Clinical and Radiographic Evaluation of Pelvic Instability- A Comprehensive Review

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ABSTRACT

The human pelvis girdle is composed of the hip, sacrum and pubic bones oriented in a ring, that endure the weight of our upper body and distribute it through the hips and legs. The three bone parts of the pelvic girdle are held together by joints and are reinforced by capsules and elastic ligaments. If any ligament is torn or ruptured, the pelvis loses its balance and starts to move excessively with exercise and other physical activities. Pelvic instability usually associated with chronic pain localized to the pelvic, suprapubic, or lower back, inner thigh regions, commonly occurs when getting up, using stairs, bending down, lifting heavy objects, and during exercise. This can occur at any age, but tends to decline with aging, due to stiffening of ligament tissues. The known causes of pelvic instability include pregnancy, parturition, trauma, and thickening of the femoral neck, insufficiency fractures, athletics, prior surgery, and osteitis pubis. Osteoporosis, fragility fracture and stress fractures in elderly can also lead to pubic symphysis fractures and pelvic instability. The diagnosis of pelvic pain is difficult and obtaining an accurate diagnosis is often challenging, particularly in patients with minor fractures and structural abnormalities. Therefore, clinical, physical and radiographic examination of pelvic pain is a critical component of the diagnostic evaluation, disease classification, therapy and treatment decision making process.

Keywords: Human pelvis girdle, clinical, radiographic, pelvic instability

INTRODUCTION

The pelvic girdle is composed of the three parts - ilium, ischium, and pubis. These pelvic bones do not have inherent stability but depend on posterior sacroiliac ligament and the pubic symphyseal ligaments for stability. The stability of pelvic ring depends on posterior ligament structures, pelvic floor muscles, sacroiliac joints, fascia and the pubic symphyses. The sacrum and ilium are fused together by anterior, posterior and interosseous sacroiliac ligaments [1].
Pelvic instability is a term widely used to describe a clinical condition characterized by pain localized to the pelvic ring, sacroiliac joints, and inner thigh regions; often it is associated with lower back pain. These symptoms are exacerbated by standing on one leg, side-lying position, or engaging in physical activities that stress muscles connected to the pubic symphysis.

The diagnostic techniques used in the management of pelvic instability depend on patient characteristics, mechanism of injury, and hemodynamic status at the time of presentation. It is a challenging problem in teenagers and young adults. The condition is often associated with proximal femoral fractures, proximal femoral migration and limb length discrepancy. Different conditions can affect hip joint, either the acetabulum or the head of femur or both, distorting its anatomy and biomechanics rendering it unstable [2, 3].

Knowing the anatomy of the pelvis and adjacent structures, biomechanics of pelvic stability and the different types of pelvic fractures can help clinicians to identify and provide appropriate initial management strategies and in-field stabilization of a pelvic fracture.

Various regions of typical pelvic instability are:

- symphysis pubis dislocation
- acetabular fractures
- pubic ramus fracture
- sacral fracture
- iliac fracture
- sacroiliac fractures

The primary function of the pelvis is to endure the human body weight and distribute it to the legs when a person is in standing position or to the ischium when a person is in sitting position. The pelvis is the connecting point for numerous muscles that connect the lower limbs to the body. There are several ligaments that connect the bones of the pelvis together. If any ligament is torn or ruptured, the pelvis loses its balance and starts to move excessively with exercise and physical activities. This condition has been associated with chronic pain in pelvic region which commonly occurs when getting up, using stairs, bending down, lifting heavy objects, and during exercise. Pelvic instability can occur at any age, but tends to decline with aging, due to stiffening of ligament tissues. The known causes of pelvic instability include pregnancy, parturition, trauma, and thickening of the femoral neck, insufficiency fractures, athletics, prior surgery, and osteitis pubis. The diagnosis of pelvic pain is difficult and obtaining an accurate diagnosis is challenging, particularly in determining mild structural abnormalities [4, 5].

**Clinical Evaluation**

Clinical examination of the unstable pelvis is important to understand the bone instability and associated tenderness. Bone instability often occurs as a result of fracture, dislocation, trauma, repetitive motion. The most common clinical evaluation in patients with pelvic fracture is pain in the anterior and posterior pelvic ring, although the latter is less frequent. In addition to chronic pain, there are other sign/symptoms associated with pelvic deformity,
specifically leg-length discrepancy, inability to flex the hip beyond a right angle, aesthetic defects due to bony prominences and posture problems.

Unstable hip joint can cause a great deal of discomfort to the patients. The complaint of the patient with regard to pain, abnormal gait, leg-length discrepancy, any limitation of hip motion and prior surgery about the pelvis are all queried and documented for both the diagnosis and for comparison between preoperative and postoperative condition [2-4, 7]. The details of prior trauma, low-energy fractures, lumbar spine fractures or spinal cord injuries should be discussed. Important factors in evaluation include whether symptoms developed suddenly or gradually and whether symptoms persisted from the onset.

An accurate and detailed patient history is needed as it will indicate the etiology of the condition that may be dysplasia with chronic hip dislocation or early childhood sepsis. It is important to understand the source of the pain. Fatigue pain related to the inefficient hip biomechanics is better treated with this approach than arthritic intra-articular pain. A patient with a stiff painful hip will not be helped with this type of extra-articular reconstruction. In this case, an intra-articular operation such as an arthrodesis, total joint arthroplasty, or resection arthroplasty may be needed. A resection arthroplasty can potentially be combined with an Ilizarov hip reconstruction (IHR) as a treatment for hip instability. The resection arthroplasty can be used to improve mobility and relieve intra-articular pain but will create an unstable hip. IHR can then be used to stabilize the hip. It is worth mentioned that the patients with hip injuries, fractures are willing to undergo a therapy of relatively long period. If any patient is found be medically not qualified for surgery, or not ready for the long duration of external fixator application, or had a recent history of intramedullary infection the procedure of IHR need to be avoided or postponed [2-4, 7-9].

**Physical Examination**

Physical examination of pelvis ring is important in early finding of pelvic fracture and helps us in evaluating the severity and requirement for more accurate diagnostic modalities such as x-ray or MRI or CT, and to prepare the earlier treatment. One should also note that the false or negative test result of physical examination may lead to underestimate the severity of injury, trauma and the delay to start appropriate treatment.

In physical examination; the following points need to be addressed:

- Range of motion (flexion, abduction, adduction) of hip joint on both sides need to be assessed and recorded [see figure 1].
- Presence of any leg length discrepancy and quantification, the amount of total limb shortening (which may be a combination of proximal migration of the hip and shortening from growth arrest of the proximal femur) can be measured using block test.
- Gait evaluation and testing for Trendelenburg sign which confirms the abductor insufficiency of the hip.
- Functional assessment pelvic instability in using Harris hip score [10-15].
Figure 1: Normal range of motion of the hip joint [16].

The Trendelenburg Test

Trendelenburg's test was first reported before radiology was available and it is widely used in orthopedic physical examination of the hip joint to test for hip abduction insufficiency.

To perform the Trendelenburg test, the patients are asked to stand on the unaffected leg single leg stance and flexes the affected leg right-angle. If the pelvis remains at the same level on the non-weight bearing side, it indicates a negative Trendelenburg sign. The patients were then asked to stand on the affected leg and flex the unaffected leg. If the pelvis drops on the contra lateral side during a single leg stand on the affected side, it indicates a positive Trendelenburg test. A delayed positive Trendelenburg test is noted if the patient had negative result when testing early but, after a short period in single leg stance, the pelvis slowly begins to drop towards the unassisted side and the patient is unable to hold the original pelvic stability. A positive Trendelenburg test demonstrates weakness in the hip abductor muscles consisting of the gluteus medius and gluteus minimus (on the side of the lifted leg) and is unable to perform their role of stabilizing the pelvis on the weight-bearing leg.

A number of different conditions may cause this Trendelenburg test to be positive. When it is observed while walking, it is called as Trendelenburg Gait. Trendelenburg gait can occur in patients with weak hip abductor muscles (gluteus medius and gluteus minimus). If the abductor muscles are too weak to support the weight while walking, a noticeable side-to-side motion will be observed. One of major symptoms of Trendelenburg gait or Trendelenburg sign can be seen by keeping one leg static, slowly flexing the other leg forward and the hip drops down and moves outward.

In a study by Bird et al. (2001), a positive Trendelenburg test along with Trendelenburg gait was found to be a better predictor of a gluteus medius tear than pain found with resisted internal rotation or hip abduction in group of 24 female patients with lateral hip pain.
One of the main objectives of pelvic support osteotomy is to eliminate the Trendelenburg and short limb gait in patients with severe hip joint injury. The patient’s ability to adduct the hip combined with weakness of hip abduction strength is a key contributing factor to the Trendelenburg gait.

In another study, Kocaoglu et al. described a rectification of Trendelenburg gait using Ilizarov Technique in 11 of their 14 patients with unstable hips. Trendelenburg gait correction depends on the patient age and size of the gluteus medius, gluteus minimus muscles. Manzotti et al. described correction of Trendelenburg sign in 9 of their 15 patients, El-Mowafi in 20 of 25 patients and Inan and Bowen in 12 of 16 patients using Pelvic support osteotomy. Gursu et al. reported that the Trendelenburg gait persisted in 8 patients from the 20 patients in his study, although improvement was recorded. Marimuthu et al. mentioned that Trendelenburg sign was corrected in most patients by Ilizarov hip reconstruction. All patients in their study had a positive Trendelenburg test preoperatively (and in 9 patients gait was corrected at final examination, 3 patients had delayed positive test postoperatively) and the authors attributed this tenaciousness to their failure to attain complete leg-length equalization or to the insufficient or excessive genu valgum at the proximal osteotomy [3, 4, 17-20].

**The Harris Hip Score**

The Harris hip score (HHS) was commonly used for evaluating patients following hip fractures and the diagnosis of osteoarthritis and pelvic instability. In the year 1969 Harris developed this score with a rating scale of 100 points to evaluate pain, walking function, activities of daily life, deformity, and range of motion. It is widely used for hip arthroplasty patients.

The Harris hip score has been tested against the Short Form health survey(SF-36) and the Western Ontario and McMaster Universities Osteoarthritis Index(WOMAC) and it has been shown to have high validity, reliability, and responsiveness. It is a functional scale calculated by parameters including pain, trauma, walking function, activities of daily living, and range of motion of the hip joint to be done preoperatively. Pain and functional outcomes in patients undergoing total hip replacement can be studied using a modified version of Harris hip score that includes only the subjective part of the original score. This modified Harris hip score covers: pain, distance walked, stairs, shoes/socks, sitting, limp, support, and public transportation. The HHS is scored on a 100-point scale, results can be interpreted with the following: a score of above 81 points indicates an excellent result; 71 to 80 points, a good result; 61 to 70 points, a fair result; and 0 to 60 points indicates a poor result [21, 22].

**Gait Analysis**

Gait analysis is the systematic analysis of biomechanics of walking and measurement of joint kinematics and kinetics. It offers an opportunity for clinical assessment of the act of walking. Gait analysis is applied majorly in clinical practice for preoperative assessment, surgical and treatment decisions, identifying biomechanical abnormalities, postoperative follow-up, and management of pelvic instability in both adolescent and elderly.
The practice of gait analysis has been around for at least a century, but only recently, with the advancement of technology, it has become a reliable tool for physical therapists and doctors to deliver accurate kinematic and kinetic data needed for selecting appropriate treatment for the patients with pelvic ring injuries. Gait analysis has also played a very important role in the study of neuromuscular disorders, sports injuries, pelvic instability, prosthetics, amputees, orthotics, and other assistive devices.

Gait analysis should be done in patients with pelvic instability as it is widely used in clinics compared to research labs, and gait measurements were found beneficial in the treating the patients with walking abnormalities. Typical findings are stance time asymmetry, and decreased ground reaction force. In other words, the patient spends less time on the abnormal lower extremity and put less weight on it while walking. Normalization of these parameters signifies successful uniform leg-length, lack of pain, trauma, and adequate strength in hip abductor muscles for stability during walking. Stance time asymmetry is not reported in a normal gait, the inability to lock the hip into extension also contributes to the abnormal gait. With IHR, extension at the proximal osteotomy helps the Patient lock the hip into extension during gait [13, 22]. The latest advances in gait analysis technologies have enhanced the ability to produce high quality data to improve diagnosis, treatment and quality of life for patients.

**Radiographic Evaluation**

Besides the regular physical examination for injured muscle tenderness, discomfort and pain with pelvis manipulation, all patients need to be examined with radiographic techniques. As the pelvis is a ring formed by ilium, ischium, and pubis, damage to any part of the pelvic ring is commonly associated with damage to another part of the ring. So, in order to fully understand the pelvic instability, supine anteroposterior, pelvic outlet (Ferguson) and inlet radiographs are made.

The diagnosis of mechanically unstable pelvic fractures was made on the basis of the difference between the heights of the two pubic bones of the pelvis on the right and left single-leg stance anteroposterior radiographs. The purpose of single-leg-stance radiographs is to identify the pelvic instability accurately in patients with pelvic fractures, pain and a history suggestive of instability [23].

Chamberlain et al. observed that radiographic images which included the entire pelvic ring and the pubic symphysis enabled clinicians to measure the relative displacement of the pubic bones. The anteroposterior pelvis radiograph is the standard test for evaluation of pelvic injury and should be performed during assessment of all patients.

Preoperatively, important x-ray views to be done include:

1. An anteroposterior (AP) pelvic radiograph including the iliac crest is used to identify the etiological factors and to evaluate the proximal migration of the greater trochanter, which is measured as the difference between the distance from sacroiliac joints to the tip of the greater trochanter on both sides through a transverse line [see figure 2A] [21].
2. An anteroposterior full-length standing radiograph (teleoroentgenogram) showing both lower extremities, to diagnose limb length discrepancy and quantify it. Limb length discrepancy can be calculated from the teleoroentgenogram (with attention to magnification that was standardized to 10%in all radiographs). The pelvic mechanical axis angle consisted a horizontal pelvic line (line joining the top of both sacroiliac joints) and a

mechanical axis line of the lower limb (represented by a line that extends from the center of hip to the center of ankle joint passing through the knee joint) [see figures 2B and 2C] [21].

3. A full length standing anteroposterior radiograph of the affected limb is used to calculate the angle between the adducted femur’s anatomical axis and either a line joining the superior aspect of the iliac crests or a line joining the lower ends of the sacroiliac joints [see figure 2C] [21]. This standing radiograph can be used to analyze preoperative degree of hip dislocation graded by the Tönnis classification.

4. A maximum adduction cross-legged anteroposterior radiograph of the pelvis (patient supine and affected hip flexed and adducted over the top of the unaffected hip) [see figure 2D] [21].

5. To detect the appropriate osteotomy site, radiographs with the unstable hip in maximum adduction need to be generated; the point where the adducted thigh (femur bone) crossed the tuber ischii is measured as the level of osteotomy. The distal femoral osteotomy needs to be performed at a level between the proximal osteotomy site and the knee joint line [21, 15].

Figure 2: (A) Pre-operative anteroposterior (AP) radiograph of the pelvis showing both hips. (B) Standing AP view of pelvis & lower extremities for malalignment & malorientation tests, the mechanical axis of the lower limb is...
represented by a line that extend from the center of hip joint to the center of ankle joint passing through the knee. (C) Pelvis anteroposterior X-ray with unstable hip in maximum adduction. (D) Supine maximum adduction X-ray of the pelvis to determine the level of proximal osteotomy [19, 21, 24].

This review concludes that techniques like Ilizarov hip reconstruction can successfully normalize Trendelenburg gait and restore knee alignment and correct limb length discrepancy. Effort at making early diagnosis and providing appropriate treatment will prevent most cases of severe hip damages. A complete clinical and radiographic evaluation of hip injuries, pain and trauma are important to provide accurate diagnostic, management, and treatment plans for pelvic instability and limb length discrepancy.

REFERENCES:


