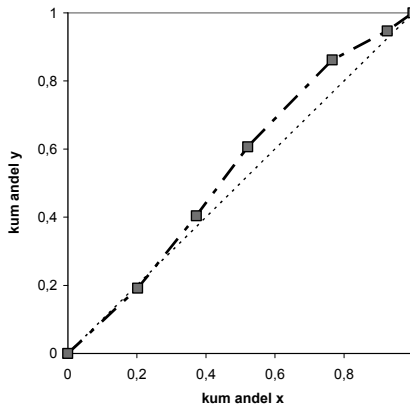


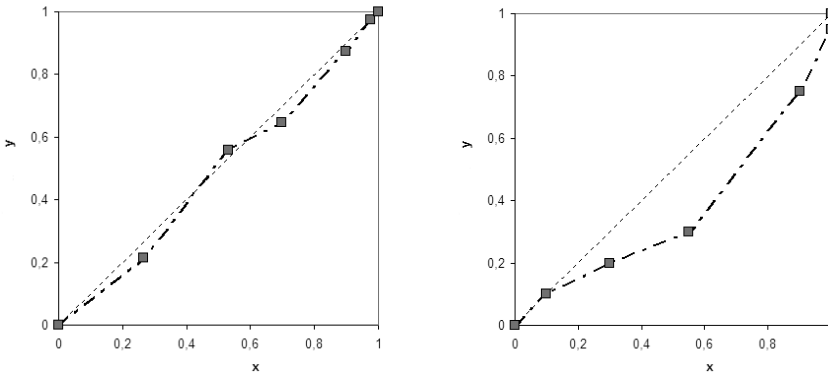
Figure 27. “Hip score” ranging from 0 (best) to 15 (worst) presented in intervals; acetabular fracture patients at 2 years post-surgery in two reduction groups.

*Svenssons method*

This nonparametric rank-based method was used to evaluate paired assessments change over time. Group changes in relative rank position and relative rank concentration in the 6 questions between 6 – 12 months and 12 – 24 months had confidence intervals spanning 0, hence not reaching statistical significance. Relative rank variance was significant, and the item with the highest individual variation was “Leg numbness”. The pattern of change is illustrated in the ROC curve in *Figure 28*. The ROC-curves in *Figure 29* show the change in “Pain” for the two reduction groups.



*Figure 28. ROC-curve for change in "Leg numbness" for acetabular fracture patients between 6 months and 24 months post-surgery, showing improvement with time.*



*Figure 29. ROC-curves for change regarding Pain at 12 and 24 months post-surgery. Reduction 0-1 mm (n=93) to the left, reduction 2 mm or more (n=20) to the right – the latter showing a worsening over time.*

# Discussion

Pelvic ring injuries and acetabular fractures, when displaced, require surgical treatment and the impact of injury and surgery affects the patient's QoL. Outcome assessment via generic QoL instruments provides information from a broad perspective, supplemented with condition-specific instruments an overall picture of treatment results can be obtained<sup>66,67</sup>.

## *Pelvic ring injuries*

The main finding in study I was generally lower HRQOL and life satisfaction scores at 24 months post-surgery, as compared to a reference population. SF-36 has not been used to a great extent in assessments of pelvic fracture patients. One study however, by Oliver *et al.*<sup>17</sup> of a case series consisting of pelvic fracture patients followed for 16–28 months post-surgery found that in 35 responders out of 55 eligible patients there was 14 % impairment in physical outcome and 5.5 % impairment in mental outcome score compared with the normal US population. In the present work, we reported substantially lowered QoL for both physical and mental domains. In a study by Van den Bosch *et al.*<sup>35</sup> they retrospectively reviewed patients with unstable pelvic ring injuries operated with internal fixation during a seven year period. SF-36 responses from 31 patients revealed PF, SF, RP and VT to be limited compared with the average reported for the Dutch population.

We included the instrument LiSat-11, with questions on satisfaction with life as a whole and 10 different items as a method of adding information in fields where SF-36 might be weak. In the case of an injured pelvis, it seemed important to include an instrument with a question regarding sexual life, for instance. Our findings from these assessments are in accordance with the findings of two other studies. In one retrospective follow-up study by Anke and Fugl-Meyer<sup>59</sup> of 69 patients three years after a multiple trauma, a total of 87% experienced a decrease in at least one of the life satisfaction items when compared with their life prior to the injury. Significantly fewer patients reported to be satisfied with life as a whole, as well as the domains sexual life, ADL, contact with friends, leisure, vocational and financial situation. The other was a study by Snekkevik *et al.*<sup>60</sup> in patients who had sustained severe multiple trauma, without neuropsychological deficits, followed for 1–3 years, who reported considerably reduced global life satisfaction at the time of final follow-up when compared with pre-trauma reports upon admission.

### *Acetabular fractures*

Study III demonstrated a higher QoL in acetabular fracture patients with anatomic reduction. Patients also reported improvement over time in physical domains of SF-36 at 24 months post-surgery. Similarly, earlier studies<sup>68</sup> showed that anatomic or near anatomic reduction of acetabular fractures was associated with better radiological as well as clinical outcome, assessed with the Merle d'Aubigné or the Harris hip score, compared to fractures where reduction was poorer. SF-36 however, or other generic QoL instruments, have only been used in a limited number of studies to describe outcome in acetabular fracture patients. The results in the present study showed a positive correlation between fracture reduction and patient related outcome when assessed via SF-36 as well as LiSat-11. This finding contradicts a recent study by Miller *et al.*<sup>69</sup> that found no correlation between SF-36 and the radiological outcome in 45 elderly patients with acetabular fractures. In another recent retrospective study<sup>70</sup>, SF-36 was one of three validated patient self-assessment measures used to study especially elderly patients after internal fixation of acetabular fractures. They concluded that functional outcome scores in their study compared favourably with functional outcome scores reported for acetabular fractures in younger populations as well as with age matched norms. In a retrospective study of patients with acetabular fractures above 60 years of age<sup>14</sup>, 26 out of 48 patients completed SF-36 surveys. Within this age group the authors concluded that the patients' scores were within one standard deviation from the reference population in all eight SF-36 domains. In the present study, in which most patients were younger, scores were also within one standard deviation when compared with reference population for all domains except physical function, albeit lower in all domains. This was true for the whole study population as well as for the subgroup above 60 years of age. There is no consensus on what can be considered a clinically relevant difference compared to references when using SF-36. A threshold of one standard deviation as described in the study by Anglen *et al.* seems too large as important differences between a study population and the reference population might be overlooked.

A lower QoL in acetabular fracture patients compared to a reference population can, as mentioned previously (Michaels, Ponsford), to a certain extent be expected since patients with orthopedic injuries score low in SF-36. Life satisfaction was low in all items except financial situation, which also can be expected in orthopaedic injuries, as previously mentioned (Snekkevik, Anke).

In a metaanalysis by Giannoudis and colleagues (2005)<sup>48</sup> the rate of THA in 16 studies was 6-25%. In the present study 14% underwent THA as a secondary procedure during the follow-up period. One important reason for this was that THA was not selected as a primary procedure despite presence of severe femoral head damage or severe acetabular impaction. Reduction

and fixation of the acetabular fracture was performed to achieve fracture healing, after which a planned THA could be performed. In recent studies<sup>69, 71</sup> the use of ORIF in combination with acute THA has been shown to be successful when used in selected elderly patients with acetabular fractures. If such an approach had been used in some of the elderly patients in the present study the number of secondary THA would conceivably have decreased.

The improvement over time in the two physical SF-36 domains, PF and RP, was still apparent at 24 months post-surgery. Persistent improvement will be assessed in a planned 60 month post-surgery follow-up. In the other 6 domains we found no change over time. Patients were closest to reference population in the domain MH, with scores well within the limit of minimal clinical relevant difference as defined by half a standard deviation. This was also the case for the domains GH and SF, where scores at the final follow-up were close to reference population mean and within half a standard deviation.

### *Strengths and limitations*

A prospective design is an advantage in QoL studies, and this was a fundamental strength in all studies in the present work. Furthermore, all studies were observational cohorts from consecutive series with no selection bias. All patients referred to us for surgical treatment with internal fixation of an injured pelvis were included. The Swedish system of personal identification numbers makes it possible to trace patients home address securely, which is especially beneficial in studies like these where the vast majority of patients were referred from other regions of the country. The number of untraceable patients was minimal compared with the situation in many other countries. For instance, Oliver *et al.*<sup>17</sup> in their study of 55 pelvic fracture patients ended up with 35 of 55 (64 %) responding. In our study only 2 of 54 patients (3 %) could not be traced and the response rate was 83 %. Noteworthy is that only one of the reachable patients without psychiatric disorder chose not to respond. In other words, in the current study design a high level of compliance was assured.

A limitation of the studies include the lack of pre-injury QoL assessment for comparison with the reference population, leading to the possibility that observed differences during follow-ups were not fully attributable to the pelvic injury. In study I there was a subgroup of patients with pelvic ring injuries that suffered their injury following a self-destructive jump, and their preinjury QoL can therefore reasonably be expected to be lower than a reference population. Attempts have been made, especially in patients with less severe injuries, to retrospectively assess QoL prior to the injury, but in the present work involving severely injured patients, it was deemed unlikely that a reliable retrospective assessment could be obtained.

In outcome studies with generic instruments it is always difficult to know to what extent associated injuries account for the reported QoL. Associated

injuries were frequent in both studied fracture groups, and especially in patients with pelvic ring injuries. A review<sup>72</sup> has pointed out that in pelvic fracture patients the rate of associated injuries is very high. Michaels and associates<sup>73</sup> showed that blunt trauma patients with orthopaedic injuries scored worse than patients without orthopaedic injuries in six of eight SF-36 domains at 12 months post-surgery. They concluded that patients with orthopaedic injuries experience prolonged disability, which by 12 months encompassed physical, psychological, social, occupational and financial components measured with the Sickness Impact Profile. This is in agreement with our findings, where patients reported a wide range of problems after pelvic fracture. Ponsford and colleagues<sup>74</sup>, studying various severely injured orthopaedic trauma patients, found significant levels of disability in all domains of the SF-36 at 12 and 24 months post-surgery, 93 % of whom were injured in MVA. This is in agreement with the present study's finding of lowered scores in all SF-36 domains at 24 months following severe orthopaedic trauma in the form of pelvic ring injuries. In the Ponsford study, patients with lower limb fractures had more pain and poorer physical outcome than patients with fractures in other locations. In the present study, apart from having a severe pelvic fracture, a lower extremity fracture was the most common associated injury.

Another study limitation was, as always in complex fracture cohorts, the number of patients. In study I patients were included over a period of three years and followed for two years. This resulted in a prospective series of comparable size, but with more responders than previously reported. Nonetheless, the major fracture groups B and C were somewhat small for comparison. In study II, inclusion criteria were extremely specific, and there was no intention of proceeding for an extended time-period, as it was a qualitative multi-professional study. In study III and IV where patients were included during four years and followed for two years there was a relatively large number of patients when comparing to other prospective series in the literature.

### *Suicidal jump*

The most important findings in study II were that all patients were still alive at four years and only one patient had made a new suicide attempt. These findings are in contradiction to the common belief that there is a high risk of further attempts in this group of patients. To the author's knowledge, QoL measurements for survivors after severe suicide attempt by jumping have not previously been reported extensively in medical literature. Therefore, the finding that these instruments could be used in this patient group was valuable. Quality of life, at follow up, was reported to be high in at least some of these severely traumatized patients. Additionally, by adding careful psychiatric assessment it was possible to increase the number of patients where

information regarding QoL aspects could be retrieved, as two of the patients who did not respond to the SF-36 accepted a request for interview.

The patient's perspective in QoL variables differed between young and middle-aged patients, where younger patients scored higher in all domains; the number of patients in this comparison was small, however. Based on the LiSat-11 instrument, satisfaction with life as a whole was higher in younger patients. Studies of survivors after jumping have shown a high rate of pre-jump treatment for psychiatric disorders. It has also been shown that patients with such disorders sustain more severe injuries when falling from a height, compared with patients without disorders. SCID-interviews in the present study revealed that eight out of 12 patients had a psychiatric diagnosis and more than half were on psychotropic medication. Based on the height of the jump in combination with the outcome from the interviews of the patients, the suicide attempts were considered as very serious. The reason for the female predominance among survivors in the present study is unclear. One possible explanation is that males jumped from greater heights than females and this reduced the chance of survival accordingly. In a case series of 50 individuals who committed suicide by jumping there were 64 % men<sup>75</sup>. As the prerequisite for inclusion in our study was a fractured pelvis we do not have any information about jumpers who survived without an injured pelvis, or jumpers who died at scene.

There are some methodological problems when studying this group of patients. If a psychiatric disorder exists, patients can be difficult to approach and exhibit reluctance in responding to mail requests or phone-calls. The results of this qualitative multi-professional study can reassure the staff in somatic acute wards, faced with the challenging situation of taking care of a multi-injured suicide jump survivor that these patients might recuperate to a satisfactory QoL.

### **Acetabular trauma questionnaire**

An instrument for evaluation of surgical treatment of acetabular fractures was developed. All patients were assessed prospectively at 6, 12 and 24 months following surgery, and SF-36 was used for comparison. We chose a six-graded VDS, for several reasons. Six distinct phrases in logical ascending order can be formulated, which has been proven fruitful in many instruments<sup>76,77</sup>, in addition to the SF-36. It makes it easier for patients to respond when instruments are used in conjunction. If too many answer alternatives are chosen, it will be difficult for patients to understand and decide. We considered four answering alternatives to be definitely too few, as it approaches answering a dichotomy. Five or six answering alternatives works fine as proven in the SF-36; it can be considered an advantage not to have a middle alternative risking to attract unproportional attention from respondents to take the "easy way out" and go for the middle without reflection. Results from a six-graded VDS are possible to dichotomise, and also to

trichotomise, in analysis and descriptive presentation. The high number of responders in our study indicates that patient burden was low.

SF-36 comes in different layouts, and we chose the two-page variant instead of the lengthier, while it seems easier to grasp. Fewer pages are naturally more appetizing for patients, especially in the case when other instruments are tagged on. When using the SF-36 together with other questionnaires, it is recommended by the originators to secure SF-36 first in the battery of questions, which we did, in order not to influence the patients prior to those questions.

Self-assessment has many advantages, evident in the case when patients are spread over a large geographical area. Patients do not need to travel far distances for follow-up; response rates can be higher which reduces bias. The patients actually express their opinion, instead of the treating physician interpreting. If the patient is allowed to reflect in the home environment stress from visiting a hospital is naturally eliminated. Patients that do well can lack motivation to show up for physical examination, especially as time passes. Patients that do poorly can also be reluctant to take part in follow-ups, especially where travelling is involved.

A general examination of the responses to the 11 initial questions showed that all 6 alternatives had been chosen by patients in all items, but there was no ceiling effect. This means that there was no need for a new answering alternative further to the right of the proposed maximum discomfort. Flooring effects are not an issue as alternatives with less discomfort than none cannot be formulated.

The responses at 6 months post-surgery were scrutinized and subjected to statistical analysis, resulting in a 2-step reduction process. Factor analysis revealed four factors in 9 questions, and when weak factors difficult to interpret were removed six items remained: pain, walking, hip motion, leg numbness, sexual life and operation scar. Correlation with SF-36 was high. The three items pain, walking and hip motion were all strong in one factor, "Hip score". The three items leg numbness, sexual life and operation scar were all strong as separate factors.

Analysis of the responses to open questions was made to influence the construction of the instrument. No specific new item was frequently reported by patients, but they amplified two of the closed questions, namely discomfort regarding peripheral neurology in the legs and discomfort regarding the operation scar. The majority of freely formulated responses concerned activities of daily living, with various inabilities reported, leading to the construction of a seventh question to assess impact on daily life activities from the pelvic injury.

During the progress of our studies several interesting publications have been made. In a study by Ovre *et al.* (2005)<sup>64</sup> they concluded that the original and modified Merle d'Aubigné-Postel scores as well as the HHS are skewed with a considerable ceiling effect limiting their use. In a following

study from the same institution Ovre *et al.* (2007)<sup>78</sup> proposed a modified HHS with lower ceiling effects and better discriminative qualities. In a systematic review study of the HHS by Wamper *et al.* (2010)<sup>79</sup> of 59 studies over half of the studies (31/59) revealed unacceptable ceiling effects and they concluded that the content validity of the HHS is inadequate.

Results from instruments producing ordinal data can be reported in different ways. The distance between the answer alternatives in ordinal data is unknown, however. Even with the calculation of various summary scores, ordinal data cannot transform into a continuous variable. A summary of the items can be done without weighting certain items, this method is used in many scores. The three first questions in our new questionnaire concerning pain, walking and hip motion can proposedly be summed into a “Hip score”, ranging from 0 (best) to 15 (worst), when 0 is representing the lowest score “No discomfort” and 5 is representing the highest score “Very severe discomfort” in each of the items. The three areas of interest in our Hip score are the same as in the original and modified Merle D'Aubigné-Postel Score as well as the HHS, but are obtained through patient self-assessment. When grouped in relation to post-operative fracture reduction into two groups, reduction 0-1 mm or  $\geq 2$ mm, our study showed that the group with anatomic reduction had superior results (*Figure 27*). This bar graph displaying frequency values illustrates that the most common result for the anatomically reduced belonged to the best group with hip scores in first (best) interval. It also illustrates decreasing frequency for each interval to the right, so that the least common result belonged to the last (worst) interval. The frequency pattern for hip scores in the group with non-anatomic reduction was quite different, where the most common result belonged to the third interval.

Ordinal data are difficult to compare between persons, but are quite suitable to measure change over time in patients. The reported result can naturally be either better, unchanged or worse. The exact distance between categories remains nonetheless unknown, exemplified by the fact that if one person reports being 2 categories better than the previous period and another person reports being 1 category better, it cannot be maintained that the first person has improved more than the other. Individuals respond based upon their own experiences; it can only be said that both persons have improved. When describing the pattern of change for ordinal data there are several nonparametric methods such as the Sign test, McNemar-Bowker, Wilcoxon signed rank test and Friedman test; they all have certain limitations. Svensson's method<sup>80</sup> is a constructive way to describe the pattern of change for ordinal data. Cell frequencies and cumulative frequencies in a contingency table are descriptive. Svensson's method ranks the paired assessments keeping the cumulative frequencies intact. Values for the three measurements relative rank position, relative rank concentration and relative rank variance are calculated with 95% confidence intervals; and an ROC-curve can be plotted. In our study 29-55% of the patients reported unchanged discomfort

between the time-points regarding the six questions, and individual variation towards both better and worse was reported. The largest individual variation was for the variable leg numbness between 6 months and 2 years.

In summary, analysis of the acetabular fracture patients responses to the closed and open questions led to the instrument composed of six questions regarding “Pain”, “Walking”, “Hip motion”, “Leg numbness”, “Sexual life”, “Operation scar” and a global question concerning impact on daily life activities as presented in *Figure 24*. Using the same methodology a questionnaire for patients with pelvic ring injuries could conceivably be created.

## Conclusions

- Quality of life in patients with pelvic ring injuries was lower than the reference population at two years following surgical treatment
- Patients surviving suicide attempts by jumping sustaining pelvic ring injuries or acetabular fractures requiring surgical treatment, had high survival and low recurrence of self-destructive behaviour; and quality of life was high in younger patients
- Quality of life in patients with acetabular fractures was lower than the reference population at two years following surgical treatment; physical domains improved with time, and quality of life was higher in patients with anatomical reduction
- Condition-specific discomfort in patients with acetabular fractures can be assessed using six questions related to discomfort concerning “Pain”, “Walking”, “Hip motion”, “Leg numbness”, “Sexual life”, “Operation scar” and one global question concerning impact on daily life activities

# Future studies

There are some natural directions for future study in line with the findings of this thesis.

- Assessment of pre-injury QoL for patients with pelvic ring injuries
- Assessment of pre-injury QoL for patients with acetabular fractures
- Study of subgroups of acetabular fracture patients, such as the elderly, and assessment of QoL and functional outcome in these groups using the new instrument described in this work
- Development of a condition-specific outcome instrument for patients with pelvic ring injuries

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## Summary in Swedish

Det övergripande målet var att studera det kirurgiska resultatet efter bäckenfrakturer med fokus på utvärdering från patientens perspektiv, av dessa ofta allvarliga skador med långtgående konsekvenser på flera plan. Alla vuxna patienter som opererades för bäckenringskada eller acetabularfraktur (ledskålen som ledar mot höftkulan) vid ortopedkliniken på Akademiska sjukhuset, Uppsala, följdes från 2003 och framåt med instrument som mäter livskvalitet. Patienterna kom från många olika regioner i landet, vanligaste skademekanismen var trafikolycka. Studie I inkluderade 54 patienter med bäckenringskada under åren 2003 – 2005 som följdes i 2 år. Två instrument användes, SF-36 för hälsorelaterad livskvalitet och LiSat-11 för livstillfredsställelse. 45 patienter besvarade enkäterna och de låg lägre än normalbefolkning i båda måttens många olika parametrar. Studie II var ett kvalitativt samarbete med psykiatrisk expertis, och inkluderade 12 patienter som överlevt självmordsförsök via hopp från hög höjd, och ådragit sig operationskrävande bäckenringskada eller acetabularfraktur. Fyra år efter skadan levde alla patienter, och SCID-intervjuer utförda av psykiatriker visade låg förekomst av självdestruktiva handlingar och hög livskvalitet i de yngre patienterna. Studie III inkluderade 136 patienter med acetabularfraktur som följdes i 2 år. Röntgenbilder efter operation delade materialet i de två grupperna 106 patienter med 0-1 mm kvarstående frakturglipa, och 30 patienter med 2 mm eller mer. 129 patienter besvarade enkäterna, och livskvalitet var högre i gruppen med bäst operationsresultat. Fysiska domäner i SF-36 instrumentet förbättrades med tiden, även om de fortfarande låg lägre än normalbefolkningen. Studie IV hade målet att utveckla ett specifikt utvärderingsinstrument för patienter med acetabularfraktur. Slutna och öppna frågor ställdes till 127 konsekutiva acetabularfrakturpatienter vid 6, 12 och 24 månader. Svaren validerades genom faktoranalys och svars kategorisering vilket resulterade i en multi-faktoriell verbalt deskriptiv skala med sex specifika frågor angående smärta, gångförmåga, höftrörlighet, känselnedsättning i ben, sexualliv, operationsärr och en global fråga om bäckenskadans påverkan på vardagslivet.

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