"PROSPECTIVE AND RETROSPECTIVE ANALYSIS OF PELVIC RING AND ACETABULUM FRACTURES IN TERTIARY CARE CENTRE "

Dissertation submitted to

M.S. DEGREE-BRANCH II ORTHOPAEDIC SURGERY

THE TAMILNADU DR.M.G.R.MEDICAL UNIVERSITY

CHENNAI, TAMILNADU

SEPTEMBER 2016

CERTIFICATE

This is to certify that this dissertation **"PROSPECTIVE AND RETROSPECTIVE ANALYSIS OF PELVIC RING AND ACETABULAM FRACTURES IN TERTIARY CARE CENTRE"** is a bonafide record of work done by **DR.S.MOHAN KUMAR,** during the period of his Post graduate study from June 2015 to May 2017 under Our guidance and supervision in the INSTITUTE OF ORTHOPAEDICS AND TRAUMATOLOGY, Madras Medical College and Rajiv Gandhi Government General Hospital, Chennai-600003, in partial fulfilment of the requirement for **M.S.ORTHOPAEDIC SURGERY** degree Examination of The Tamilnadu Dr. M.G.R. Medical University to be held in April 2017.

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DECLARATION

I declare that the dissertation entitled **"PROSPECTIVE AND RETROSPECTIVE ANALYSIS OF PELVIC RING AND ACETABULUM FRACTURES IN TERTIARY CARE CENTRE"** submitted by me for the degree of M.S ORTHOPAEDICS is the record work carried out by me during the period of September 2015 to September 2016 under the guidance of **Prof.N.DEEN MUHAMMAD ISMAIL,M.S.Ortho.,D.Ortho.,** Director I/C, Professor of Orthopaedics, Institute of Orthopaedics and Traumatology, Madras Medical College, Chennai. This dissertation is submitted to the Tamilnadu Dr.M.G.R. Medical University, Chennai, in partial fulfilment of the University regulations for the award of degree of M.S.ORTHOPAEDICS (BRANCH-II) examination to be held in April 2017.

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INTRODUCTION

High energy injuries like road traffic accidents fall from height and crush injuries are on the increase and pelvic injuries are common outcome in such cases especially in young adults. Associated injuries encountered with pelvic ring disruptions like neurovascular (iliac artery and sacral nerve roots) and visceral (bladder, urethra and intestine) injuries makes its management more challenging and complex. There is significant morbidity and mortality with pelvic ring injuries. The mortality may present early due to haemorrhage or associated injuries and late because of multi organ dysfunction or sepsis

Most of the pelvic ring disruptions are unstable injuries. Most of the injuries can be managed with non-operative techniques like pelvic belt, slings, skeletal and skin traction initially, mainly aiming to stabilize the fracture temporarily or establish haemostasis. Conservative management in non-articular reduction of sacroiliac joint may lead to long standing pain and discomfort due to arthritis. Hence decision making in such complex injury place a crucial role in determining the functional outcome.

Initially, the literature gave more importance to the life threatening complications other than the pelvic ring disruption, leading to poor outcome which were projected in early studies. Lack of knowledge regarding the biomechanics of bony and ligament complex and the pattern of injury, the techniques of internal fixation of sacroiliac joint and symphysis pubis led to poor functional outcome in patients who survive this injury.

In my study, a detailed briefing regarding the anatomy and biomechanics of pelvic ligament complex, the mechanism and classification of different types of pelvic ring fractures followed by detailed clinical examination and radiological survey of the patients with pelvic ring injuries and various surgical management for them. Analysis of functional outcome in patients managed surgically and conservatively and associated various factors in the outcome of patients with pelvic ring injuries.

AIM OF THE STUDY

The aim of the study is to prospectively and retrospectively analyse the functional outcome in patients with isolated pelvic ring fractures and those combined with acetabulum fractures and various factors influencing the outcome in such patients.

REVIEW OF LITERATURE

1806–1865: Joseph-Francois Malgaigne - History of pelvic fracture treatment starts with his work

1904–1969: Sir Frank Wild Holdsworth-The application of a pelvic sling with skeletal traction

1948: Holdsworth –describes relation between bony and ligaments injuries with functional outcome. He studied on 50 pelvic fractures and demonstrated the mechanism of pelvic fracture. On careful observation of his studies it shows close association between anatomic reduction and prognosis in form of functional outcome

1961: Young & Burgess classifications is based on the original Pennal /Sutherland description

1970: Slatis and Karaharju conducted a comparative study with a series of 22 cases with unstable pelvic injuries. All the patients in their study were treated with trapezoidal external frame and finally they came to the conclusion that the patients with unstable injuries treated with external fixation had decreased incidence of late musculoskeletal complications

1970: Shanmugasundaram-The Locked symphysis, a rare type of pelvic injury was first reported by him.

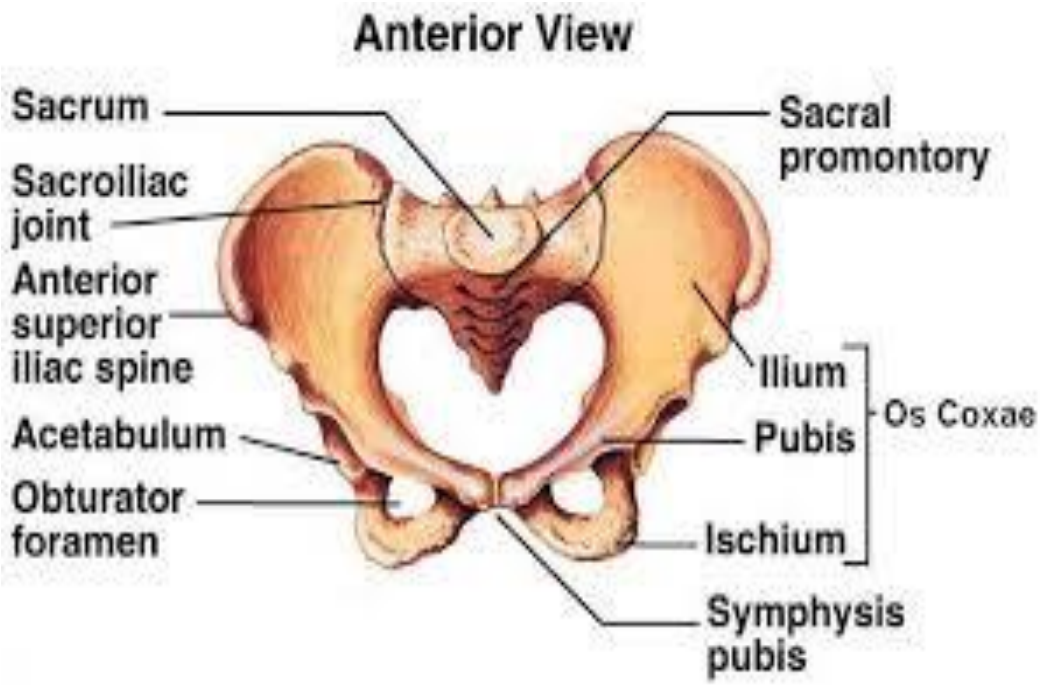
1980: Penal et al- Pelvic fracture classification on the basis of direction of injury force

1983: Marvin Tile - A research on patients with pelvic injury was done. The classification made by him, which is followed across the world now, was based on the stability of the injured pelvis and the direction of the injuring force vector. The classification, biomechanics and management of pelvic fractures with modern surgical techniques was explained in detail in his book entitled “fractures of pelvis and acetabulum”.

1985: Edwards et al - A study on 50 patients with unstable pelvic injury treated with external stabilisation was conducted by him. Their study concluded that pelvic injuries with vertical instability cannot be stabilised with anterior external frame.

APPLIED ANATOMY

The pelvic ring consists of the sacrum, the two SI joints, the two innominate bones on each side embryological origin from os ileum – os pubis – os ischium joined together with symphysis pubis. These bony complex does not have any inherent stability, the soft tissues mainly the ligamentous structure constitutes the stability to pelvis to withstand high forces.



The pelvic cavity contains a variety of soft-tissues and can be divided into the greater or false pelvis, comprising 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 structures and reproductive organs.

OSSEOUS ANATOMY OF SACRUM

Ziran et al and Ebraheim et al have recently described the important osseous landmarks of posterior pelvis and sacrum and their specific orientation with relation to radiographic imaging. S1 sacral ala is important bony landmark. Dysmorphisms of superior ala either concave or convex should be kept in mind. Sacralisation of the L5 vertebral body or Lumbarisation of S1 body may be present.In order to minimize the chance of an in-out-in screw, the entry point for sacroiliac joint screw should be inferior and posterior to the superior ala on the lateral ilium.

Confluence of ala with iliac cortex form the iliac cortical density which is seen in lateral view x-ray.

OSSEOUS ANATOMY OF ILIUM

A nutrient artery present lateral and anterior to the joint in the inner table is one of the reason for bleeding during surgery of this area. There is a coalescence of lumbosacral plexus and gluteal vessels located near the joint, constituting important source of bleeding both during injury as well as during internal fixation. The neurovascular structures along with piriformis muscle exits pelvis through the greater sciatic notch.

ACETABULUM

It is useful for the surgeon to divide the acetabulum and innominate bone into anterior and posterior columns. The anterior column comprises

the anterior border of the iliac wing, the entire pelvic brim, the anterior wall of the acetabulum, and the superior pubic ramus. The posterior column comprises the ischial portion of the bone, including the greater and lesser sciatic notch, the posterior wall of the acetabulum, and the ischial tuberosity.

LIGAMENTOUS ANATOMY AND THEIR STABILITY [36]

SACROILIAC JOINT

Sacroiliac joint is formed by the direct contact of sacrum and ilium embryologically. There occurs little or no movement in the sacroiliac joint due to strong anterior and posterior ligament

The ligaments of sacroiliac joint are divided into deep and superficial ligaments.

DEEP LIGAMENT

Interosseous sacroiliac ligament

It is one of the strongest ligament of the body. The tuberosities of sacrum and ilium are united by interosseous ligament.

SUPERFICIAL LIGAMENTS

It is further divided into anterior and posterior sacroiliac ligaments.

Posterior sacroiliac ligament

It has two different types of bands

1. Oblique fibres (Bichat’s ligament): Extends from ridge of sacrum to the posterior superior and posterior inferior iliac spine.

2. Longitudinal fibres (Zaga's ligament): Extends from posterior superior iliac spine to the lateral portion of the sacrum.

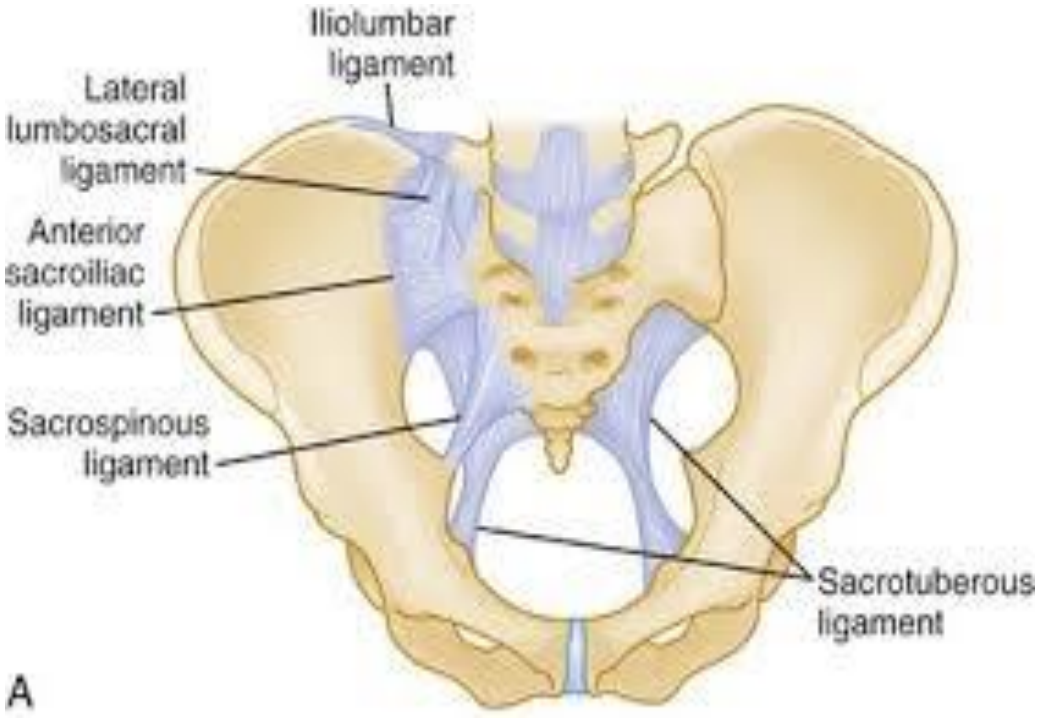
Anterior sacroiliac ligaments

Flat, strong bands of ligaments having transverse and oblique fibres which connect anterior surface of sacrum and adjacent ilium

CONNECTING LIGAMENTS

Sacrotuberous ligament

It is an extremely strong ligament which connects lateral part of the dorsum of the sacrum and the posterior surfaces of posterior superior and inferior iliac spines to the ischial tuberosity.



Sarospinous ligament

Strong triangular ligament extend from the lateral margin of sacrum and the coccyx to the ischial spine. On its course sacrospinous ligament converts two notches into greater and lesser sciatic foramen.

Iliolumbar ligament

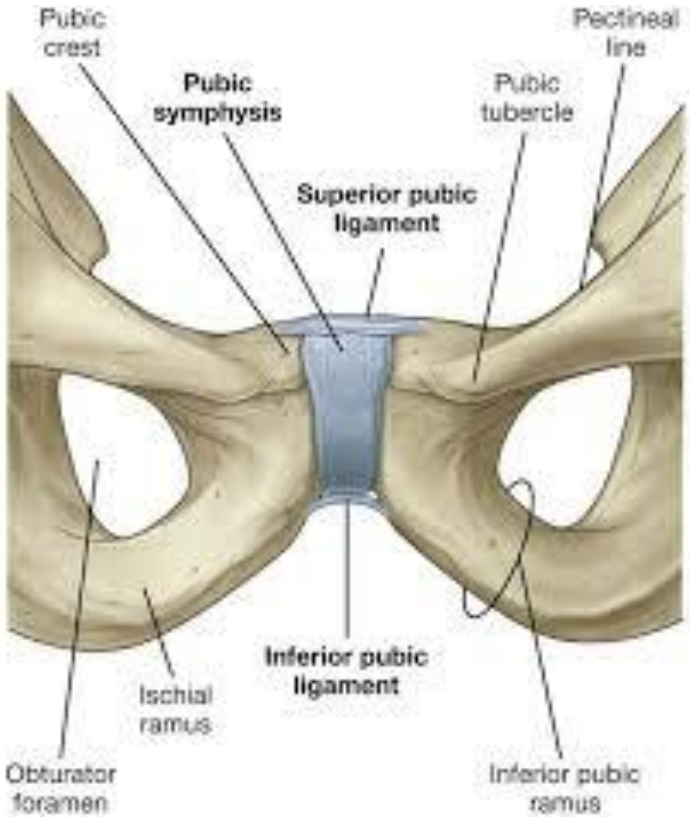
the iliolumbar ligament extend from the tip of the fifth lumbar transverse process to the iliac crest bilaterally.

Lateral lumbosacral ligament

It is attached from the L5 transverse process to the ala of sacrum.

ANTERIOR PELVIC STABILITY

Symphysis pubis



The hyaline cartilage covering the opposed bony surfaces are further reinforced by fibro cartilage and fibrous tissue bonding together

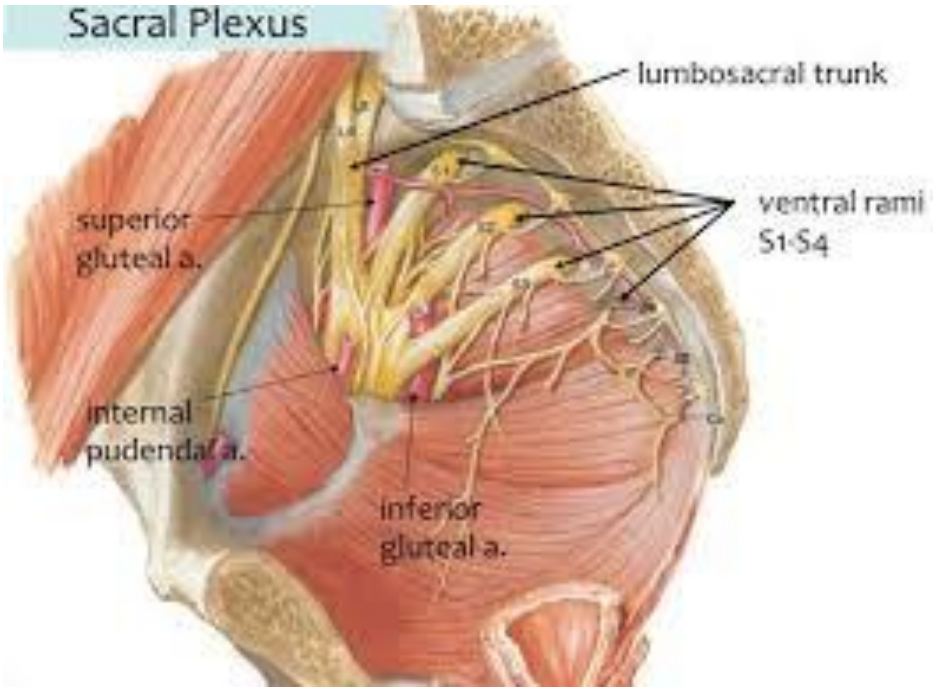
the hyaline cartilage. The dense fibrous ligaments merge with the hyaline cartilage anteriorly and superiorly, inferiorly.

STRUCTURES AT RISK DURING PELVIC RING DISRUPTION

Lumbosacral and coccygeal nerve plexus

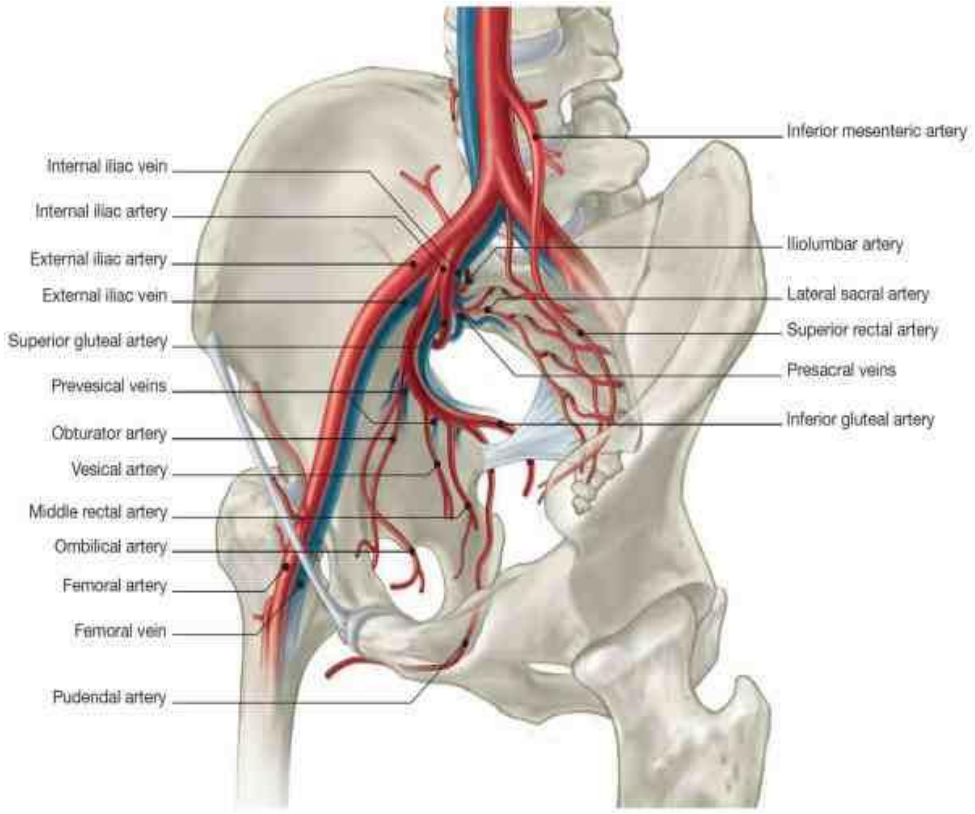
The plexus are of important in sacroiliac joint fixation surgeries. Sacroiliac disruptions associated with these plexus injury have been well documented including the femoral nerve injury.

The lumbosacral plexus formed by L4-L5 and first four sacral roots are situated in front of the anterior sacroiliac joint. They are critical structures at risk of injury during sacroiliac disruptions. These structures are at risk both during injury and also percutaneous fixation of sacroiliac joint. The lumbosacral plexus finally ends in two terminal branches, the pudental and sciatic nerve. It also has many collaterals.



VASCULAR ANATOMY

The most important cause of mortality following pelvic ring disruptions is massive haemorrhage from major blood vessels. This



mandates that one should have detailed knowledge of vascular structures in pelvic cavity. These structures can also be injured during surgical procedures. In managing pelvic ring injuries with haemorrhage, embolization of bleeding vessels is also a lifesaving procedure. The arteries at risk are discussed below.

Median sacral artery

Frequently injured in sacroiliac disruptions which is continuation of aorta.

The superior rectal artery

It is rarely injured and it is a continuation of superior mesenteric artery.

The internal iliac artery

Originating from the common iliac artery in false pelvis it is the vessel of critical importance. It splits into anterior and posterior divisions. Pelvic injuries may injure the internal iliac artery or sometimes common iliac artery if injury force is high.

Posterior division

superior gluteal artery , iliolumbar artery and lateral sacral arteries are branches from this division which are more prone to injury in sacroiliac joint disruptions.

Anterior division

It gives rise to mainly visceral branches supplying the bladder, genitalia and a portion of rectum. The internal pudental and inferior gluteal artery are the lumbar and perineal branches arising from anterior division.

The pelvic veins

The venous plexus being thin walled may bleed torrentially following pelvic injuries.

VISCERAL ORGANS

The bladder, male urethra and the gastro intestinal tracts are the visceral organs at risk of injury.

Urinary bladder

Frequently injured when it is full, mainly by the sharp spikes of fractured ends in case of fracture dislocation of sacroiliac joint and in association of other pelvic bone fractures like displaced rami fractures

Urethra

The bulbous and the membranous portion of the male urethra are commonly injured.

Gastro intestinal tract

The pelvic colon, rectum and the anus of lower gastro intestinal tract are injured more commonly in open pelvic injuries make an important cause of mortality when associated with sepsis.

.

BIOMECHANICS OF PELVIC RING

Understanding of pelvic stability is important while managing these injuries. The pelvis as a osseous complex lacks inherent stability, the stability is mainly by the integrity of the ligaments

Anteriorly, the intact pubic symphysis withstands external rotation. The main function of symphysis is to prevent the anterior collapse of pelvis during weight bearing.

Intact posterior sacroiliac complex is most important for pelvic stability. It is complex network of ligaments making it to withstand the transference of weight bearing forces from the spine to lower extremities

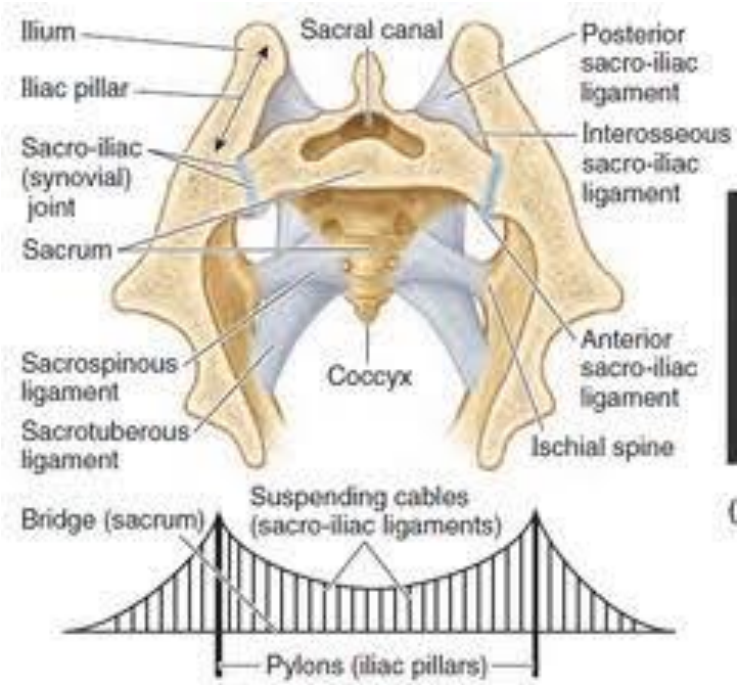
External rotation and shearing forces are opposed by the anterior sacroiliac ligaments. The posterior displacement of pelvic ring is opposed by one of the strongest ligament in the body, the posterior sacroiliac ligament complex.

The horizontally running fibres of sacrospinous ligament withstands the external rotation of hemi-pelvis and the vertically running fibres of the sacrotuberus ligament withstands the vertical displacement of hemi-pelvis.

Posterior tension band

- Posterior ligaments together forms the posterior tension band of pelvis, the transversely placed ligaments resist the transverse

rotational force and the vertically placed ligaments are assigned to oppose the shearing longitudinal force.



- Tiles described sacrum was suspended between two posterior superior iliac spine with posterior ligamentous complex like suspension bridge.

CONCEPT OF SACROILIAC STABILITY

The pelvic ring is considered as a single anatomical structure for practical purpose. The corner stone in managing patients with pelvic injury is analyzing the sacroiliac stability. The energy of the insult is directly proportional to the degree of pelvic instability. Stable, partially unstable and completely unstable are the three types of stability forming the basis for classifying the pelvic injuries

STUDIES ON SACROILIAC BIOMECHANICS

Division of ligaments

Pennal in 1961 demonstrated that cutting the pubic symphseal ligaments alone allows pelvis to open only 2.5cm, further opening opposed by posterior ligament complex. Cutting the anterior sacroiliac

ligaments makes the pelvis to open like a book. Translations at sacroiliac joint occur with division of posterior sacroiliac ligaments making the entire hemipelvis unstable.

The actual contribution of various ligaments to pelvic stability is much more complex, which was reported by the recent study from Tile`s laboratory.

Division of osseous complex

It is not possible to break the pelvis in just one spot because the whole pelvis behaves like an intact ring structure. In the clinical study conducted by Gertzbein and Chenoweth, patients with minimally displaced fracture at one spot were subjected to technetium bone scan and uptake was noted in sacroiliac region in all cases.

MECHANISM OF INJURY

Force patterns

The direction of force causing injury has high predictable value on the fracture patterns and this was first described by Pennal [26]. Four types of injury was described as per forces act on pelvis and they are

- Anterior–posterior compression injuries (APC)
- Lateral compression injuries (LC)
- Vertical shear injuries (VS)
- Combined mechanical injuries (CM)

Antero-posterior compression (APC)

Pelvis opens like a book with this direction of force. Force may be of two types either direct or indirect. Direct is again of two types, either a direct posterior crush on the posterior superior iliac spines or by the direct pressure to the anterior superior iliac spine. The indirect force is mainly thorough the external rotation of femur.

Lateral compression (LC)

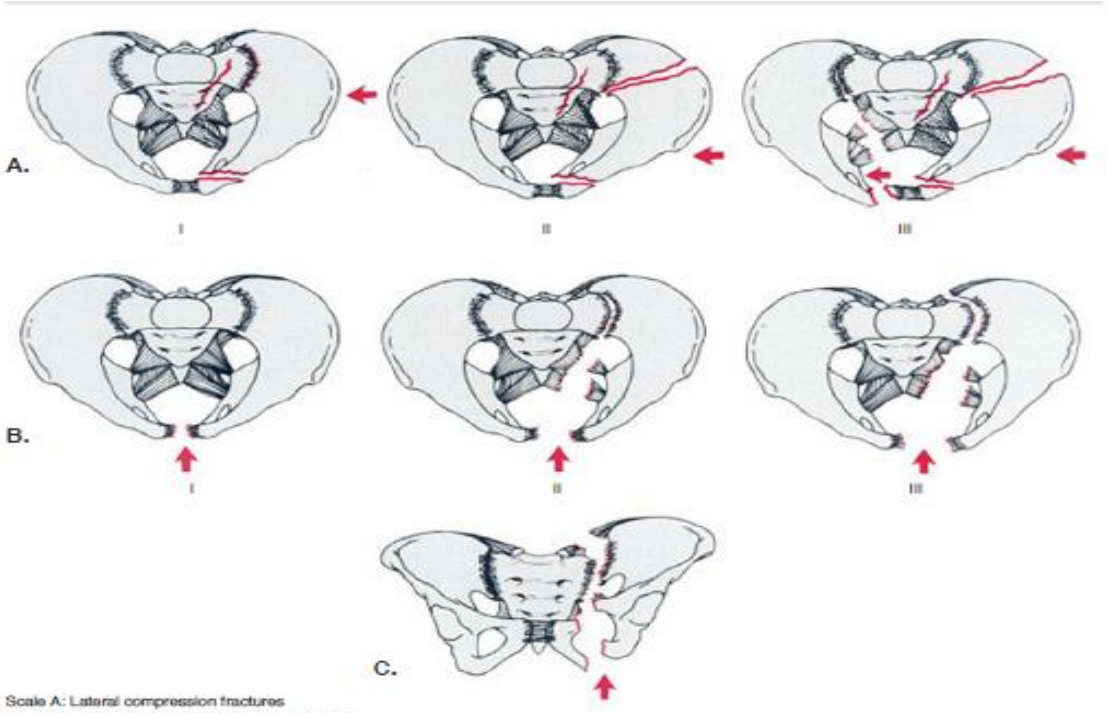
Generally the lateral force vector causes pelvis to collapse towards midline. Lateral force applied directly on the iliac crest or to the greater trochanter causes major thrust to the posterior sacroiliac complex

When subjected to only pure compression without any shearing element, the outcome is stable anterior lesion with the posterior soft tissue remaining intact. In combination of both compression and shearing element the outcome is unstable pelvic injury with both anterior and posterior lesions.

Posterior injuries can be an intact posterior complex with impacted fracture of anterior sacrum, crushed anterior sacrum with rupture of posterior sacroiliac ligament complex and impacted sacroiliac joint with ruptured posterior ligamentous complex.

Vertical shear (VS)

The injuring force vector acts perpendicular to the main trabecular pattern of the posterior pelvic complex in either posterior or vertical plane. The pelvis becomes highly unstable with major disruption of ligamentous complex and marked displacement. Traumatic hemipelvectomy is produced if the injuring vector force is severe.



Scale A: Lateral compression fractures
Scale B: Anteroposterior compression fractures
Scale C: Vertical shear fracture

YOUNG AND BURGESS CLASSIFICATION

I -LC: anterior injury = rami fractures

- LC I: sacral fracture on side of impact
- LC II: crescent fracture on side of impact
- LC III: type I or II injury on side of impact with contralateral open book injury

II -AP compression (APC): anterior injury = symphysis diastasis/rami fractures

- APC I: minor opening of symphysis and SI joint anteriorly
- APC II: opening of anterior SI, intact posterior SI ligaments
- APC III: complete disruption of SI joint

III – Vertical Shear

IV Combined

Force pattern and its effect on viscera and soft tissue

The strong vector force causing ligament disruption will also produce effects on the surrounding soft tissue namely the vessels, nerves and viscera. Lateral compression injuries damages the bladder or urethra and injury to sacral nerve roots are produced when compression occurs at the sacrum. Avulsion of vessels by violent traction is produced in vertical shear injuries**.**

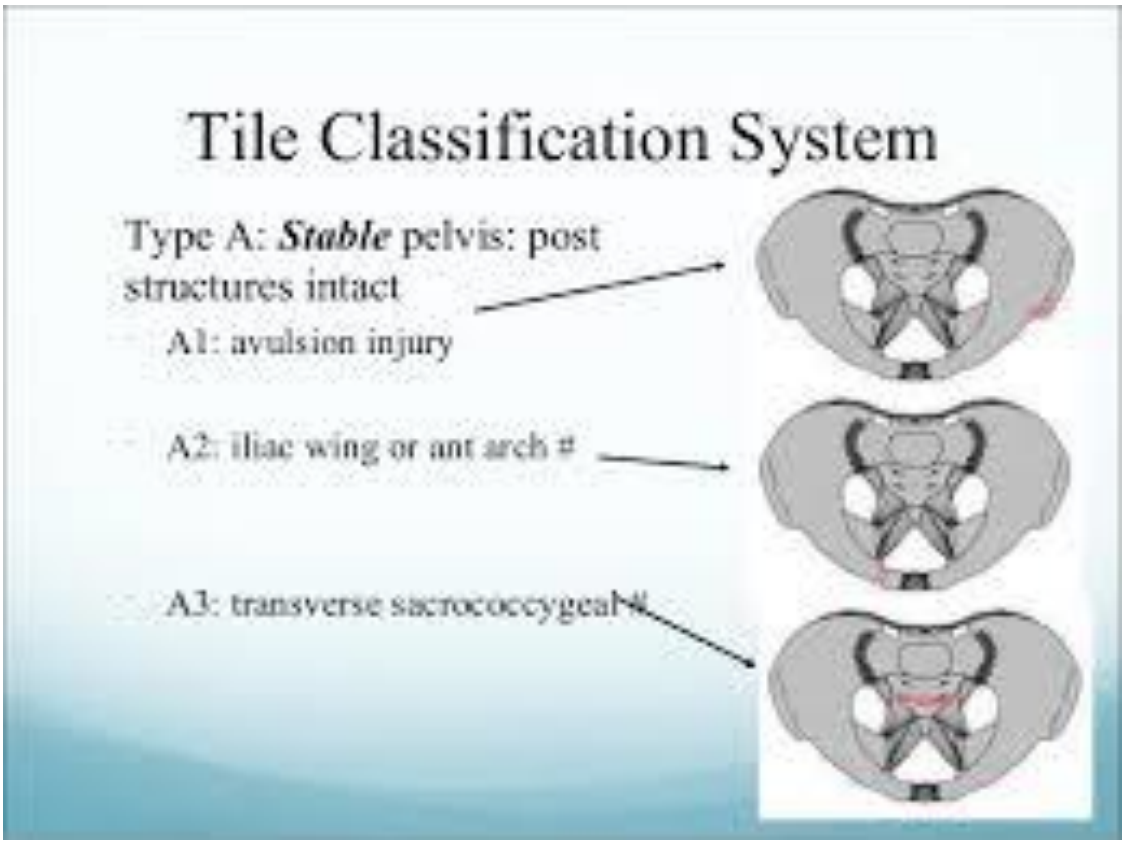
CLASSIFICATION

The main goal of classification is to aid in the management of the injured patients**.**

Historical considerations

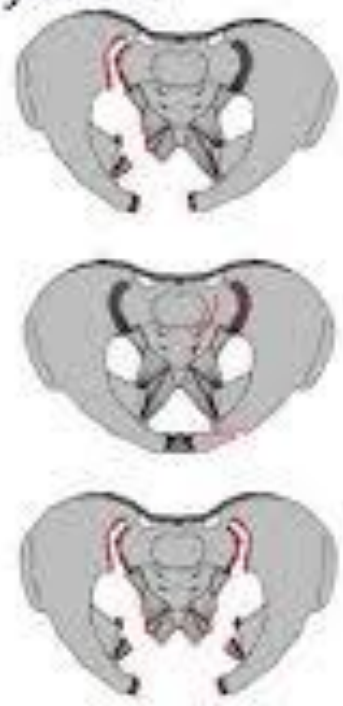
Joseph Francois Malgaigne, a French surgeon was the first to describe a classification system for pelvic fractures. Pennel and Sutherland in 1961 reported that typical and reproducible injury patterns are produced by major force vectors. Tile modified original Pennel classification and his classification system was entirely based on force vector. The Young-Burgess classification is same as Pennel with addition of complex group.

Initially the instability was not addressed in early classifications. In 1988, a classification based on the concept of force vector and stability was put forward by Tile [32]. At last the classification followed worldwide is modified Tile's classification adopted by AO working group.



Tile Classification System

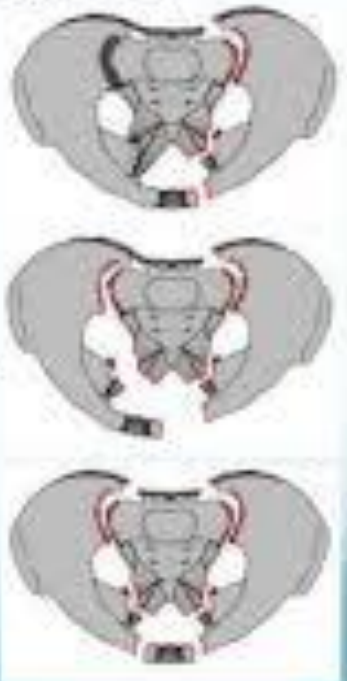
- Type B: ***Partially stable*** pelvis: incomplete posterior structure disruption
  - **B1**: open-book injury
  - **B2**: lateral compression injury
  - **B3**: contralateral / bucket handle injuries



Tile Classification System

Type C: ***Unstable*** pelvis: complete disruption of posterior structures

- C1: unilateral
- C2: bilateral w/ one side Type B, one side Type C
- C3: bilateral Type C



JUDET AND LETOURNEL CLASSIFICATION

ELEMENTARY TYPES

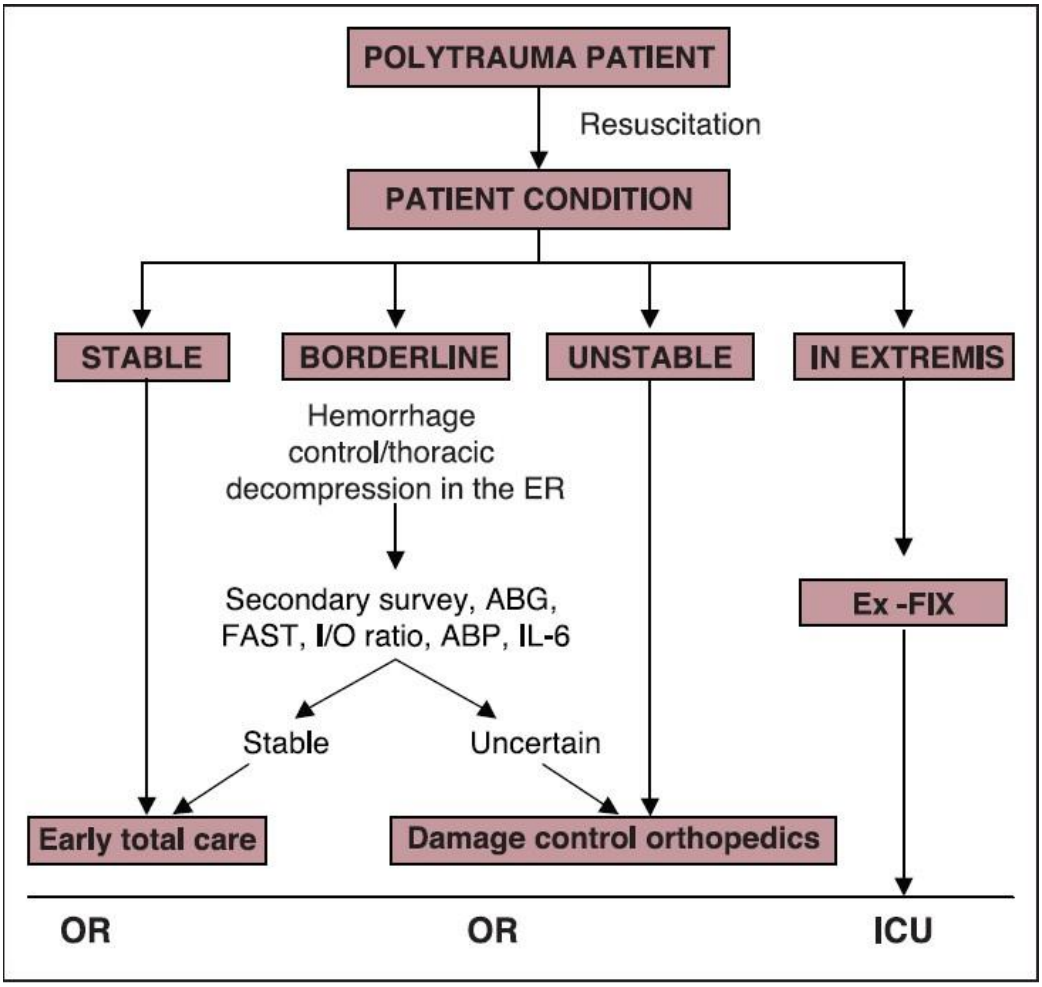
- Posterior wall
- Posterior column
- Anterior wall
- Anterior column and
- Transverse fractures

ASSOCIATED FRACTURE TYPES

- T type fractures
- Combined fractures of the posterior column and wall
- Combined transverse and posterior wall fractures
- Anterior column fractures with a hemitransverse posterior fracture and
- Both-column fractures.

CLINICAL ASSESSMENT

Most of the patients with pelvic ring disruptions are polytrauma patients. Hence clinical assessment begins with general assessment. Initially a rapid primary survey is done for 3-5 minutes assessing the airway, breathing and CNS status. If there is hemodynamic instability it should be followed by resuscitation and then a detailed secondary survey is done with thorough skeletal examination, GIT, CNS and excretory system examination.



DAMAGE CONTROL ORTHOPAEDICS [14,29]

- An approach that include temporary stabilization of orthopaedic injuries so overall physiology of the patient can improve.
- It's purpose is to avoid worsening of the patient's condition by the "second hit" of a major orthopaedic procedure and to delay definitive fracture repair until a time when the overall condition of the patient is improved.
- Minimally invasive surgical techniques such as external fixation/pelvic binder are used initially.
- Damage control focuses on control of hemorrhage, management of soft-tissue injury, and achievement of provisional fracture stability, while avoiding additional insults to the patient.

Patients selection for damage control orthopaedics (DOC)

- Patients who had orthopaedic injury are divided into following groups
  i) Stable - local preferred method
  ii) Borderline - damage control orthopaedic is preferred
  iii) Unstable – damage control orthopaedics
  iv) In extremis - – damage control orthopaedics

Inspection

Clinical inspection of the patient is more important than other investigation. Thorough inspection, looking for the external injuries, wounds, contusions and bruises. The genitalia must be inspected for any bleeding. The attitude of the patient indicates the displacement of pelvis mostly. Look for pelvic asymmetry and limb length difference

Palpation

Palpation is painful and it is ideally done under anaesthesia. Pelvic compression and distraction test, bi-trochantric compression test, palpation of sacroiliac joint, pubic symphysis and knee joints should be palpated. The integrity of distal neuro-vascular structure must be examined. For instability or impaction, pelvic traction test done and finally to rule out occult open injuries rectal and vaginal examination should be done.

RADIOLOGICAL ASSESSMENT

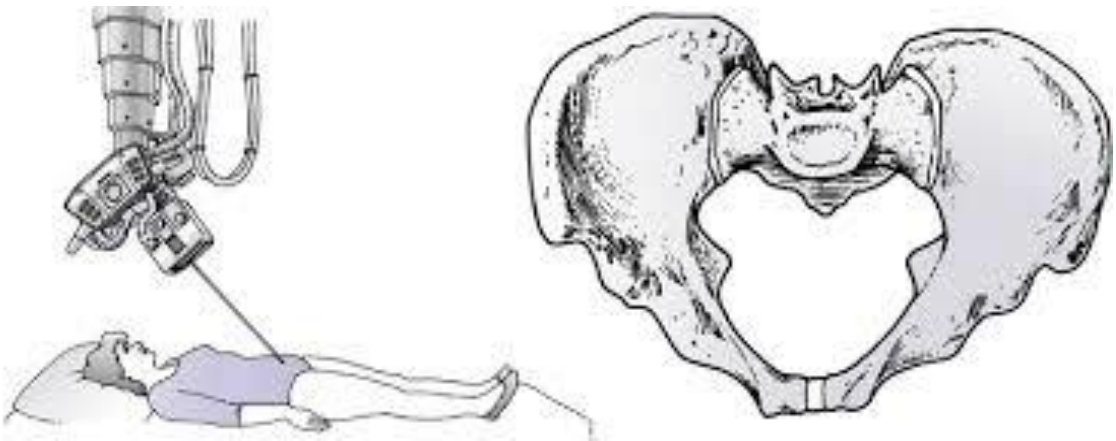
The standard protocol is to have the following three views of pelvis.

AP view

The standard AP view is taken with the patient supine and the X-ray beam directed perpendicular to the mid pelvis. Lot of information about both anterior and posterior lesions can be obtained from AP view. Other tell-tale signs of instability like displaced avulsion fracture of either end of sacrospinous ligament and avulsion fracture of tip of L5 transverse process may be evident.

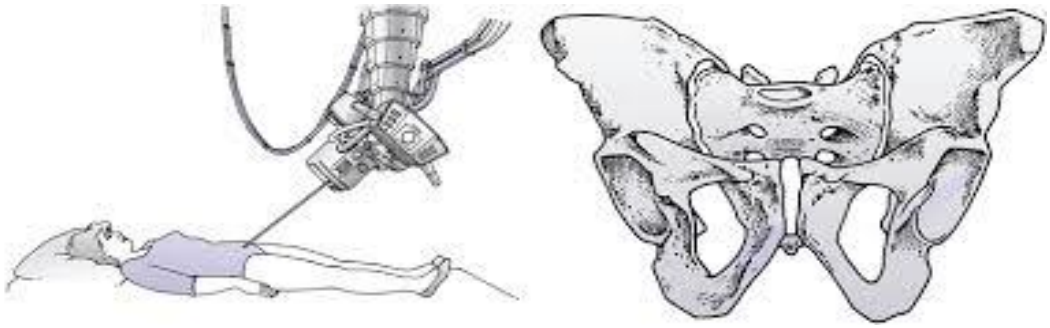
Inlet view

This view is obtained with the patient lying supine and the x-ray beam directed from the head to mid pelvis at an angle of 45 degree to the x-ray table. In this true pelvic inlet view the anterior and posterior displacement of pelvis seen at the best**.**



Outlet view

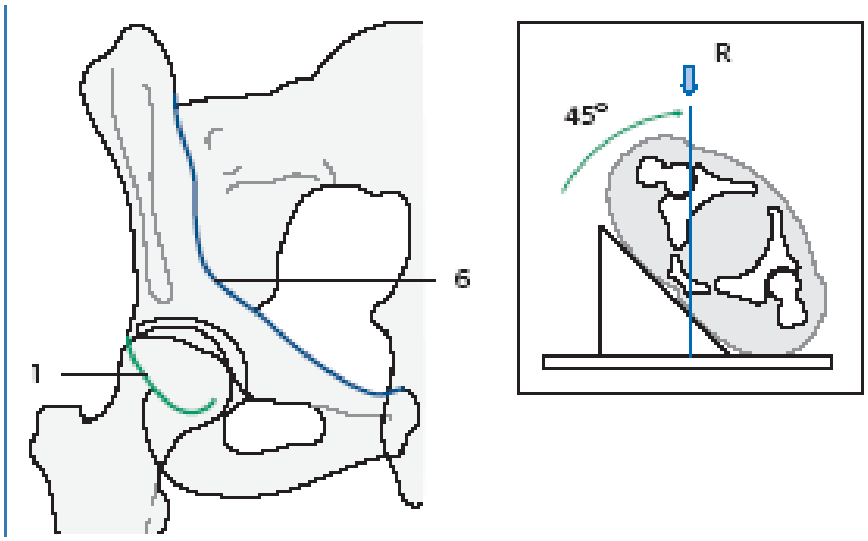
This view is obtained with the patient lying supine and the x-ray beam directed from foot to symphysis at an angle of 45 degree to the radiographic plate. With this view superior displacement of the posterior of the pelvis and either superior or inferior displacement of the anterior portion of pelvis can been made out.



JUDET OBLIQUE RADIOGRAPHS

These are 45° oblique pelvic radiographs.It emphasizes acetabular columns. Coccyx tip should lie above the center of the femoral head to ensure adequate rotation

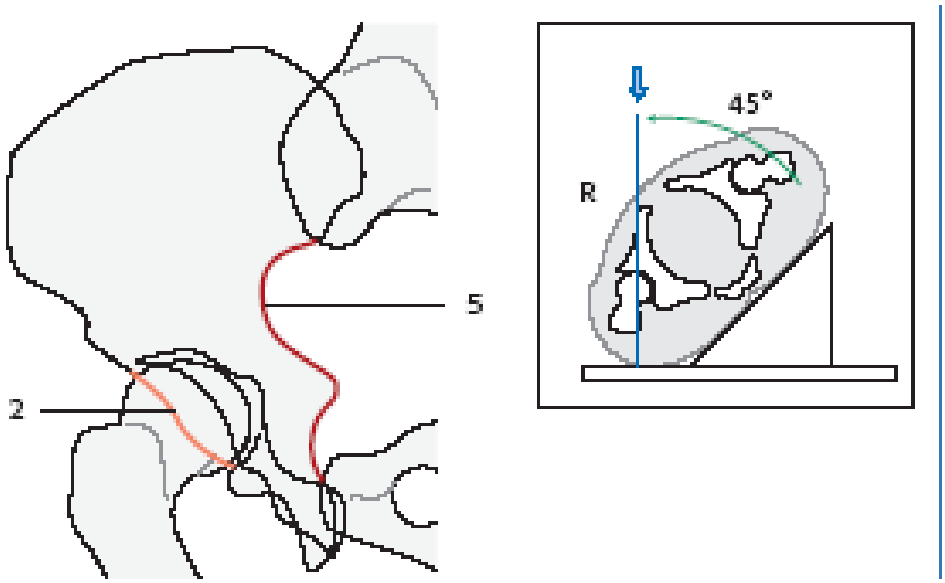
OBTURATOR (INTERNAL) OBLIQUE



This view is taken with injured side up. Coccyx is centered over ipsilateral femoral head.

- Obturator foramen in full profile
- Highlights pelvic brim, anterior column and posterior wall
- Assess congruency of femoral head in acetabulum.

ILIAC (EXTERNAL) OBLIQUE



This view is taken with injured side down. Coccyx is centered over contralateral femoral head.

- Iliac wing in full profile
- Highlights posterior column, anterior wall, posterior border of innominate bone and quadrilateral plate
- Assess congruency of femoral head in acetabulum

COMPUTED TOMOGRAPHY

CT scan is the investigation of choice for mainly assessing the stability of posterior sacroiliac joint. It gives clear demarcation between the impacted and stable or disrupted and unstable. Three dimensional reconstruction of pelvis helps in appropriate management of the injury.

NUCLEAR SCANNING

There is limited value for nuclear scanning in pelvic injuries. Technetium getting deposited in the subchondral bone of sacroiliac joint in osteoblastic areas suggest microavulsion fracture of subchondral bone.

MAGNETIC RESONANCE IMAGING

Pelvic injury with sacral fractures where entrapment of sacral roots can be visualised with MRI and occult ligamentous disruption in sacroiliac joint can be detected.

MR venogram is useful in detecting pelvic vein DVT.

INVESTIGATIONS FOR ASSOCIATED INTRAPELVIC SOFT TISSUE INJURIES

Angiography

It is both diagnostic and therapeutic. Angiography helps in locating the bleeding vessel and it can be also used in embolizing the vessel in management. It is indicated mainly when there is no improvement in hemodynamic status of the injured patient even after resuscitation and external skeletal stabilisation.

It is also useful in surgical exposure while fixing pelvic and acetabular fracture to rule out **corona mortis** (a communication between inferior epigastric artery and obturator artery

CORONA MORTIS

Ascending cystourethrogram

It is helpful in cases of bladder and urethral injuries, to locate the site of injury and its type, whether partial or complete.

Computer tomography for other injuries[5]

CT study of brain, chest, abdomen are routinely done if patients had suspected associated injuries

MANAGEMENT PROTOCOL

GENERAL ASSESSMENT

The protocol of Advanced Trauma Life Support (ATLS) should be followed for general assessment, resuscitation and for diagnosing skeletal and associated injuries. This is followed by thorough clinical survey of pelvic ring injury for its stability and its associated soft tissue injuries.

INITIAL MANAGEMENT [3]

Initial management of pelvic injury patients starts with stabilisation of general condition as per ATLS guidelines.

A- Airway

B- Breathing

C- Circulation

D- Disability

E- Exposure/Environment control

AIRWAY:

Primary survey in ATLS is assessing airway patency. The airway can be opened by chin lift and jaw thrust. If patient is unconscious, obstruction in airway can be cleared by suction apparatus and secured by endotracheal tube. All patients should receive 100% of oxygen through non- re breathing mask.

In this survey securing cervical spine with cervical collar is also done.

BREATHING:

Tension pneumothorax, haemothorax, flail chest in poly traumatized patient should be assessed immediately and emergency procedures like needle thorococentesis, intercostal drainage should be done.

CIRCULATION:

Circulatory problem mostly due to haemorrhage which is often from external injuries, pelvic fractures lead to retroperitoneal haemorrhage and intra-abdominal bleeding.

Amount of bleeding in closed fractures:

Single rib fracture – 125 ml

Radius / ulna fracture - 250-500 ml

Humerus fracture - 750 ml

Tibia/fibula fracture – 500-1000 ml

Femur fracture – 1000-2000 ml

Pelvic fracture - >2500 ml (massive)

Blood loss is assessed clinically by

- The level of consciousness
- Skin temperature and colour
- Nail bed capillary refill time
- Rate and quality of pulse

In case of circulatory loss it is managed mainly by crystalloids (0.9% normal saline, Ringer lactate). For that two intravenous lines (16-gauge) are started and blood is obtained for laboratory investigation.

An initial bolus of 1-2 L is given in an adult (20 mL/kg in a paediatric patient), and the patient's response is assessed.

While assessing the patient, if shock is not recovered, then blood has to be started immediately. In case of greater than 1 to 2 units of transfusion, blood should be warmed to 37 degree to prevent hypothermia. Patients receiving > 6 unit's transfusion may require replacement of clotting

factors with infusion of fresh frozen plasma or cryoprecipitate and platelet transfusion.

PELVIC DAMAGE CONTROL

- Closed reduction of pelvis at emergency trauma ward
- External fixation [6,13]
    - Wrapping of pelvis with sheets at greater trochanter level while limb in internal rotation and with knee mild flexion.
    - External fixator
        - Anterior external fixator
        - Supra-acetabular external fixator
    - Pelvic C-clamp[11]
- Control of haemorrhage [25]
    - Preperitoneal Pelvic Packing (PPP) [6,11]

      In mechanically unstable pelvic fractures, pelvic packing can be done along with external fixation, if patient's condition is not improving with fluid therapy.
    - Angiography (AG)[16,20]
        I. After non pelvic source of bleeding is excluded, patients with pelvic injury and hemodynamic instability or on-going bleeding should be considered for angiographic embolization[8,9]
        II. In CT scan demonstrating arterial intravenous contrast, extravasation in the pelvic cavity may require embolization even though patient is haemodynamicaly stable.[12,16]
- Control of contamination
    - Repair of genitourinary and rectal injuries

- Debridement of necrotic tissue in open injury

Decision making

Basically four scenarios exist for pelvic ring injuries based on patient's-

- Hemodynamic stability
- Stability of injury.

1. Stable hemodynamic and stable sacroiliac injury
2. Unstable hemodynamic and stable sacroiliac injury
3. Stable hemodynamic and unstable sacroiliac injury
4. Unstable hemodynamic and unstable sacroiliac injury.

Aggressive resuscitation should be done for hemodynamically unstable with stable sacroiliac joint injured patients and once the general condition of the patient is stabilised then definitive management of sacroiliac disruption can be planned. If the displacement is minimal, conservative management is followed.

If there is much displacement with unacceptable deformity early closed or open reduction and internal fixation can be planned.

In patients with vertically displaced unstable sacroiliac disruption with stable hemodynamics , close observation for 18 to 36 hours with upper tibial pin traction is followed. This is mainly done to ensure that no further bleeding occurs.

The management of patients with both hemodynamic and sacroiliac joint instability is a challenging problem.

First, the patient is resuscitated and necessary embolization of bleeding pelvic vessel is done to arrest the bleeding. A pelvic binder or pelvic belt, along with upper tibial pin traction and conventional external fixator frame can be applied as a part of resuscitation. Once the patient become stable, definitive fixation can be planned later.

APPLICATION OF EXTERNAL FIXATOR

1. Iliac crest external fixator
2. Supra acetabular external fixator

ILIAC CREST EXTERNAL FIXATOR

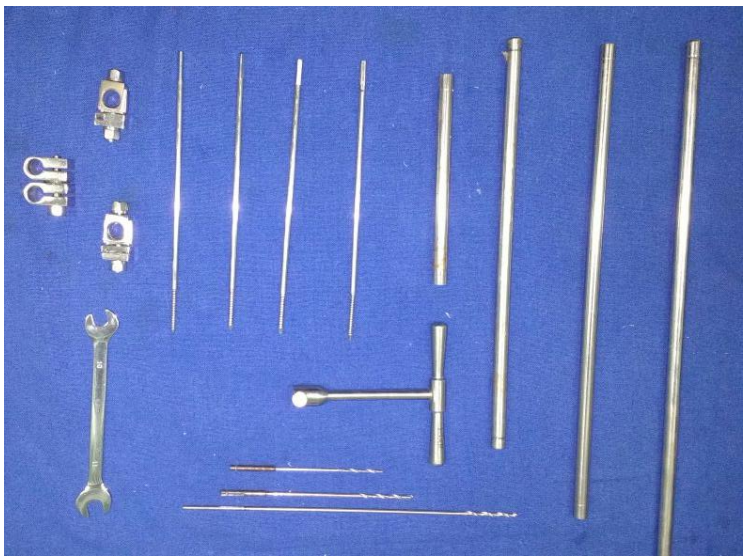
Preparation:

In operating room or in an emergency room, place the patient in supine position and prepare the area of anterior ilium from approximately 5cm above the umbilicus to groin and drape with sterile sheets.

Reduction

- Manual reduction is used to reduce the pelvis.
  Apply a large towel around the pelvis and twisting of towel ends gives a compression force across the pelvis which will reduce the pubic diastasis
- If the pelvis is unstable with vertical migration or posterior displacement, then a supracondylar femoral pin along with application of 25-30 pounds of traction will reduce the vertical displacement of pelvis.

Pins and frames



- Pins should be at least 5 mm in diameter.
- Smaller pelvis requires 4-mm pins to avoid fracture of iliac wing and loss of purchase.
- Pins with adequate length are used to sustain postoperative swelling and also to perform abdominal surgical procedures.
- Construction of the frame is done prior to surgery.
- Avoid placing cross bars between two frames and also avoid frames too close to the abdomen.

Technique

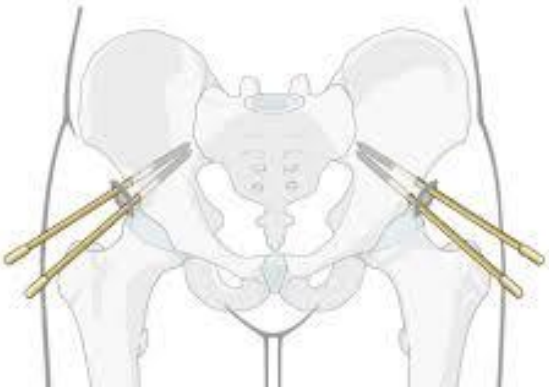
- 1st pin is placed about 2 cm posterior to anterior superior iliac spine.

- Needle or a small probe can be placed in the surface of inner & outer tables of iliac wing to get orientation of pin insertion.
- Place the pins on outer third of iliac crest to avoid damage to inner table.
- Place the two pins in convergent manner.
- Connect the clamp with rods and reduce the rods with tube to tube clamp.

SUPRA ACETABULAR FIXATOR

Technique

- Make a Skin incision 2-3 cm distally from anterior superior iliac spine.
- Dissect soft tissues and aim the pins 20-30 degrees medially.
- Starting point is confirmed with image intensifier.
- In iliac oblique view starting point for medio-lateral direction should be in apex of anterior inferior iliac spine.
- Self-tapping pins are placed and confirmed with image intensifier.



RECONSTRUCTION PHASE (DEFINITIVE MANAGEMENT)

Timing of surgery :

- Definitive surgery within 2 to 3 weeks offers improved radiographic and functional outcomes in pelvis and acetabulum fractures[10].
- After 3 weeks, callus and fibrous tissue formation occurs which limit the ability to obtain an anatomic reduction, needing more extensile approaches resulting in poor functional outcomes.
- The ideal window period for definitive procedures is 6 days to 3 weeks after injury [15].

Factors affecting timing of surgery:

- Haemodynamic instability
- Biochemical parameters
- Comorbid conditions
- Associated injuries [7,8]
- Bed sore/Morel-Lavallee lesion

Conservative management:

Stable, undisplaced Tiles type A, Young and Burgess type Lateral Compression type I,Antero Posterior Compression type I can be managed conservatively.

Definitive fixation:

1) Stage wise approach
2) Single stage
   Anterior –posterior
   Anterior -posterior-anterior
3) Closed or open reduction

INDICATION FOR OPERATIVE REDUCTION

- Rotationally unstable and vertically stable (Tile B, APC II).
- Pubic symphysis diastasis more than 2.5 cm.
- Pubic rami fracture with more than 2 cm displacement.
- Rotationally unstable fractures with limb length discrepancy more than 1.5cm.
- Unacceptable pelvic rotational deformity.
- Vertically unstable (Tile C, APC III, LC III).

Rotationally unstable fractures can be treated with external fixation as definitive treatment or anterior plating for pubic diastasis.

Percutaneous pubic ramus screw (antegrade or retrograde) can also be used for anterior fixation

Tiles advocated double plating for pubic diastasis in type C injuries. In Tile type C (Rotationally and vertically unstable)

fractures, anterior ring can be fixed with anterior plating or external fixator, posterior ring can be fixed with percutaneous screw, trans-iliac rods or anterior plating .

Sequence of fixation

For fixation of both anterior and posterior pelvic ring disruption, sequence of fixation is controversial.

If posterior ring is reduced in good position, percutaneous screw fixation is enough for sacro iliac joint disruption followed by anterior reduction.

Whereas if posterior ring is not reduced,an anterior reduction and temporary fixation should be done initially and then posterior open reduction and screw fixation performed followed by anterior definite fixation .

DEFINITIVE FIXATION OF SACROILIAC JOINT DISRUPTIONS

Treatment options available are

1. Percutaneous ilio sacral cancellous screw fixation.
2. Open reduction internal fixation with ilio sacral cancellous screws.
3. Open reduction and internal fixation with reconstruction plate through anterior intra pelvic approach.
4. Open reduction internal fixation with reconstruction plate through posterior extra pelvic approach.

DEFINITIVE FIXATION OF PUBIC DIASTASIS

- Single superior plate (Single-Plate)
- Superior and anterior plate (Dual-Plate)

DEFINITIVE FIXATION OF ILIAC WING FRACTURES

- Reconstruction plate with 3.5mm screw system
- Multiple lag screw

SURGICAL APPROACHES TO SACRILIAC JOINT

Surgical approaches to the pelvis and acetabulum carry a risk of injury to neurovascular structures during exposure.

Anterolateral intrapelvic approach [30] (Olerud approach)

The anterolateral approach corresponds to lateral window of ilioinguinal approach. Direct visualisation of anatomical structures and applying screws close to SacroIliac joint is easy through this approach.

- Skin is incised 4 cm proximal to the highest point of the iliac crest to a point just distal to the anterior superior iliac spine.
- Aponeurosis of external oblique muscle is erased from iliac crest subperiosteally. Care should be taken to protect lateral cutaneous nerve of thigh which runs close to anterior superior iliac spine. Bleeding from avulsed nutrient vessels in iliac bone may occur and should be sealed with bone wax.
- Blunt dissection is carried out subperiosteally along the internal iliac fossa, down to the pelvic brim and sacroiliac joint. Medial retraction of iliacus and psoas muscles will expose the ala of sacrum.
- Major risk in this approach is injury to L5 nerve root which is avoided by staying close to sacroiliac joint.

POSTERIOR EXTRAPELVIC APPROACH

Since there is no inter nervous plane in this approach, damage to neurovascular structures is less. But since most of the patients are having associated injuries, positioning the patient in prone is very difficult in acute cases. Soft tissue coverage in posterior approach is less which leads to delayed or impaired wound healing and subsequent infections.

SKIN INCISION

- Place the patient in prone position with adequate bolsters support. About 1 to 2 cm proximal and lateral to the posterior superior iliac crest, skin incision is started and extended downwards up to the level of the greater sciatic notch.
- Subperiosteally gluteus maximus is erased from ilium, along with medius and minimus. Posterior inferior iliac spine and the lower part of the Sacroiliac joint are now exposed by extending dissection distally.

- Care should be taken while dissecting greater sciatic notch to prevent injury to superior gluteal artery and its accompanying nerve. Excessive traction of gluteus maximus may also injure these structures.
- Mobilise the pirifiormis muscle in greater sciatic notch to palpate anterior aspect of SI joint.
- If necessary, elevation of the erector spinae and multifidus muscles is done which will expose the dorsal surface of the sacrum.

FIXATION OF SACROILIAC JOINT:

a) Cancellous screw fixation
b) Plate osteosynthesis
   i) Anterior
   ii) posterior
c) Tran-iliac bars or rods in combination with posterior screws.

Posterior approach

After exposing Sacroiliac joint, thorough debridement and anatomic reduction of joint should be done. Bone reduction clamps can be used to reduce the ilium with sacrum, across the SI joint and also to align sacral fractures. Reduction can be assessed by using Fluoroscopy as well as with direct

visualization. Alignment of the disrupted joint can be palpated anteriorly by a finger through the greater sciatic notch.

After reduction, a 6.5mm cancellous screw can be used to fix sacroiliac joint as lag screw. 3.5mm screws with reconstruction plate also can be used. The plate can be used as a reduction tool by doing over contouring.

The midpoint of a line from the iliac crest to the greater sciatic notch and 15 mm anterior to the crista glutea- the entry point for the lag screw is made, which is at right angle to the surface of the ilium.

Advantages and disadvantages

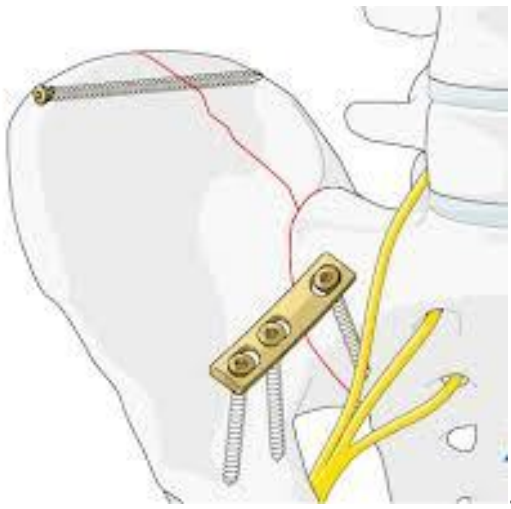
- Good visualisation of the sacroiliac joint and good reduction can be achieved. Posterior aspect is strongest in plate fixation compare with anterior.
- The disadvantage is wound dehiscence.
- In patients with severe soft tissue injury it is contraindicated.

ANTERIOR APPROACH [30]

The patient is placed supine with the injured side tilted up with a roll for easier access and manipulation. After exposing anterior aspect of SI joint, ilium which is usually displaced superiorly and posteriorly is reduced by hip flexion and in line

traction. Reduction clamp is placed from the sacral ala to the ilium along the inner table to bring the ilium into place.

A Schanz pin placed in the ilium which can be used to get reduction. Temporary reduction can be held with K wires. After adequate reduction is obtained, permanent fixation is done commonly by one or two reconstruction plates. Screws should be parallel and away from sacroiliac joint. Over sacral ala one screw is enough provided it is in good purchase. Avoid damage to L5 nerve root or lumbo sacral trunk.



Advantages and disadvantages:

- Advantage of this approach is that fixation of both anterior and posterior can be done in single sitting and thus exposure to sacroiliac joint is easy.
- Reduction of the sacroiliac joint is easy and good with success rate of 85% to 95%.
- Major disadvantage of this approach is injury to fifth lumbar-nerve root while doing dissection or retraction.

- Up to 30% of patients have injury to lateral cutaneous nerve of thigh in this approach.

ILIOSACRAL SCREW FIXATION

I. Open
II. Closed(percutaneous)
    a) Supine position
    b) Prone position

Percutaneous screw fixation:

This technique was popularized by Routt who report on a large series of patients operated in the supine position. Understanding of sacral anatomy and good imaging technology will make this percutaneous screw insertion easy.

Position and drape:

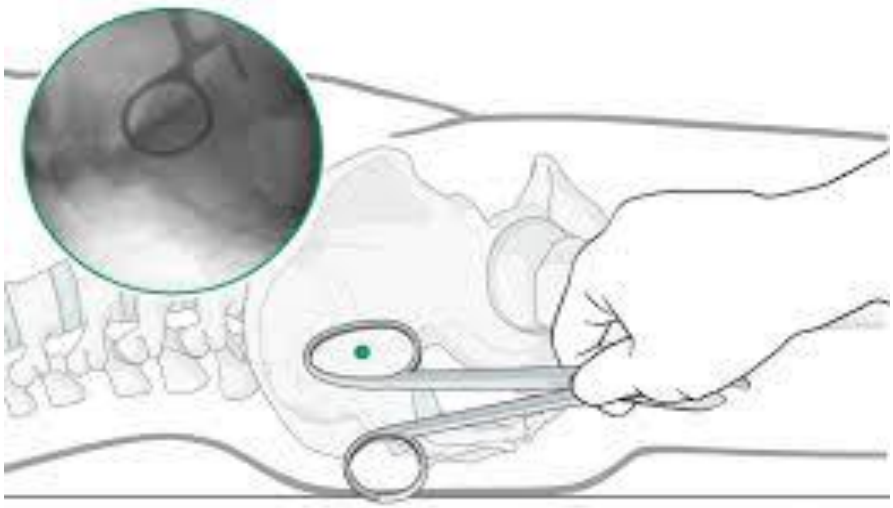
Place the patient in supine position and drape from nipple to groin. Affected limb is also draped so as to give traction for reduction. Before that check whether Antero-Posterior, inlet, outlet views are visible in C arm image intensifier.

A bump is used to lift the buttock off the bed to achieve a better entry point. Inhalational anaesthesia like nitrous oxide in bowel lumen can obscure anatomic details and make the procedure more difficult. Gas bubbles in the intestine lumen

which is leaked from endothelial capillaries can obscure outlines of sacral foramina.

Entry point

- Make an entry point in lateral view over triangular area between ventral and dorsal aspect of sacrum, posterior to iliocortical density.
- Entry point and reduction can be held with cannulated bone spike.



Reduction:

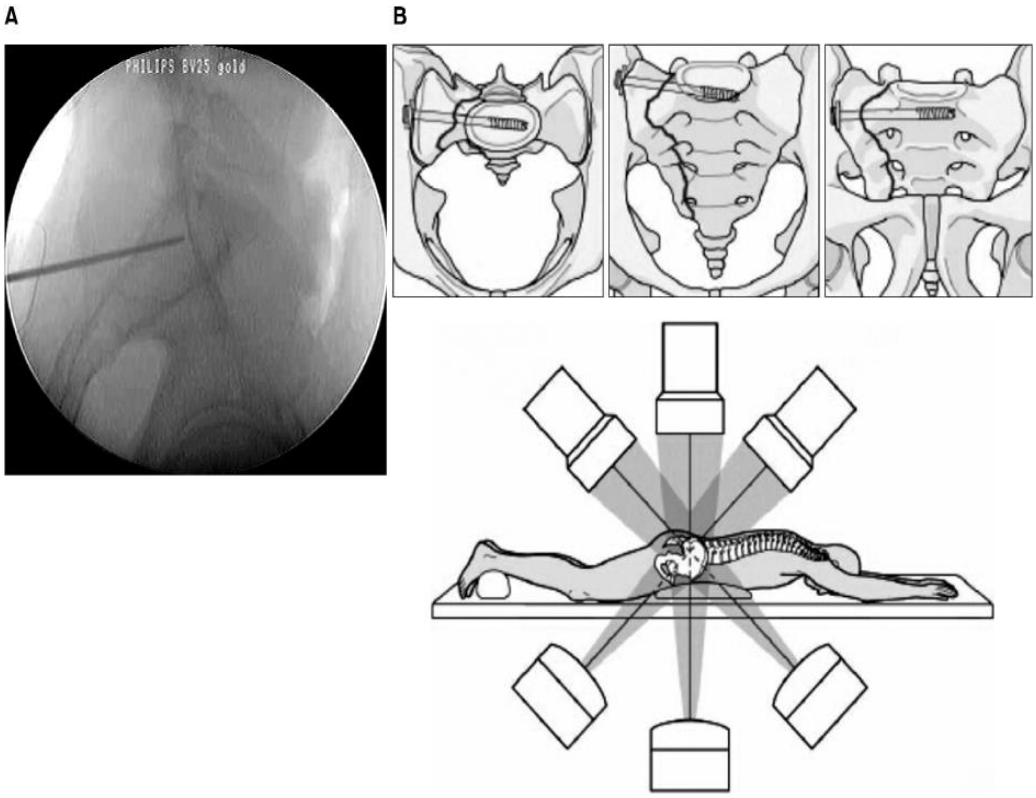
- While the lateral fracture fragment is displaced superiorly and posteriorly reduction can be achieved by giving traction with the hip held in flexion.
- The leg is abducted or externally rotated to reverse the deforming forces with traction as per mechanism of injury.
- A Schanz pin placed in the ilium can be used as a joystick to reduce the hemi pelvis in position.

Screw insertion:

A guide wire is inserted and checked with the outlet view where the wire is above the first sacral foramen and inlet view where the wire is aimed toward the first sacral body.

- In lateral view, the wire should lie posterior to the iliac cortical density and within the ventral and dorsal surface of sacrum [38].
- Once guidewire position is adequate, the length of the wire should be measured to apply cancellous screw.
- Partially threaded 6.5 mm cancellous screw is used.

  A washer is used when the degree of compression required is more. Usually one screw is enough but in case of highly unstable dislocation two screws may be required. The placement of second screw in S1 may be difficult, so it may be inserted in S2 body. In about 30% patients dysmorphism of S1 body is seen, in such cases, screw is placed in S2 body.
- For application of iliosacral screw for sacral fracture, fully threaded 6.5 mm cancellous screw is applied which crosses midline as through and through and engages in opposite side of sacral ala .



Advantages

- ❖ Less soft tissue dissection
- ❖ Minimal blood loss
- ❖ Minimal operative duration
- ❖ Cost effectiveness
- ❖ Low wound healing problem

SACRAL DYSMORPHISM [24]

While applying sacroiliac screw, knowledge of posterior pelvic anatomy and its variation is important to ensure safe placement. Following features indicates dysmorphic sacrum.

1. Upper sacrum collinear with iliac crest
2. Mammillary process in the alar region

3. Uppermost sacral foramen are larger, mis-shapen and irregular
4. Residual disc space between upper and second sacral segments
5. Alar slope more acute on lateral view
6. Tongue –in groove in sacroiliac articulation in CT scan
7. Anterior cortical indentation

ROLE OF MODIFIED STOPPA'S APPROACH:

Pelvic ring fractures involving anterior region, and associated fractures of anterior column of acetabulum is fixed using modified Stoppa's approach.

The ilioinguinal approach is performed by majority of surgeons and showing a potential to high complication rates for those fractures.

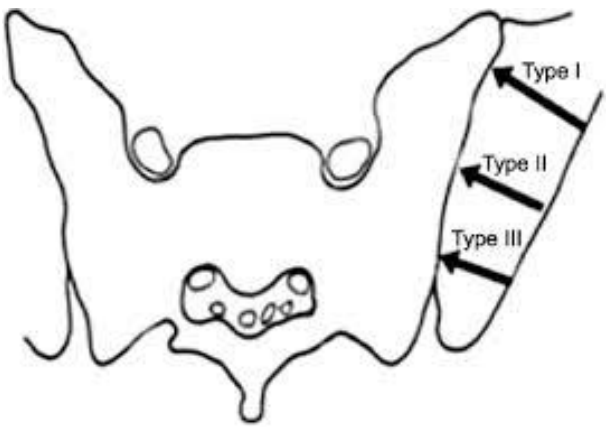
- The modified Stoppa'sapproach is used for applying an infrapectineal plate for the treatment of anterior injuries of the pelvic ring and acetabulum fractures.
- The advantages of this approach is smaller surgical incision and soft parts dissection, which reduces risks of complications and allows for placing plates directly at the inner surface of the pelvis.

CRESCENT FRACTURE

- This fracture is defined when the fracture line passes through the portion of the sacroiliac joint and exits through the ilium. The fragment which contains PSIS and PIIS is called crescent fragment [4].

The sacro-iliac ligaments hold the portion of the iliac wing to the sacrum. This bone fragment resembles a crescentic moon, hence the term.

- Three types of crescent fractures are type I anterior, type II middle, type III posterior. Most common type is II which need sacro iliac screw fixation definitely. In type I most of the fragment is attached to sacro iliac ligaments and type III only posterior fragment is avulsed.



- It comes under lateral compression type II in the Young–Burgess classification system.
- Open reduction and internal fixation of this fracture done through most commonly by anterior iliac fossa approach. Reconstruction plate or lag screw is used for fixation.

PUBIC DIASTASIS FIXATION

Indications:

- Pubic Diastasis more than 2.5 cm.
- Vertical shear injuries

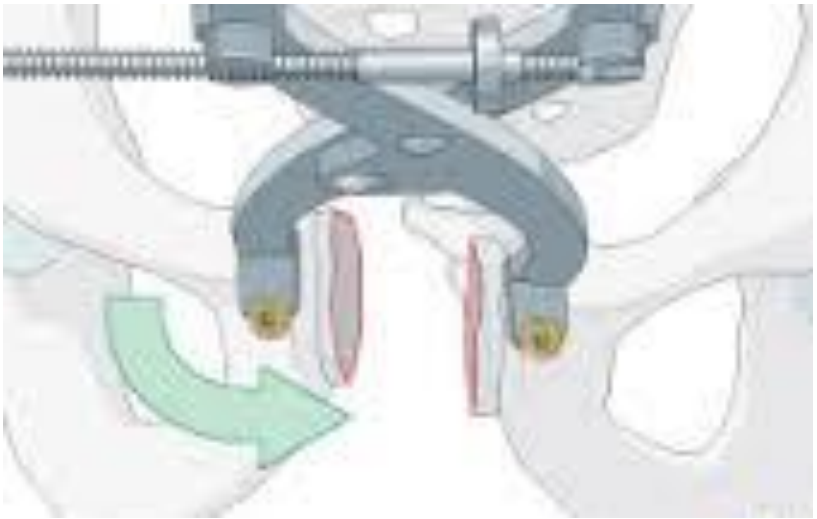
SURGICAL APPROACH FOR PUBIC DIASTASIS FIXATION [2]

- After palpating bony landmarks, make 15cm curved horizontal incision over lower abdomen, 1cm above symphysis pubis.

Pfannenstiel incision

- After incising subcutaneous fat ligate the superior epigastric vessels. Incise rectus sheath and make dissection deep and lateral upto external inguinal ring

- Reach the symphysis pubis and space of Reitz and retract the bladder. Reduce the symphysis with reduction clamp



Reduction of symphysis pubis

- Place the 4 hole recon plate/Asian dynamic compression plate in either superior alone, or anterior and superior as dual plate for definitive fixation

- Place the screw in superior plate as medial screw in vertical fashion and 2nd screw in oblique fashion to avoid injury to structures in obturator foramen. In anterior plate fixation avoid placing screws more prominently in posterior aspect to reduce bladder injury.

Fixation of rami fractures:

Indication:

- Rami fractures with vertical shear injuries
- Rami fracture which displace more than 2.5 cm

Techniques:

1) Open reduction internal fixation with recon plate
2) Percutaneous screw fixation
  a) Retrograde screw fixation
  b) Antegrade screw fixation

Prerequisite for percutaneous screw fixation is-reduction before inserting screw. This can be achieved by closed or small stab incision over fracture site and reduction with bone hook.

Obturator outlet view and iliac inlet views are very important views to place the screw percutaneously.

Loss of reduction in rami fracture mostly at the level medial to lateral border of obturator foramen.

Antegrade screw fixation:

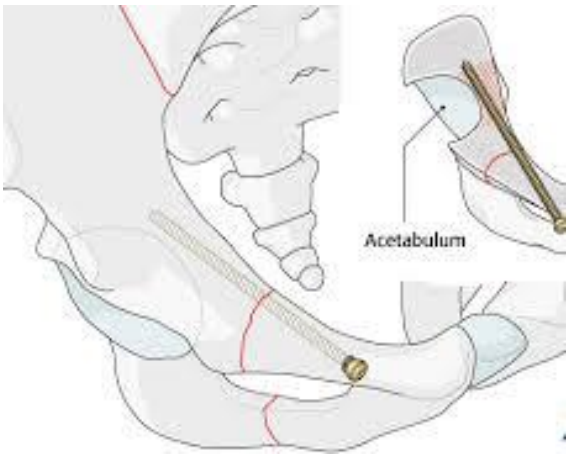
This fixation is mostly used for

- Rami fracture lateral to obturator foramen,
- Middle of the ramus
- Morbidly obese patient.

A midpoint on a line between the tip of greater trochanter and a point 4 cm posterior to ASIS is taken as entry point in supine or prone position. A 6.5 mm cancellous screw is used for fixation. The failure rate is less when compared with retrograde fixation.

Retrograde screw fixation:

- This is mostly for fracture involving more medial ramus.
- Small incision over opposite pubic tubercle is applied. Sliding hole is first created with a 3.5/4.5 mm drill bit.



- A 6.5 mm/7.3 mm cannulated cancellous screw is inserted after guide wire placement upto just medial to acetabulum.
- Biplanar obturator outlet views and inlet views are obtained to confirm screw placement.

MATERIALS AND METHODS

Place of study : Institute of Orthopaedics and Traumatology, Rajiv Gandhi Government General Hospital, Chennai

Type of study : Prospective and retrospective study

Sample size : 40 (Prospective-25, Retrospective- 15)

Period of study : Prospective study from September 2015 to September 2016, Retrospective study from 2014

INCLUSION CRITERIA

1. Pubic diastasis
2. Iliac wing fractures
3. Sacro-iliac joint disruption
4. Pelvic fractures with associated injuries (head injury, chest injury, abdominal and pelvic visceral organ injuries, other skeletal fractures and spine fractures)
5. Pelvic fractures with acetabulum fracture
6. Closed/open pelvic fractures.

EXCLUSION CRITERIA

1. Paediatric population
2. Isolated acetabulum fractures
3. Pathological fractures

PREOPERATIVE EVALUVATION

In acute presentation, patients with pelvic ring disruption, ATLS protocol was followed. All stabilised patients were subjected to the following

- Detailed clinical examination
- Complete haemogram
- Renal function tests
- Radiographs of the Pelvis (Antero-posterior, Inlet and Outlet views).
- CT pelvis with 3D reconstruction
- CT abdomen/CECT KUB with cystogram/CT study for associated injuries
- MRI of sacroiliac joint

IMPLANT AND INSTRUMENTS

In closed percutaneous fixation 6.5 mm partially threaded cannulated cancellous screw was used. In open reduction and internal fixation anteriorly, two or three holed reconstruction plate with 3.5mm cortical screws are used. In open reduction and internal fixation posteriorly, either cancellous screw or plating can be done.

CHOICE OF APPROACH

- In patients where closed reduction of the sacroiliac joint is obtained and are not associated with other pelvic fractures, percutaneous fixation is done.
- In patients where closed reduction cannot be obtained, open reduction and internal fixation done through anterior approach.

- In patients with associated iliac wing, acetabulum and rami fractures, antero-lateral approach is used, so that other fracture fixation can be done through same approach.

POSTOPERATIVE PROTOCOL

1) Nil per oral until bowel sounds and passing of flatus.
2) Drain was removed on the 2nd post operative day when collection being less than 20 ml for a period of 8 hours. Post operatively intravenous antibiotic was administered for 5 days and oral antibiotic for another 7 days.
3) All patients were treated with prophylactic low molecular weight heparin postoperatively for two weeks and Aspirin for further 6 weeks. High risk patient was treated with 3 months of Aspirin.
4) Suture removal was done on 12thpost operative day
5) Oral diet was started only after flatus was passed and bowel sounds returned. Postoperative bowel regime should be aggressive and it should be a part of post operative protocol.
6) Patient was mobilised from bed to chair using uninjured leg as a pivot on the 1st post operative.
7) Touchdown weight bearing done for 10 to 12 weeks
8) Aid free ambulation after 12 weeks.
9) Progressive return to full activity usually began after 6 months.

10) Avoid of sitting crossed leg upto 3 months to reduce strain in sacroiliac joint.

FOLLOW UP

Patients were followed up at 4 weeks, 12 weeks and at 6 months. At each visit patient is subjected to the following,

1) Local tenderness of the sacroiliac joint while Tenderness on external rotation after 12 weeks

2) Clinical examination includes gait, Trendelenberg test, sacral /pubic tenderness, strength of lower limb muscle group

3) Functional ability of the patient (history)

4) Assessment of implants (radiographs) for:

   a) Loosening
   b) Infection
   c) Failure

5) Radiographic assessment
   i) -AP view
   ii) -Inlet view
   iii) -Outlet view

6) CT of SacroIiliac joint

FUNCTIONAL ASSESSMENT AFTER PELVIS FRACTURE

MAJEED SCORING SYSTEM

I. Pain (30 Points)	
Intense, continuous at rest	0-5
Intense with activity	10
Tolerable, but limits activity	15
With moderate activity, abolished by rest	20
Mild, intermittent, normal activity	25
Slight, Occasional or no pain	30
II. Work (20 Points)	
No regular work	0-4
Light work	8
Change of job	12
Same job, reduced performance	16
Same job, same performance	20
III. Sitting (10 Points)	
Painful	0-4
Painful if prolonged or awkward	6
Uncomfortable	8
Free	10
IV. Sexual Intercourse (4 Points)	
Painful	0-1
Painful if prolonged or awkward	2
Uncomfortable	3
Free	4

V. Standing (36 Points) A Walking aids (12 Points)	
Bedridden or almost	0-2
Wheel chair	4
Two Crutches	6
Two Sticks	8
One Stick	10
No Sticks	12
VI. B Gait Unaided (12 Points)	
Cannot walk or almost	0-2
Shuffing small steps	4
Gross limp	6
Moderate limp	8
Slight limp	10
Normal	12
VII. C Walking distance (12 Points)	
Bedridden or few metres	0-2
Very limited time and distance	4
Limited with sticks difficult without prolonged standing possible	6
One hour with a stick limited without pain	8
One hour without sticks slight pain or limp	10
Normal for age and generation condition	12

Functional outcome grading	**Points**
Excellent	>85
Good	70-84
Fair	55-69
Poor	<55

OBSERVATION

AGE INCIDENCE AND DISTRIBUTION

Age in years	No.of patients	Percentage
11-20	8	20
21-30	10	25
31-40	8	20
41-50	7	17.5
> 50	7	17.5
Total	**40**	**100**

SEX INCIDENCE

In our study male to female ratio is 32:8

MODE OF INJURY

Majority of patients suffered road traffic accidents followed by patients who sustained fall injury.

Mode of injury	No. of patients	Percentage
RTA	32	80
Fall from height	8	20

TYPE OF INJURY (CLASSIFICATION)

Classification	No. of patients
A1	1
A2	3
B1	9
B2	11
C1	14
C2	2

ASSOCIATED INJURIES

Associated injury	No. of patients
Bladder injury	1
Urethral injury	4
Multiple rib Fracture	1
Scapula Fracture	1
Distal radius	2
Acetabulum Fracture	7
Femur Fracture	3
Head injury	2
Spine injury	2
Humerus Fracture	2
Both bone leg Fracture	3
Perineal laceration	2
Clavicle	2

SURGICAL PROCEDURES

Various surgical procedures, implants and approaches used are as follows.

Procedure	No. of cases
Closed reduction and percutaneous iliosacral screw fixation under fluoroscopic guidance for SacroIliac joint distruption	7
Open reduction of pubic diastasis with plate	9
Open reduction and reconstruction plate fixation of iliac wing fractures	7
Emergency pelvic external fixation in unstable patient followed by elective percutaneous iliosacral screw fixation	3
Open reduction and internal fixation with reconstruction plate for SacroIliac joint	7
External fixation alone	5

SURGERY FOR ASSOCIATED INJURIES

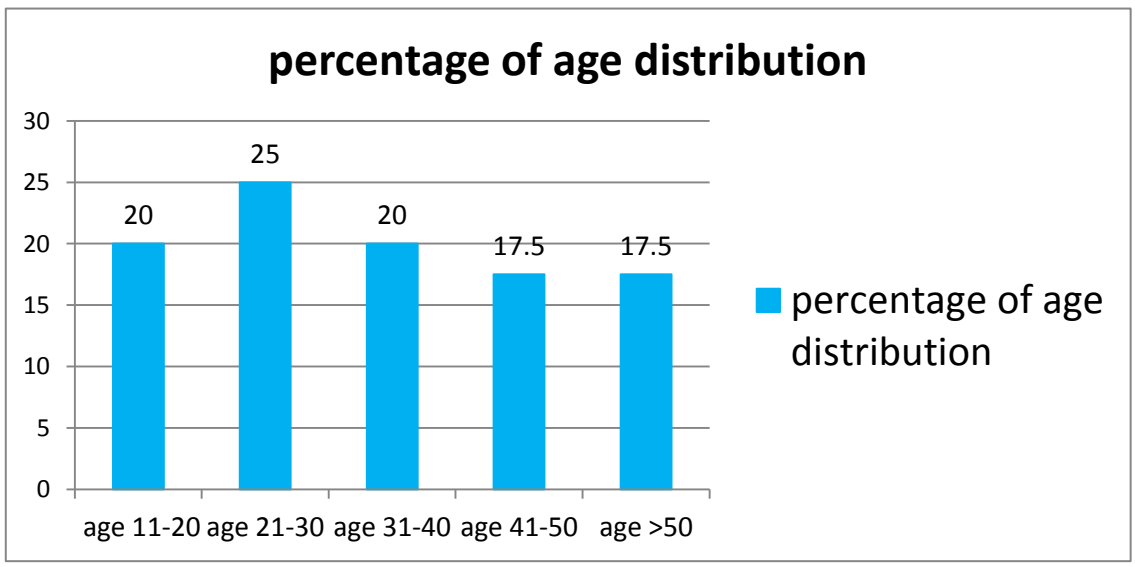
Urethral injury repair done	2
Fixation of long bone fractures	3
External fixation for compound long bone fracture	3
Posterior stabilisation for spine fracture	2
Repair for perineal laceration	2

DISCUSSION

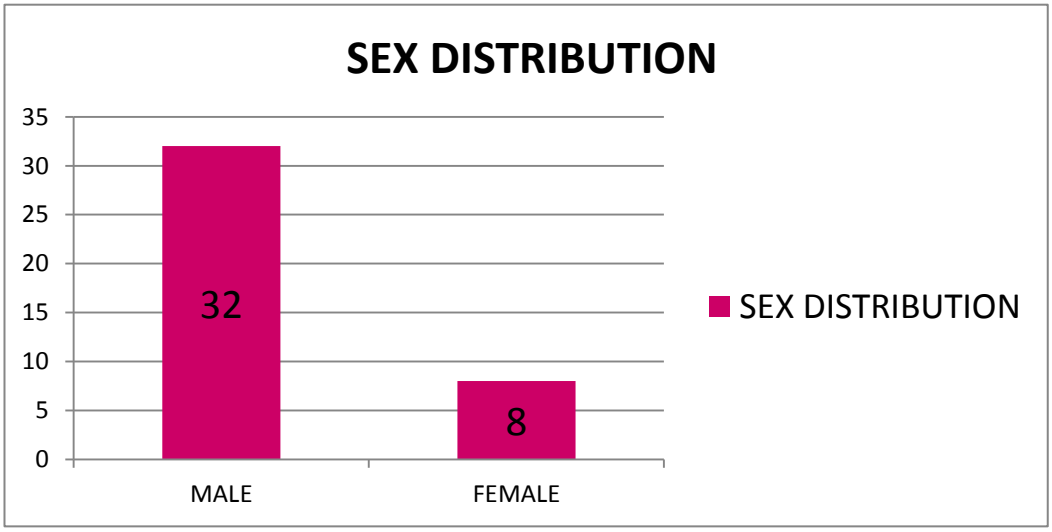
Despite aggressive resuscitation which also included application of external fixators, the mortality of 10 % remains unchanged. This led to clinical trials on internal fixation which showed that early open reduction and stable internal fixation improves the chances of survival and more importantly, reduces the incidence of late musculoskeletal morbidity.

Totally 40 patients in our study who got admitted in our institution with pelvic ring fractures from the period of 2014 to 2016 were analysed.

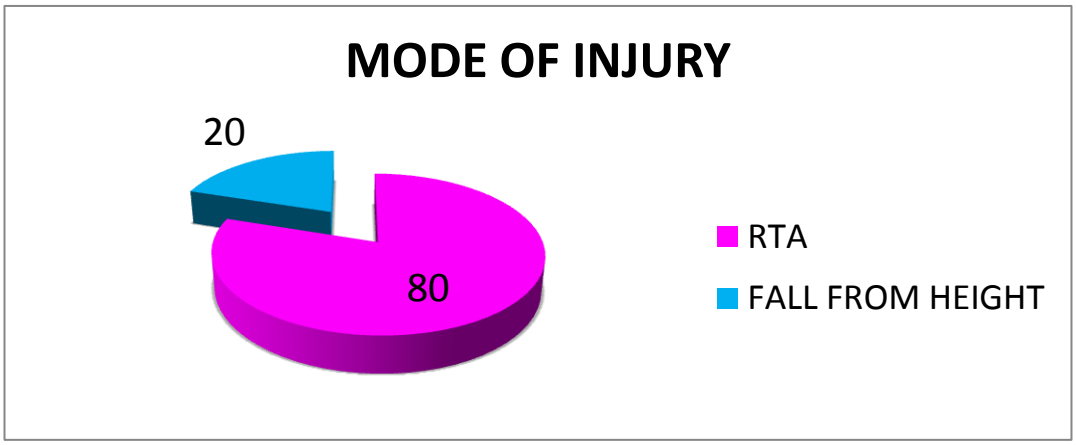
Commonest age group in our study is 20 -30 years. The mean age in our study is 33.5 years with range from 16 to 75, whereas Cole et al[5] reported an average age of 32 years.



Males are most commonly sustained such pelvic injury with (4:1) 32:8 male to female sex ratio. Cole et al [5] reported male preponderance with a male: female ratio of 36.28 in 64 patients. .



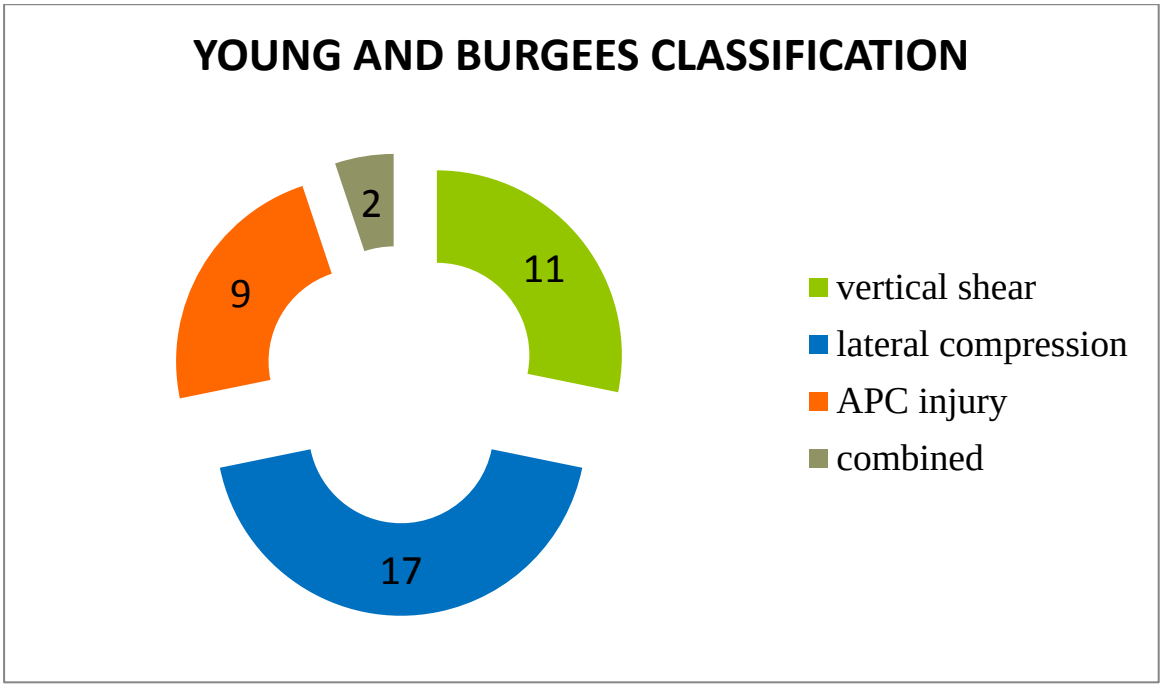
High velocity road traffic accidents accounts for 80% of our patients which is most common mode of injury in other study also[1, 18]. 20% patients have history of fall from height. Sunny Brook Medical Centre's prospective study reported 81% road traffic accidents [28].



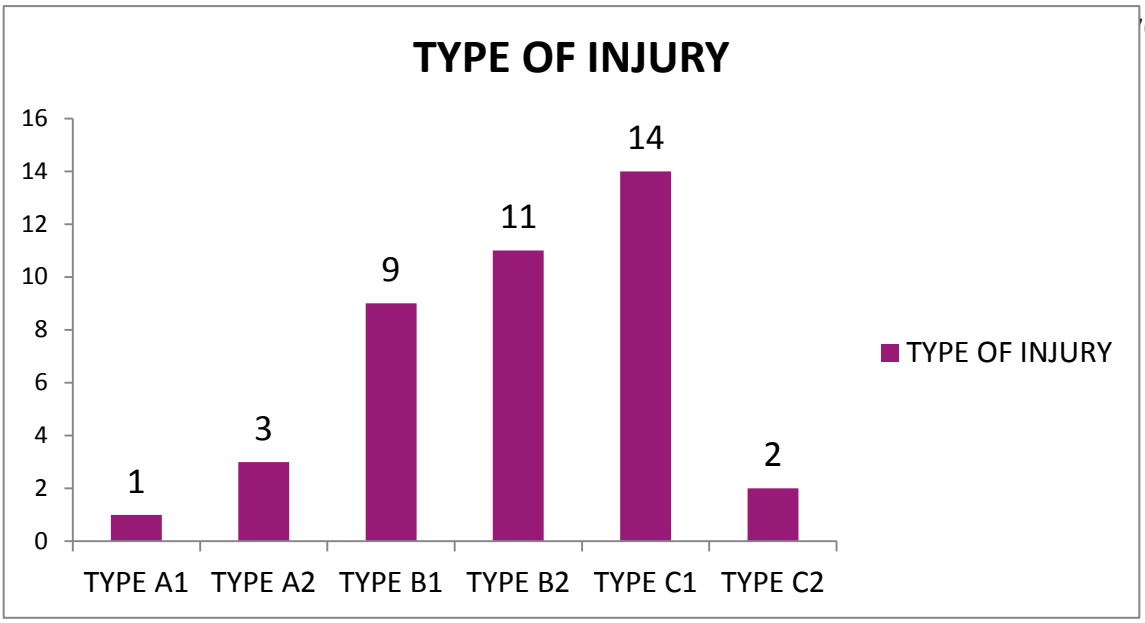
52.5% of our patients had associated injuries. Our study shows skeletal injuries to be most common associated injuries which are the

same as reported by Cole et al[5]. Urethral injuries are the most common visceral injuries. In Van Veen study 9 urethral injuries were reported [35].

Most common Young and Burgees type of injury is lateral compression injuries (17 cases /42.5%) with vertical shear injury 11 cases (27.5%).



As per Tiles classification, commonest injury was type B 20 cases others type A 4 cases, type C injury were 16. Tile's type C1 (unilateral vertical shear) was most common subtype (14 cases/ 35%) which correlate with Adam et al study [1]. We did not encounter any case with Tile's type C3. Cole et al [5] in their series of 64 vertically unstable injuries 75% of cases was Tile's type C1.



In our study 8 patients presents initially with haemodynamic instability which are managed with pelvic external fixation[7,19] along with initial resuscitation [23]. Of these 3 cases underwent definitive fixation with percutaneous posterior screw fixation.

Sacral fracture with neurological deficit was noted in two of our patients on admission. Neurology improved clinically at about 8 weeks of follow up.

Timing of definitive fixation depends on associated injuries and initial haemodynamic stability and resuscitation. Patients who need more than 3 units of blood transfusion in first 72 hours have more mortality rate and relatively less functional outcome. In our study delayed fixation was most commonly due to associated injuries and comorbid conditions.

Supine position was used when closed reduction of sacroiliac joint was possible and usually patient was less than 3 weeks

after injury and when anterior pubic diastasis plating was done. Prone position was used when symphysis pubis diastasis less than 2.5cm or anterior pelvic ring disruption just involved body of pubis without much displacement.

Definitive fixation was done in 18 patients with less than 3 weeks of their index admission and 14 patients had delayed definitive fixation after 3 weeks.

Definitive fixation for Sacroiliac joint disruption in less than 3 weeks allows closed reduction and percutaneous screw fixation which give excellent functional outcome in our study.

Parameters	No. of cases	Tiles type B (mean MFOS *)	Tiles type C (mean MFOS)
<3 weeks operated	19	9 (89)	6 (85.5)
>3 weeks operated	14	5 (83.6)	8 (68.62)
P value		0.255	

* MFOS –MAJEED FUNCTIONAL OUTCOME SCORE

In our study 19 patients had definitive fixation within 3 weeks of admission and all of them show excellent Majeed functional outcome score (MFOS), mean score for type B is 89, type C is 85.5 when compared with surgery done after 3 weeks (14 patients).The result is not significant as $p<0.05$ due to small sample.

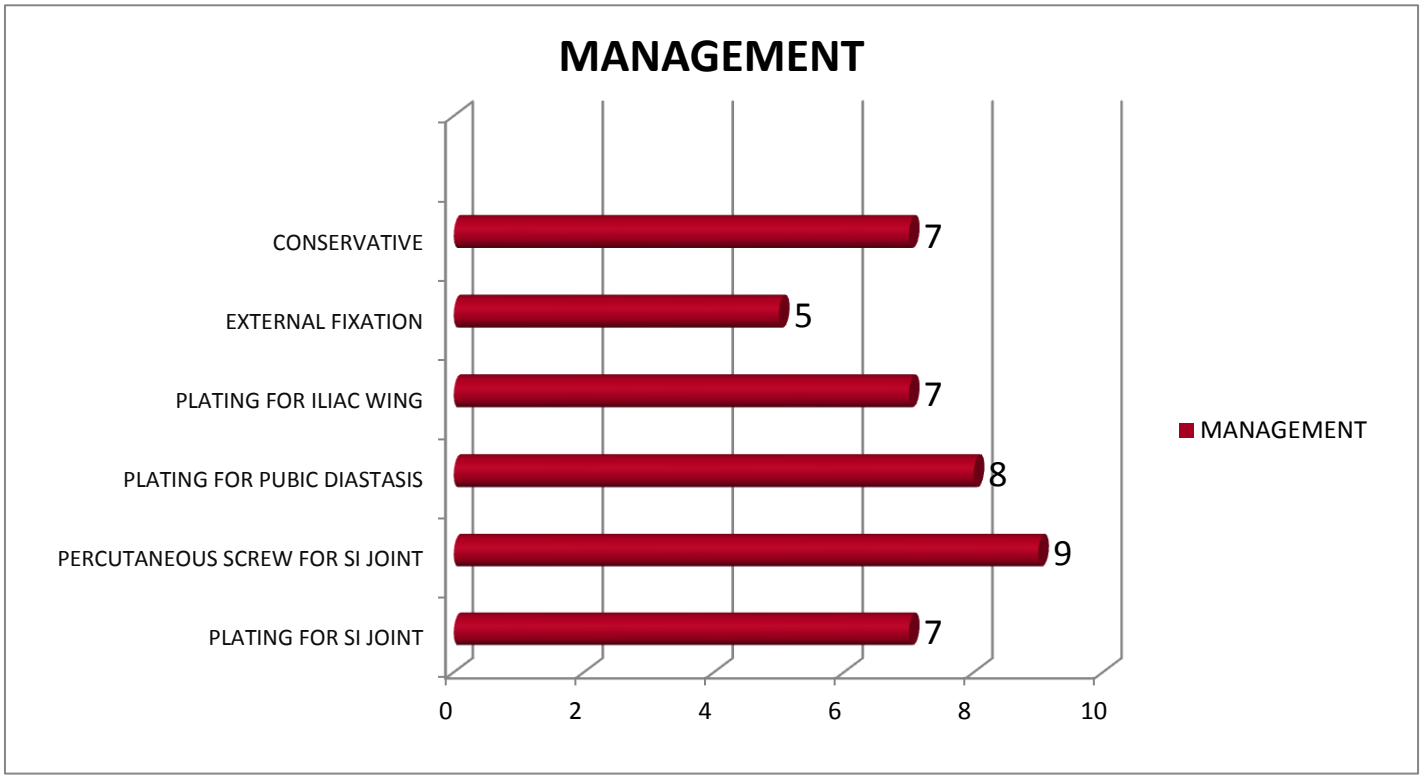
Sequence of fixation in less than 3 weeks cases fixed first posteriorly by closed reduction and screw fixation followed by

anterior symphysis plating. In delayed cases fixation was done in the sequence of anterior dissection – posterior sacroiliac joint reduction and stabilisation followed by anterior stabilisation.

Our study symphysis fixation was done by superior plating method and found adequate stability in our patients. Pubic diastasis more than 2.5 cm necessitate surgical fixation in the form of reconstruction plate [2,37].

We did Sacroiliac joint fixation using anterior reconstruction plate for 7 patients and percutaneous posterior screw fixation for 9 patients. In final follow up screw group shows mean Majeed functional score of 90.22 and plate groups shows 80.14. Our study finding correlates with other studies that the posterior percutaneous screw fixation has better stability and functional outcome results than plate fixation.

Displaced iliac wing fractures are managed with open reduction and internal fixation by reconstruction plate for 7 patients with final functional outcome score of 85.42 showing similar results in other studies[31]. Seven patients in our study were managed conservatively of which 5 patients are Tiles type B with minimal displacement and their mean MFOS was 85.33.



Seven patients in our study associated with acetabulum fracture for which reconstruction plate fixation was done in same stage.

Mortality rate in our study is 2.5 % .This refers to a patient who sustained anteroposterior compression injury (type b) to pelvis with associated compound perineal and urethral injury with severe contamination and patient expired.

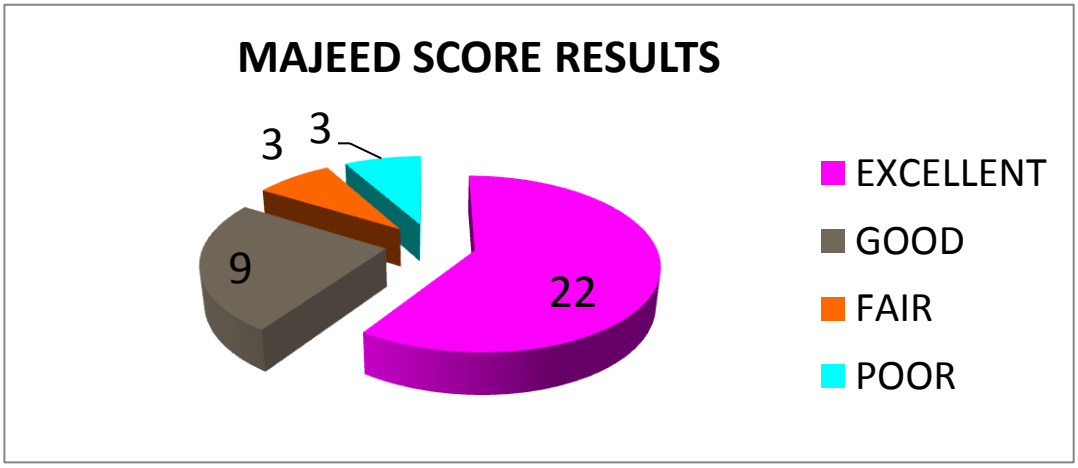
On follow up objective patients evaluation using oral questionnaire and clinical examinations shows none of the cases had impotence (male) and dyspareunia (females).

Prospective 25 cases with average follow up of 5.8 months range from 3 months to 11 months. Retrospective 15 cases managed from 2014 onwards.

Majeed outcome scoring system[22] has the advantage of including sexual function analysis which is psychologically the most important factor which is not included in other scoring systems. The functional outcome of these patients are analyse with Majeed outcome scoring system which include pain, sitting, standing, sexual intercourse, walking and radiological analysis.

Of these 40 cases 20 patients had excellent, 9 patients have good results. All these excellent, good score patients went back to their original job functions. Fair and poor results were mostly due to associated injuries and delayed presentations. Tiles type B fracture of 12 patients, type C of 7 patients were managed with excellent results, similar results are found in other studies also[20,21].

Mean score for type B is more than type C which is statistically significant.



Group Statistics

	Classific Recoded	N	Mean	Std. Deviation	Std. Error Mean
Majeed Score	Type B	19	**83.53**	10.162	2.331
	Type C	14	**75.07**	16.108	4.305
	P value		**0.037**		

Interpretation: The P-Value is 0.037. The result is significant at $p < 0.05$ (Group B Mean score is significant that of Group C mean score)

The incidence of deep vein thrombosis in unstable sacroiliac joint disruptions was 10-80% in various studies. We used thromboprophylaxis in patients who underwent open reduction and internal fixation through anterior approach. We didn't have any deep vein thrombosis as a complication in our study.

Gait disturbance was noted in 8 patients (18.42%) in which all patients are associated with lower limb fractures. One of the patients had pre-operative sciatic nerve injury which gradually recovered and gait improved

COMPLICATIONS ON ADMISSION:

Two patients in our study had L5 nerve root palsy on admission which improved to motor power of 3+ in 9 months. However, Cole et al[6] reported 19 cases of neurological injury in his series.

POST SURGICAL COMPLICATIONS:

One patient had implant failure in the form of screw breakage in pubic symphysis plating during follow up but the patient is asymptomatic. Other complications following surgery is included in table

Table: complication after surgery

Complications	No. of cases	Percentage	management
Implant failure (screw breakage)	1	2.5%	Conservative
External iliac artery injury (Surgery done 4 months post fracture)	1	2.5%	Above knee amputation
Wound dehiscence	1	2.5%	Flap cover
Superficial infection	1	2.5%	Antibiotics
Death	1	2.5%	-

CONCLUSION

- Pelvic ring injuries involving high energy trauma are better managed in tertiary care centre. Haemodynamic resuscitation measures and efficacy in initial evaluation and temporary stabilisation procedures are lifesaving in nature. We concluded that experienced and well equipped orthopaedic unit is an absolute necessity in ensuring not only a good functional outcome but also save the life of patients on initial presentation.
- Definitive skeletal stabilisation done less than 3 weeks have given excellent MFOS in our study when compare to patients with delayed presentation and operated after 3 weeks.
- Patients coming under Tiles type B and type C classification have shown that operative intervention ensures early return to their original job and excellent functional outcome in our study.
- Posterior percutaneous sacroiliac joint screw fixation is the dictum when it can be closely reduced and far superior than anterior sacroiliac joint plating in functional outcome and stability

CASE ILLUSTRATION

Case -1:

Ip no:133441

Occupation : Student

Date of admission :15/12/2015

Date of surgery : 25/12/2015

Date of discharge :7/1/2016

Age & sex: 19 yrs male

Mode of injury: Road traffic accident.

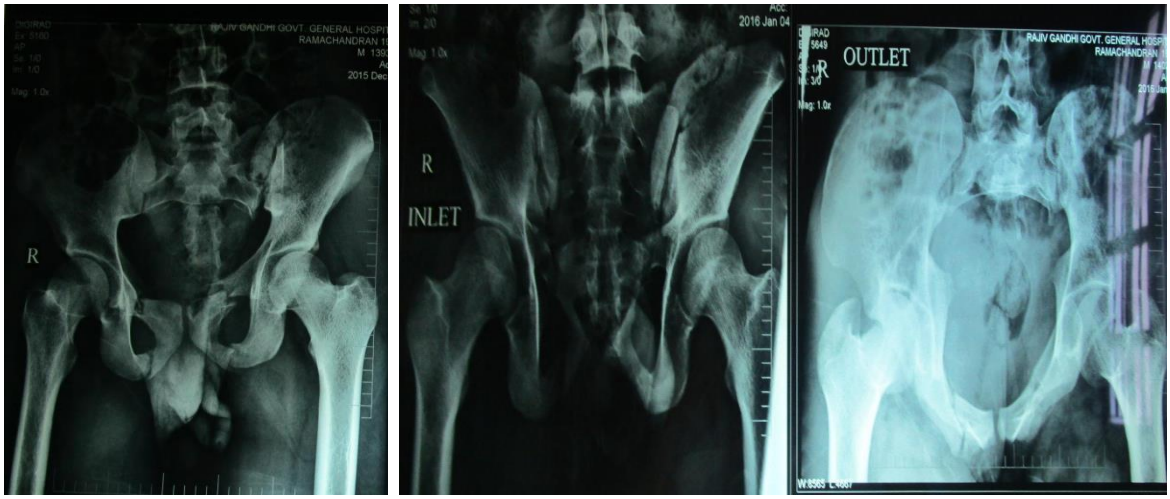
Classification: Bilateral superior and inferior pubic rami fracture with left side sacroiliac fracture disruption (crescent fracture). Tiles type B2

Management: open reduction and internal fixation for SI joint fracture disruption with recon plate

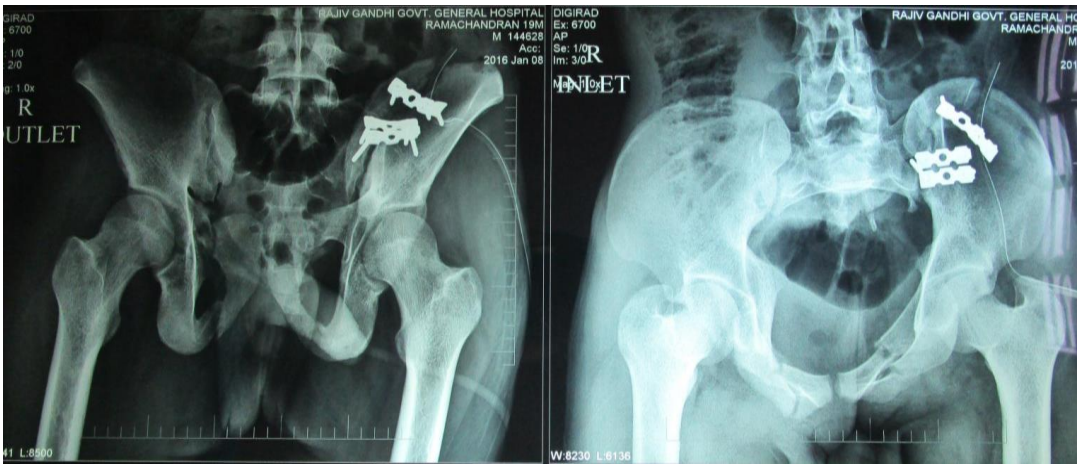
Majeed functional outcome score: excellent (90)

Post op Follow up: 9 month

PRE OP XRAYS

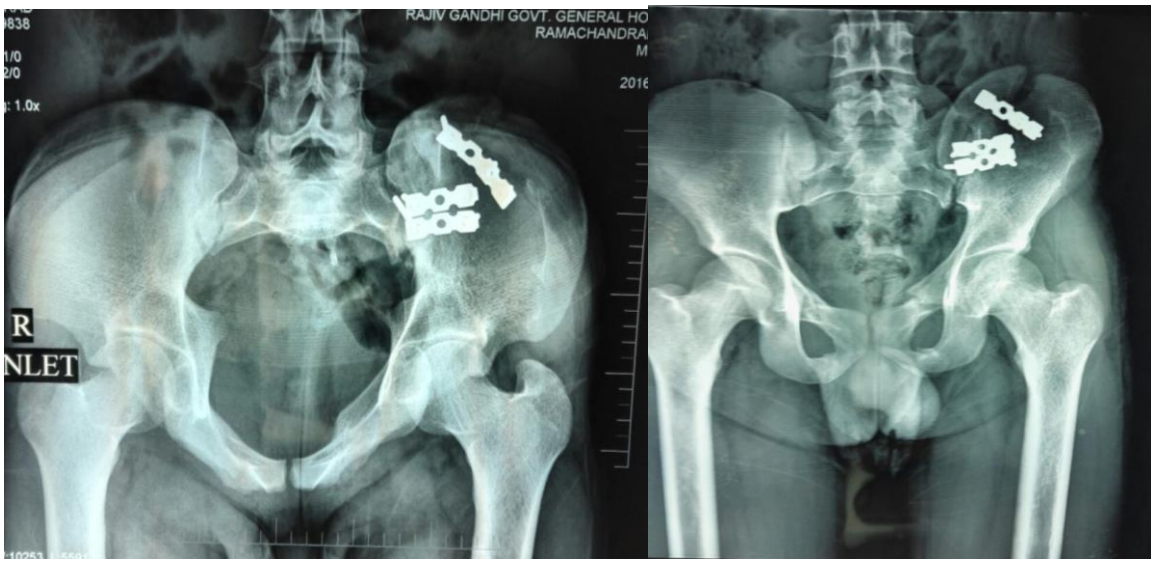


IMMEDIATE POST OP XRAYS



FINAL FUNCTIONAL OUTCOME AT 9 MONTHS

XRAY AT 9 MONTHS



Case -2:

Age & sex: 25 yrs male

I.P. no:5797

Occupation :Own business

Date of admission :1/8/2014

Date of surgery : 11/8/2014

Date of discharge :22/8/2014

Mode of injury: Road traffic accident.

Classification: pubic diastasis (APC type II)

Management: Initially treated with external fixation later open reduction and internal fixation for pubic diastasis with reconstruction plate

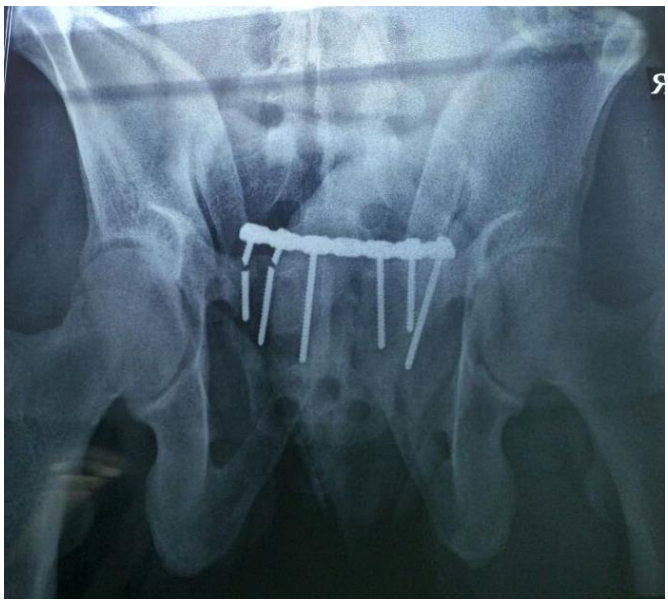
Majeed functional score: excellent (89)

Post op Follow up: 24 month

Complication: Implant failure (broken screws) patient is asymptomatic

PRE & POST OP XRAYS

IMPLANT FAILURE AT 16 MONTHS



FUNCTIONAL OUTCOME AT 24 MONTHS

I.p.no:66434

Occupation: farmer (manual labourer)

Date of admission :23/6/2015

Date of surgery : 06/7/2015

Date of discharge :18/7/2015

Case -3:

Age & sex: 48 yrs male

Mode of injury: Fall from height

Classification: Bilateral superior and inferior pubic rami fracture with Right side sacroiliac fracture disruption with iliac wing fracture (Tiles type C1.1)

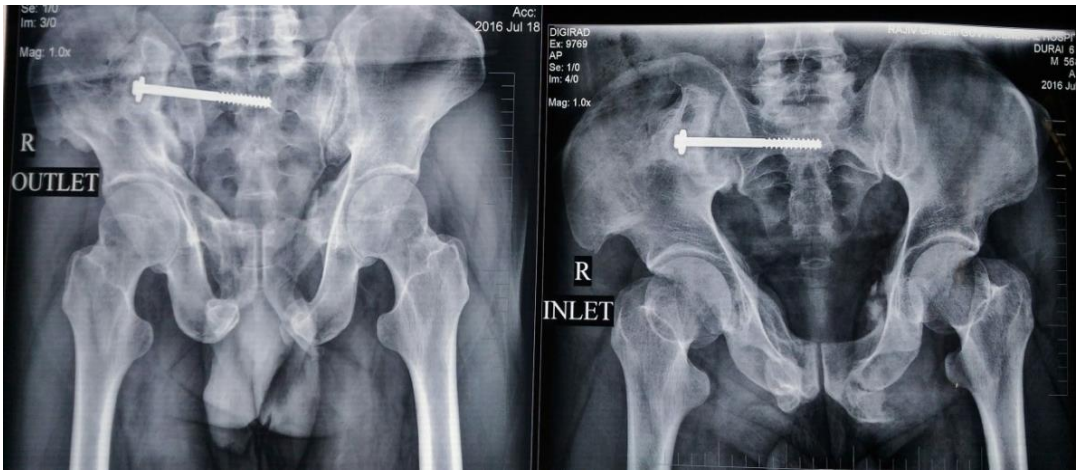
Management: Percutaneous screw fixation for SI joint disruption

Majeed functional outcome score: excellent (88)

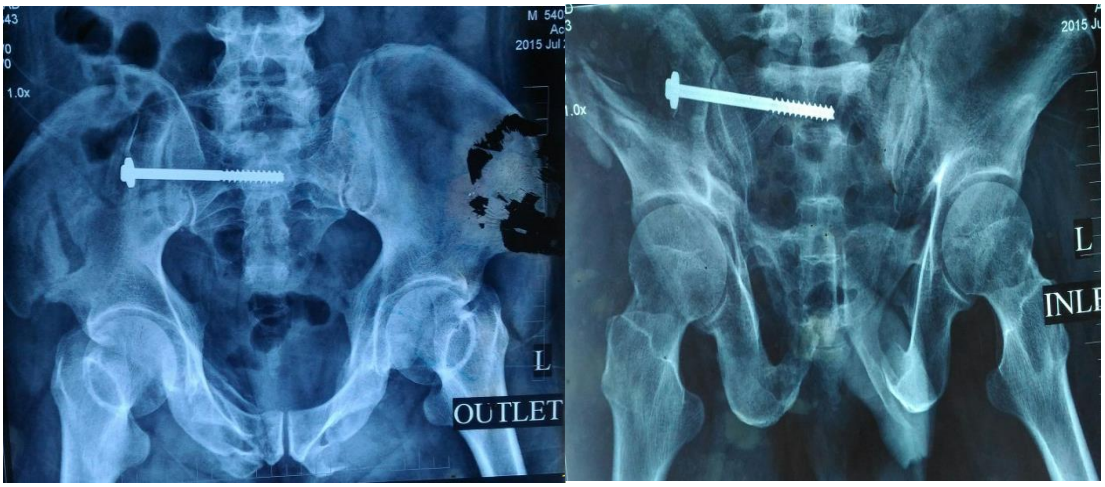
Post op Follow up : 10 months

PRE OP XRAYS

2 MONTHS FOLLOWUP



FINAL FUNCTIONAL OUTCOME AT 10 MONTHS



Case -4:

Age & sex: 55 yrs male

Mode of injury: Road traffic accident.

Classification: Left side sacroiliac fracture disruption (crescent fracture) with pubic diastasis (Tiles type B2)

Management: open reduction and internal fixation for SI joint fracture disruption and pubic diastasis with recon plate

Ip no: 68559

Occupation : Manual labourer

Date of admission :9/3/2015

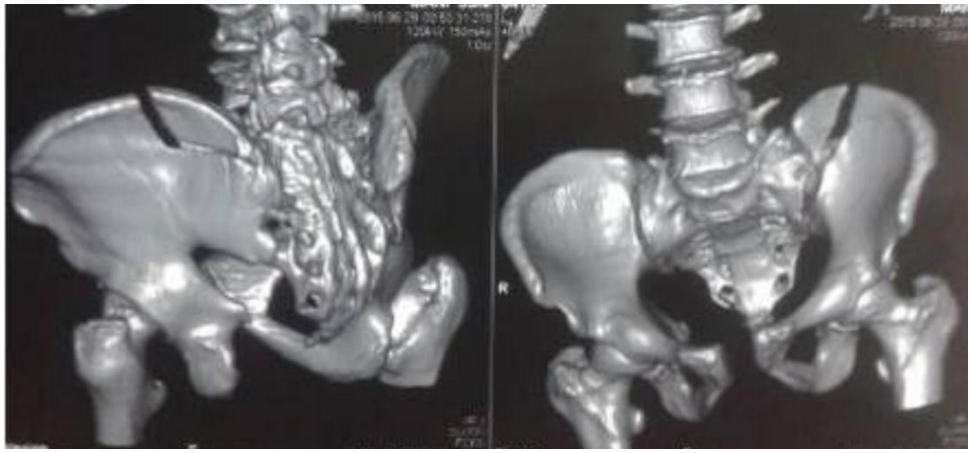
Date of surgery : 21/3/2015

Date of discharge :2/4/2015

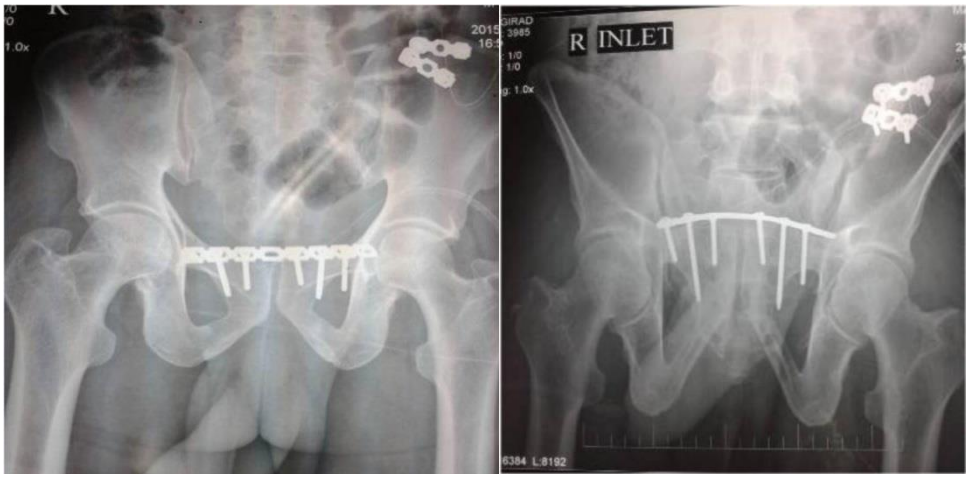
Majeed functional outcome score: excellent (86)

Post op Follow up: 16 month

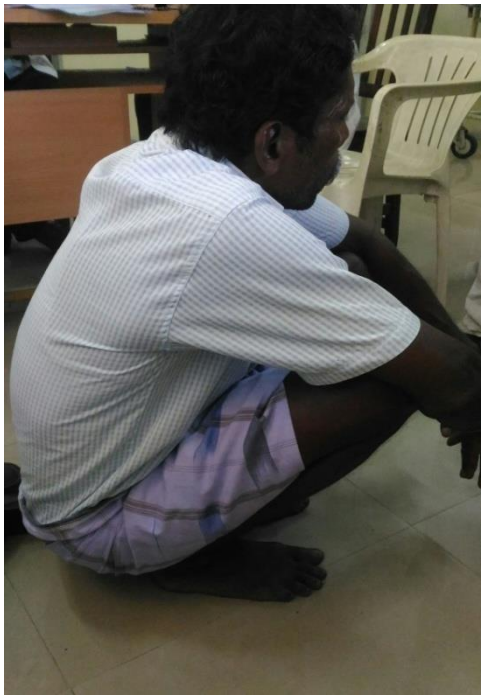
PRE OP IMAGE



POST OP XRAYS



FUNCTIONAL OUTCOME AT 16 MONTHS



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MASTER CHART

s.no	Name	Age /sex	Date of admission	Mode of injury	Diagnosis	mechanism of injury	Associated injury	Tiles classification	Procedure	Complication	Follow up	result	surgery for associated injury	Majeed score
1	Krishnan	33/ m	3/9/2015	RTA	iliac wing # extent uptosi joint with joint disruption and rami #	Vertical shear	no	TYPE C1	Orif with recon plate for si joint	None	17 months	excellent		86
2	Maria pandy	25/ m	12/8/2014	RTA	iliac wihsi joint disruptionng # wit	Vertical shear	no	TYPE C1.2	Orif with recon plate for si joint	none	20 months	excellent		88
33	Sakthivel	32/ m	4/2/2016	Accidental fall	iliac wing #	Lateral compression	Multiple rib # ,scapula#	TYPE A2	Orif with recon plate for iliac wing	None	5months	Excellent		85
4	Thirumal	16/ m	8/18/2015	Fall from height	iliac wing # with rami #	Vertical shear	Distal radius #ith ant column of acetabulum fracture	typre c1.2	Orif with recon plate for iliac wing #	None	11 months	Excellent		86
5	Rakesh	16/ m	7/13/2015	Fall whie playing	asis avulsion	Avulsion injury to asis	No	TYPE A1	Conservative	None	12months	Excellent		88
6	andal	48/f	5/16/2016	RTA	b/l sup and inf rami #	APC injury	urethral injury,vaginalinjury,perineallaceration,iliac vessel injury	TYPE B1	ext.fixation	septicemia		expired	urethral repair,vaginalrepair, raw area debridement ,rtak amputation	0
7	mani	55/ m	6/29/2015	RTA	pubic diastasi with iliac wing # with si joint disruption	vertical shear	no	TYPE C1	recon plate for pubic diastasis and iliac wing	none	13 months	excellent		88
8	murugavel	41/ m	7/12/2016	Fall from height	pubic diastasis	vertical shear	no	TYPE C1.3	asiandynaamiccompresion plate for pubic diastasis	none	2 months	excellent		87
9	prabhu	31/ m	2/8/2016	RTA	si joint disruption with rami # lt side	APC injury	subtrochanteric and t type acetabulum fracture	TYPRE B2.1	external fixation followed by locking plate for pubic diastasis and percutaneous screw for si joint	none	7 months	good	dhs for subtrochanteric #	85
10	shafi	30/ m	7/24/2016	RTA	pubic uptiondiastasis with rtsi joint disr	APC injury	perinealtear,urethralinjury,gr 3a comp SOF#,gr 1 comp BB leg #	TYPE B1	ext fixation		1 month	good	supra pubic catheter for urethral injury	80
11	syedgoush	40/ m	1/16/2016	RTA	pubic diastasis	APC II INJURY	no	TYPE B1	recon plate for pubic diastasis and percutaneous screw for si joint	none	7 months	excellent	no	88
12	velmurugan	42/ m	2/3/2016	RTA	pubic diastasis	APC II INJURY	l3-4 fracture without deficit	TYPE B1	asiandynaamiccompresion plate for pubic diastasis	none	7 months	GOOD	POST stabilisation for l3,l4 fracture	87
13	vinoth	18/ m	5/13/2016	fall from tree	pubic diastasis	APC INJURY	proximal humerus	TYPE B1	recon plate for pubic diastasis	none	4 months	good		86

14	rajesh	29/m	5/16/2016	RTA	pubic diastasis with zone 2 sacrum #	vertical shear injury	no	TYPE C1.3	Conservative	l4,l5 weakness	3 months	good		82
15	murugan	37/m	7/10/2016	RTA	pubiiscdiastas	APC injury	gr 3a tibial plateau #	TYPE B1	external fixation		2 months	fair	ext fixation for tibial plateau #	58
16	durai	48/m	6/23/2015	fall from height	rt side si joint disruption with ilac wing # with b/l rami #	vertical shear	no	type c1.1	percutaneous si joint screw fixation	none	15 months	excell ent	none	88
17	ramachandran	19/m	12/15/2015	RTA	lt side si joint disruption with ilac wing # with b/l rami #	vertical shear	no	TYPE C1.1	recon plate for si joint	none	9 months	excell ent	none	90
18	amir	18/m	6/20/2015	RTA	rt side si joint disruption with ilac # with sacral ala # and rami #	Lateral compression	posterior urethral injury,sciatic nerve injury	TYPE B2.1	pelvic external fixation	bed sore	14 months	good	urethral repair	83
19	amudha	60/f	4/15/2016	RTA	sacrum zone 2 # with rami #	Lateral compression	acetabulum	TYPE B2.1	Conservative	no	5 months	excell ent		89
20	balathandayut ham	56/m	6/17/2015	RTA	iliac wing #	Lateral compression	no	type a2	lag screw and recon plate fixation	no	14 months	excell ent	no	89
21	loganathan	50/m	10/7/2015	RTA	rtsi joint disruption ,iliac wing fracture ,spr #	vertical shear injury	urethral injury	TYPE C1.1	ext fix followed by percutaneous screw for si joint	no	10 months	excell ent	no	88
22	manikandan	23/m	3/23/2016	RTA	pubic diastasis with sijt disruption	vertical shear injury	no	TYPE C1.2	percutaneous screw for si joint	no	6 months	excell ent		89
23	preethi	26/f	6/15/2015	RTA	sacrum # si joint disruption ,blspr and ipr #	vertical shear injury	no	type c2	initialy skeletal traction followed by percutaneous screw fixation for si joint	no	12 months	good	no	77
24	viswanathan	29/m	3/28/2016	RTA	pubic diastasis with sijt disruption with acetabulum #	vertical shear injury	acetabulum#	TYPE C2	recon plate for si joint and acetabulum 3	ilia vessel thrombosis leads to above knee amputation	6 months	poor		48
25	lakshimi	32/f	6/11/2016	RTA	zone 2 lt sacrum # with b/lspr and ipr #	lateral compression injury	no	type b2	conservative	no	3 months	fair		80
26	kannadasan	24/m	6/20/2015	RTA	inf pubic rami 3	lateral compression injury	clavicle3	type b2	conservative	no	12 months	excell ent		88

27	senthilkumar	39/m	4/11/2016	fall from height	rt sup and inf pubic rami #	lateral compression injury	L2 # without deficit,distal radius # lt	type b2	conservative	no	4 months	good	post stabilisation for L 2 #	85
28	sudha	28.f	9/11/2015	fall from height	rtspr and ipr # with si joint disruption	vertical shear injury	d12 # with paraplegia	TYPE C1	conservative	no	11 months	poor		90
29	arivazhagan	25/m	1/18/2014	RTA	pubic diastasis	apc injury	no	type b1	recon plate for pubic diastasis	screw broken	32 months	excellent		79
30	vadivu	32 /f	8/7/2014	RTA	iliac wing # with ant wall of acetabulum # with ant hip dislocation	lateral compression injury	ant hip dislocation with ant wall of lt acetabulum #	type a2	recon plate for iliac wing	no	24 months	good	recon plate for ant wall # and open hipreduction	55
31	devika	16/f	6/20/2016	RTA	b/l sup and inf pubic rami with rt sacrum	lateral compression injury	subtrochantericfracture, perineal laceration extend upto anal sphincter,head injury	type b2.1	ext fix followed by percutaneous screw for si joint		2 months	fair	anal spihncter repair, ext fixation for subtrochanteric #	94
32	dineshkumar	24/m	1/17/2015	RTA	sacral ala# with sup and inf pubic rami #	lateral compression injury		type c1.3	percutaneous screw for sacrum #	no	19 months	excellent	no	46
33	krishnammal	75/f	8/6/2016	RTA	rt sacrum zone 2 # with b/l rami #	lateral compression injury	bladder injury,bowelinjury,closed tibia and humerus #	type c1.3	ext fixation		1 month	poor	bladder repair ,internal fixation for tiba and humerus 3	78
34	ramadoss	46/m	12/23/2013	RTA	lt rami 3 ,sacrum #,si joint disruption	vertical shear injury	no	typec1.1	open reduction and screw fixation	no	28 months	excellent		80
35	prakash	57/m	5/3/2013	RTA	lt rami # with sijt disruption ,iliac wing #	lateral compression injury	acetabulum#	type c1.1	open reduction and recon plate fixation	no	35 months	excellent		69
36	mohammedali	34/m	8/8/2013	RTA	rtsi joint disruption with pubic disatasis with rami #	vertical shear injury	femoral head # with acetabulum #	type c1.1	percutaneous screw for si joint ,recon plate for rami #	no	32 months	fair	open reduction for hip and femoral head#	
37	bhuvanesh	19/m	8/20/2016	RTA	ltsi joint fracture dislocation ,iliac wing # with ltspr and ipr #	lateral compression and vertical shear combined	renal injury	type c1.2	orif with recon plate for si joint ,crescent # ,iliac wing	no			conservative	76
38	sakthivel	19/m	8/16/2016	RTA	rt sacral ala # b/lspr&ipr # pubic diastasis	lateral compression	no	type c1.3	recon plate for pubic diastasis	no				75
39	Jayshankar	48/m	4/9/2014	RTA	Rt si joint disrupt with acetabulum #	Vertical shear	Acetabulum	Typec1	Cancellous screw for si joint	No	21 months	Excellent	Conservative	87
40	Gurunathan	55/m	22/6/2014	RTA	Lt rami #,si joint disrupt,iliac wing #	Combined	No	Type c1	Recon plate for si joint	No	24 months	Excellent		86