

INTRODUCTION

Management of acetabular bone stock deficiency in revision of a previous hip arthroplasty, or in primary deficiencies resulting from either an abnormality in growth or a condition that alters the shape of the acetabulum, is recently considered one of the major surgical challenges in arthroplasty. That is why many orthopedic clinicians and researchers are working daily all over the world for finding a variety of solutions for this condition⁽¹⁾.

The number of revision hip arthroplasties in orthopaedic surgery is increasing because of still rising numbers of primary arthroplasties. However, the success rates of revision are unsatisfactory due to the inferior quality of periprosthetic bone. With a failure rate of 23% using cemented hips after a mean follow-up of 4 years. Furthermore, it is generally agreed that the failure rates in young and active patients are even higher. A failure rate of 35% for the cup and 39% for the stem of cemented revisions in patients younger than 55 years, after 10 years implantation⁽²⁾.

A successful outcome in treating acetabular defects requires good orientation about applied surgical anatomy of the acetabulum, careful preoperative planning, identification of complex defects, and durable, stable reconstruction. Acetabular deficiencies are classified according to clinical radiographs, anticipated bone loss during removal of implants, and intraoperative assessment of host bone stock⁽³⁾.

Therefore reviewing the literature of anatomy of the acetabulum is markedly important, plus focussing on the columns concept of the acetabular anatomy⁽⁴⁾.

Etiology of Acetabular Defects:⁽⁵⁾

Primary Cases: (i.e. no previous arthroplasty)

- Osteoarthritis.
- Trauma.
- Hip dysplasia.
- Avascular osteonecrosis.
- Rheumatoid arthritis.
- Ankylosing spondylitis.
- Tumours.

In acetabular dysplasia the acetabulum (socket) is too shallow or deformed. The center-edge angle is measured as described by Wiberg. In coxa vara the femur head grows at too narrow angle to the shaft, in coxa valga the angle is too wide. Usually primary total hip replacement in adults is enough for management of acetabular defects accompanied with hip dysplasia⁽⁶⁾.

Some benign tumours affect the hip bone and can cause acetabular bone stock defect. Malignant tumours and more common bone metastases which can cause acetabular lesions, are mostly ossific and not lytic lesions. While, acetabular defects in such cases are caused after tumour resection.

Treatment of acetabular defects caused by bone tumours or after tumour resections recently has many surgical techniques and a variety of supplementary prosthesis⁽⁷⁾.

Revision Cases: (i.e. after previous arthroplasty)

- Aseptic loosening.
- Hemiarthroplasty with acetabular protrusion.
- Failed resurfacing arthroplasty.
- Septic loosening.
- Osteolysis.

It is useful to use some system of classifying bone loss to facilitate surgical planning. The simplest is to describe the cavitary morphology and place in relation to the rim and the hip bone⁽⁸⁾.

Many classification schemes have also been formulated. The most commonly used are those that are easy to remember, easy to reproduce, useful in guiding treatment options. Systems referred to most often in the literature are those of the American Academy of Orthopaedic Surgeons AAOS⁽⁹⁾, and the Paprosky classification system⁽¹⁰⁾.

Management:

Diagnosis

Preoperative diagnosis, it is important to understand the nature and extent of the bone defect before undertaking the reconstruction operation through⁽¹¹⁾:

a) Clinical features.

b) Radiological features.

- x-ray
- C.T. scan
- MRI
- bone scan

c) Intraoperative diagnosis; by inspecting and palpating the acetabulum⁽¹²⁾.

Treatment

Management principles include the use of structural biological grafts to fill the defects with or without prosthetic reconstruction when needed. Also prostheses can be used alone in some cases⁽¹³⁾.

AIM OF THE STUDY

The aim of this study is to:

- Review the literature and recent studies about the aetiology and incidence of acetabular defects.
- Discuss the types of defects in acetabular bone stock according to shape of bone loss.
- Focus on methods of acetabulum reconstruction using biological grafts and ways of their preparations, or using prosthesis, or combination of both methods.

ANATOMY OF THE ACETABULUM

Osteology of the acetabulum:

The acetabulum is a hemispherical hollow on the outer surface of the innominate bone, formed by the fusion of its three component parts: the ilium, ischium and pubis which meet at a - Y - shaped cartilage forming their epiphyseal junction. The anterior one-fifth of the acetabulum is formed by the pubis, the superior posterior two-fifths by the body of the ilium and the inferior posterior two-fifths by the ischium. The prominent rim of the acetabulum is deficient inferiorly as the acetabular notch. The heavy wall of the acetabulum consists of a semilunar articular part, covered with hyaline cartilage, which is open below, and a deep central non-articular part, the acetabular fossa. The acetabular fossa is formed mainly from the ischium and its wall is frequently thin⁽¹⁴⁾.

The acetabular surface is orientated approximately 45° caudally and 15° anteriorly. The acetabulum has a mostly circular contour in its superior margin, but it has only enough hemispherical depth to allow for 170 degree coverage of the femoral head. Femoral head coverage within the acetabulum is augmented by the labrum, which runs circumferentially around its perimeter to the base of the fovea, where it becomes the transverse acetabular ligament⁽¹⁵⁾.

From its lateral aspect the acetabulum forms an inverted - Y - one limb forming the **anterior column** and one forms the **posterior column**.

The **anterior column** (Fig.1,2,3) extends from the iliac crest to the symphysis pubis and includes the anterior wall of the acetabulum. The **posterior column** (Fig.1,2,3) begins at the superior gluteal notch and descends through the acetabulum, obturator foramen, and inferior pubic ramus and includes the posterior wall of the acetabulum and ischeal tuberosity. The superior – weight bearing area, which includes a portion of both the anterior and posterior columns, has been called the **acetabular dome** or **roof**⁽¹⁶⁾.

Figure (1): Anatomically defined anterior column of acetabulum. Arrowheads indicate anterior inferior iliac spine; curved arrows, iliopectineal eminence; and straight arrows, pubic tubercle. Schematic representation shows anatomically redefined anterior (*dotted area*) and Letournel-defined posterior (*striped area*) column in internal projection.

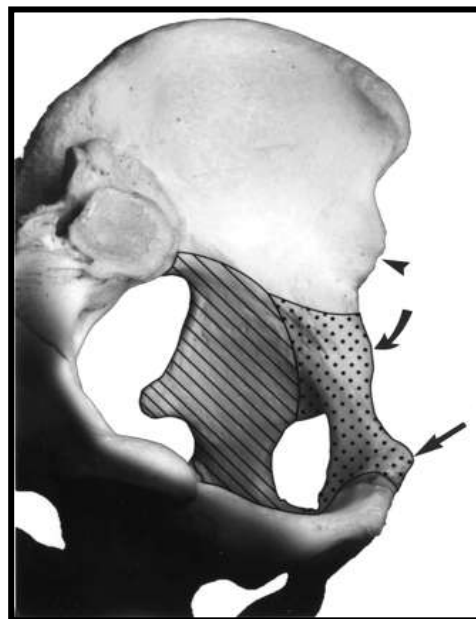


Figure (2): Anatomically defined anterior column of acetabulum. Arrowheads indicate anterior inferior iliac spine; curved arrows, iliopectineal eminence; and straight arrows, pubic tubercle. Schematic representation shows anatomically redefined anterior (*dotted area*) and Letournel-defined posterior (*striped area*) columns in obturator oblique projection.

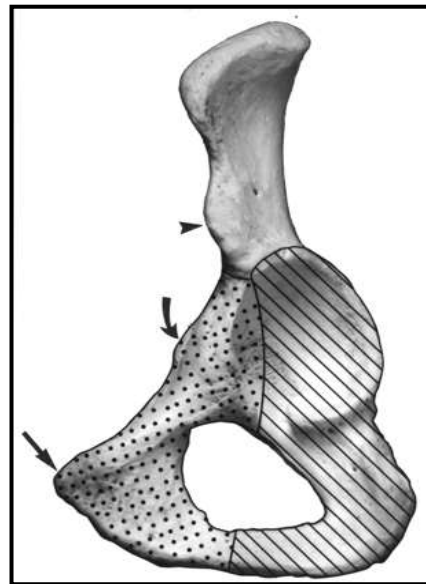
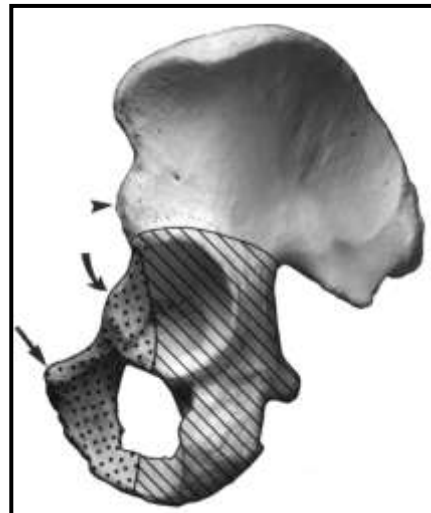


Figure (3): Anatomically defined anterior column of acetabulum. Arrowheads indicate anterior inferior iliac spine; curved arrows, iliopectineal eminence; and straight arrows, pubic tubercle. Schematic representation shows anatomically redefined anterior (*dotted area*) and Letournel-defined posterior (*striped area*) columns in lateral projection.



AJR 2004; 182:1363-1366 American Journal of Roentology John H. Harris, Jody S. Lee, Kevin J. Coupe and Thea Trotscher.

The two strong osteal columns of bone surround the acetabulum, transmitting the stresses between the trunk and lower extremities. The columns vary in thickness as they pass around the acetabulum.

In general, expanding the acetabulum more than one third beyond the acetabular diameter (i.e., over reaming the acetabulum) will risk creating a pelvic discontinuity, rendering the columns incompetent. Reaming one quarter of the acetabular diameter is safe, preserving approximately 50% of the cross-sectional bone area of the anterior and posterior columns⁽¹⁵⁾.

Congruence:

Although the articular surfaces of the acetabulum and the head of the femur are reciprocally curved, the hip joint consists of two incongruent shapes. Incongruity implies limited contact between the two surfaces under low loading conditions, with a gradual increase in the area of contact with increasing load. Because of this it is usual to think of the incongruity as a means to distribute load and protect the underlying cartilage from excessive stress. An important factor in the functioning of such a mechanism is the compressibility of the cartilage. The incongruity of the hip joint is determined by an arched acetabulum and a rounded femoral head⁽¹⁴⁾.

The quadrant system of the acetabulum:

With the increasing popularity of transacetabular screw fixation for cementless acetabular prosthesis, the potential for intrapelvic neurovascular complications has been increased. **Wasielowski et al. (1998)**⁽¹⁵⁾ has developed studies to avoid these potential complications. The acetabulum can be divided

into **four quadrants** by intersections of lines, line **A** and **B**. **line A** extends from anterior superior iliac spine through center of acetabulum to posterior aspect of fovea, dividing acetabulum in half. **Line B** is drawn perpendicularly to line A at mid point of acetabulum, dividing it into quadrants: **anterosuperior**, **anteroinferior**, **posterosuperior** and **posteroinferior**.

The **anterior-superior** and **anterior-inferior** quadrants should be avoided because of the high probability of injury to external iliac artery and vein and obturator nerve, artery and vein. Injury can occur during drilling, depth gauging, tapping, or screw intersection.

The use of the **posterior-superior** and **posterior inferior** quadrants utilizes stronger bone, avoids these neurovascular structures, and allows the use of screws up to 35 mm length⁽¹⁷⁾.

Capsule

The strong but loose fibrous capsule of the hip joints permits the hip joint to have the second largest range of movement (second only to the shoulder) and yet support the weight of the body, arms and head. The capsule is attached proximally to the entire periphery of the acetabulum beyond the acetabular labrum. The capsule covers the femoral head and neck like a sleeve and attaches to the base of neck. The capsule has two sets of fibers: longitudinal and circular. The circular fibers form a collar around the femoral neck called the zona orbicularis. The longitudinal retinacular fibers travel along the

neck and carry blood vessels. As the line of gravity falls posterior to the axis of the hip joint, the combined weight of the body seeks to extend the hip joint in normal standing and make the trunk fall backwards to the ground. To resist the stretching action on the anterior joint capsule in normal upright posture, the hip has two very strong anterior ligaments.

Ligaments

The hip joint is reinforced by three main ligaments.

- * At the front of the joint, the strong [iliofemoral ligament] attaches from the pelvis to [femur]. This Y-shaped ligament is also known as the ligament of Bigelow. This ligament seeks to resist excessive extension of the hip joint. It is often considered to be the strongest ligament in the human body.
- * The [pubofemoral ligament] attaches across the front of the joint from the pubic bone of the pelvis to the femur. This ligament is oriented more inferiorly than the iliofemoral ligament and reinforces the inferior part of the hip joint capsule. It also blends with the medial part of the iliofemoral ligament.
- * The posterior aspect of the hip joint capsule is reinforced by the [ischiofemoral ligament] that attaches from the ischial part of the acetabular rim to the femur.

There is also a small ligament called [ligamentum teres] or the ligament of the head of the femur. This ligament is a triangularly shaped band with its base on both sides of peripheral edge of acetabular notch. This structure is not that important as a ligament but can often be vitally important as a conduit of a small artery to the head of the femur. This arterial branch is not present in everyone but can become the only blood supply to the bone in the head of the femur when the neck of the femur is fractured or disrupted by injury in childhood.

Blood supply and nerve supply of the hip joint

The hip joint is supplied with blood from the [medial circumflex femoral] and [lateral circumflex femoral] arteries, which are both usually branches of the [deep artery of the thigh] (profunda femoris), but may also arise directly from the [femoral artery]. There is also a small contribution from a small artery in the ligament of the head of the femur which is a branch of the [posterior division of the obturator artery], which becomes important to avoid [avascular necrosis] of the [head of the femur] when the blood supply from the medial and lateral circumflex arteries are disrupted (e.g. through fracture of the neck of the femur along their course).

The hip has two anatomically important anastomoses, the cruciate and the trochanteric anastomoses. These exist between the femoral artery or profunda femoris and the gluteal vessels.

The hip joint is supplied by a number of nerves ([proprioception], [Pain and nociception|nociception], etc...) including the [femoral nerve], the [obturator nerve], [superior gluteal nerve], and the [nerve to quadratus femoris]⁽¹⁸⁾.

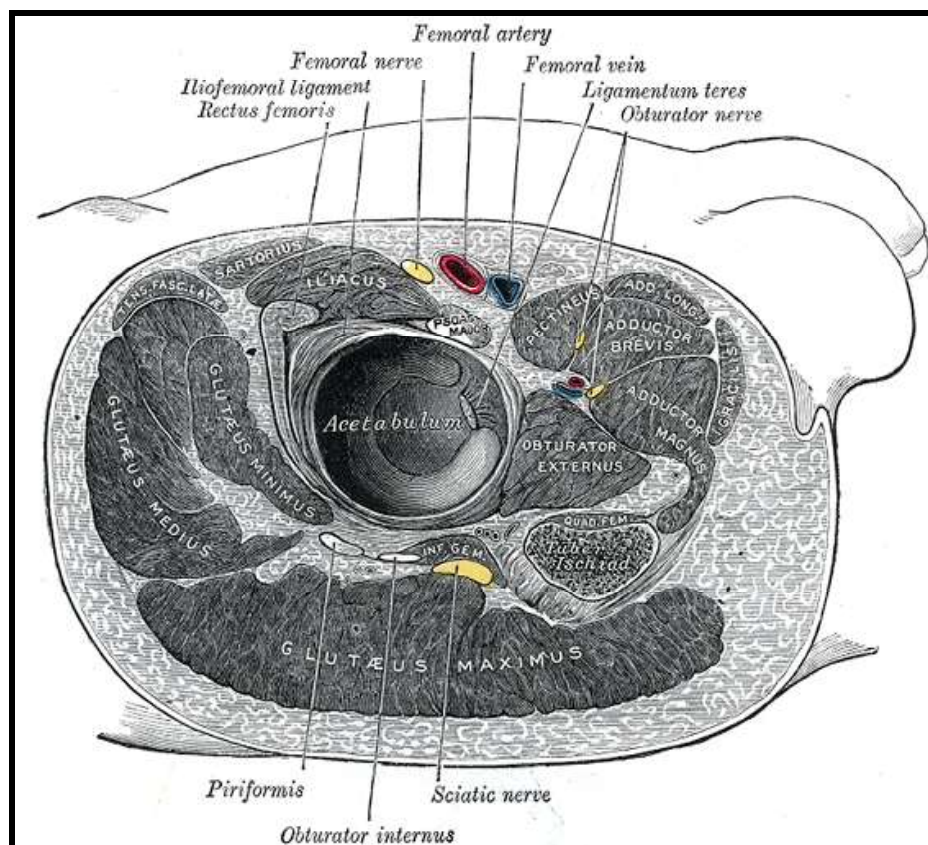


Figure (4): Structures surrounding right hip-joint. Gray's Anatomy of the Human Body Coxal Articulation of Hip-joint.

Embryology of the hip joint:

The child's hip begins in intrauterine development as a condensation of mesoderm in the lower limb bud that rapidly differentiates to resemble the adult hip by eight weeks of life. The developmental instructions are transmitted through

complicated cell signaling pathways. From eight weeks of development to adolescence, further growth of the hip is focused on differentiation and the establishment of the adult arterial supply. The postnatal growth of the child's hip is a product of concurrent acetabular and proximal femoral growth from their corresponding growth plates. Absence of appropriate contact between acetabulum and proximal femur yields an incongruent joint. Multiple disease processes may be understood in light of this growth process, including Legg-Calvé-Perthes disease and developmental dysplasia of the hip⁽¹⁹⁾.

Hip bone, cartilage, muscle, and connective tissue all arise from the primitive mesoderm.

- At 4 to 6 gestational weeks, the hip joint develops from the cartilaginous anlage;
- By 7 weeks a cleft develops between precartilagenous cells which are programmed to form the femoral head and acetabulum. In turn, the femoral head, when properly positioned, forms the large, cup-shaped cavity on the lateral surface of the pelvis known as the acetabulum.
- By 11 weeks, the hip joint formation is largely complete;
- Femoral head is completely encircled by the acetabular cartilage; the pelvis and femoral head are composed primarily of cartilage rather than bone. Both structures

remain susceptible to alterations in development arising from both external mechanical uterine forces, as well as the forces exerted by the developing musculature and fetal and infant movement, or lack thereof.

- At late gestation, femoral head grows more rapidly than the acetabular cartilage, so that at birth the femoral head is less than 50% covered;
- At birth, acetabulum is at its most shallow and most lax stage in order to maximize hip range of movement (ROM) which facilitates the delivery process;
- Hip is uncontained in extension and adduction reflecting hip shallowness;
- After several weeks, acetabular cartilage develops faster than the femoral head, which allows progressively more coverage; Growth and development remain dependent on normal femoral head placement.
- Normal occurrence of hip shallowness and capsular laxity in the neonatal period are initial factors involved in developmental dysplasia of the hip (DDH)⁽²⁰⁾.