Hip Anatomy in Femoral Acetabular Impingement

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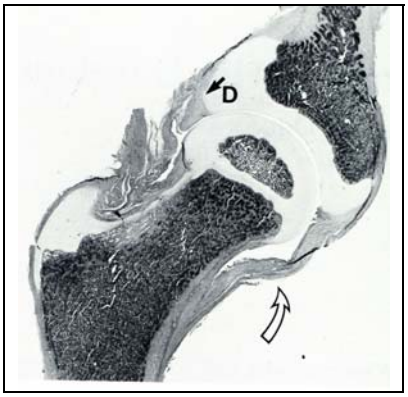
There are 70 million people in the United States who are affected by arthritis (4). Hip pain is a common complaint among these patients and it is a diagnostic and therapeutic challenge for physicians.

Recently there has been an explosion of our knowledge and understanding of osteoarthritis and possible treatments for hip pain. Pathologic changes involving the acetabular labrum have increasingly been attributed as a cause for hip pain, but why and how do they occur (11, 14, 19, 20, 27)?

There are 240,000 Total Hip Arthroplasties performed annually in the United States (1). By understanding hip anatomy and pathology we can provide information through imaging to aid in the diagnosis of osteoarthritis of the hip. The goal is to help in the development joint preserving therapies rather than to watch the progression of joint destruction leading to Total Hip Arthoplasty.

Growth and Development

Figure 1: Hip Growth



The acetabular cartilage complex is interposed between the ilium, ischium, and the pubis. This complex is composed of epiphyseal growth-plate cartilage adjacent to these bones and articular cartilage around the acetabular cavity. Interstitial growth of the triradiate cartilage leads to expansion and enlargement of the acetabulum (25). Development of the acetabulum and femoral head depends on a located femoral head exerting appropriately directed forces on the acetabulum. Thus the normal development of the hip requires a balanced interaction between the growth of the acetabulum and the femoral head (12). The depth and spherical shape of the acetabular development is based on this relationship (12,21,25,37). Soft tissue structures about the hip joint also play an important role in providing joint stability during development of the hip joint. The acetabular labrum contributes from one-fifth to one-half of the socket depth at birth and plays a significant role in the containing the femoral head at birth (37). Disturbances leading to instability result in a spectrum of anatomical variations found in developmental dysplasia of the hip.

The femoral head and the greater trochanter share a common physis up to the age of four. This then separates into two distinct physes. Disturbances of this separation process can result in premature closure, delayed separation, and eccentric closure with abnormalities involving the femoral head, neck, and greater trochanter (21).

Labral Properties

Osteoarthritis of the hip joint has been observed in conjunction with labral tears and degeneration (2, 3, 7, 9, 11, 14, 15, 19, 20). The function of the labrum however has been poorly understood and previously not well established. The labrum is not in a position in the normal adult hip to bear any substantial portion of the joint load. The joint load in the normal adult hip is directed more medially toward the acetabular roof. Therefore any mechanical role for the labrum is quite limited.

The acetabular labrum is soft and conforms to the femoral head. Ferguson (6) proposed that the labrum seals fluid in the intra-articular space preventing contact of the articular cartilage surfaces and produces a uniformly pressurized fluid film lubrication layer. This slows the expression of fluid from the cartilage layers, protecting the cartilage from excess deformation and stress. Loss of this labral seal would therefore result in instant depletion of the film layer leading to increase cartilage stress and deformation (6, 10).

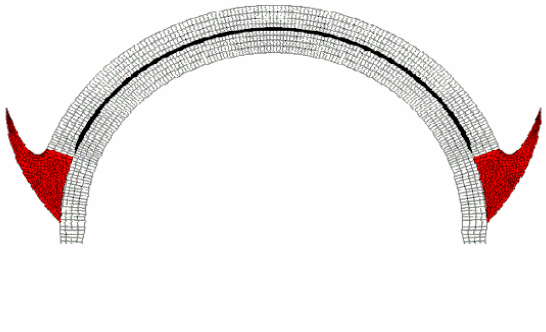


Figure 2: Labral seal Ferguson et al

Hip Biomechanics

Articular pressure is determined by the magnitude and direction of force and the size of area that transmits that resultant force. Therefore increased articular pressure from increased weight, deformity, subluxation, or incongruous surfaces leads to decreased articular cartilage resistance and a breakdown in the articular cartilage equilibrium (22,27).This concept of excessive and eccentric axial overloading of the joint has been shown to lead to the development of osteoarthritis in developmental dysplasia of the hip (15). This, however, does not explain osteoarthritis in young patients with normal appearing skeletal structures (7).

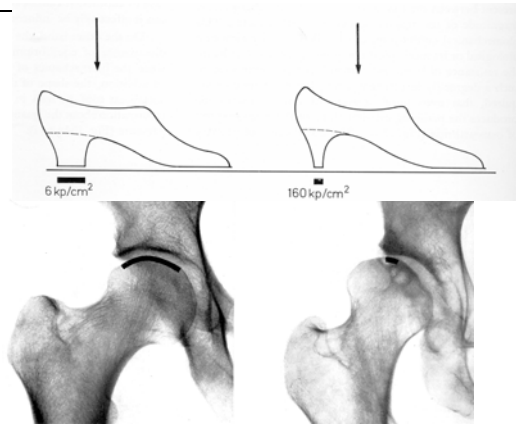


Figure 3: Joint Loading

We are accustomed to thinking about joint loading and stability when discussing etiologies of osteoarthritis in the knee and hip. However, motion is the other function we need to consider when considering the etiology of osteoarthritis of the hip (7) .

Femoral Acetabular Impingement

So what is impingement and how does it lead to osteoarthritis? Why did it take so long to be recognized?

Any osseous stop of joint motion can be called impingement. Impingement is well recognized in the shoulder as a cause of shoulder pain. Impingement in total hip arthroplasty is recognized as a cause for postoperative dislocation, joint dysfunction and component loosening. Impingement was also described as a complication of neck fractures by Ganz in the late 80's, however its relationship to possible articular cartilage damage was not immediately recognized.

Stulberg (33) described variations in femoral head/neck configurations on AP radiographs in young patients with osteoarthritis leading to the term "pistol grip deformity".
The association between OA and variations in the femoral head and neck has also been described in slipped capital femoral epiphysis and Legg-Calve-Perthes Disease, however these did not consider impingement as the process (32, 35).

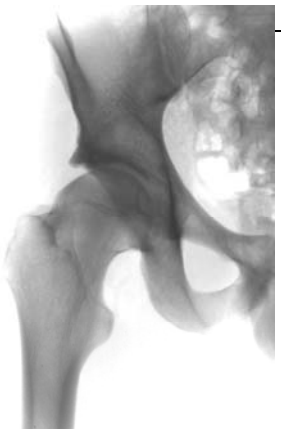


Figure 4: Pistol Grip Deformity

Goodman (8) described hip impingement, but did not describe its possible pathomechanical relationship to osteoarthritis.

Ganz et al (23) became concerned with impingement as a source of hip pain in patients with progressive osteoarthritis following periacetabular osteotomy. This led to intra-operative observations of a mechanical impingement secondary to anatomical variations of the proximal femur and acetabulum. Based on these clinical experiences, Dr. Ganz and his colleagues (2, 7, 13, 17, 18, 24, 29, 31) proposed the concept of femoral acetabular impingement based on these variations in the morphologic features of the hip resulting in abnormal contact during motion. This abnormal contact results in lesions of the acetabular labrum and adjacent articular cartilage. Early detection of any cartilage abnormalities or labral tears is important when considering surgical therapy. These findings can directly affect the outcome of successful surgery.

There are two basic mechanisms for impingement that are described as Cam Impingement and Pincer Impingement.

Cam Impingement

Cam Impingement results from alterations of the femoral head-neck junction. These include loss of femoral head-neck offset such as seen in the pistol grip deformity, SCFE, fracture deformity, and in residual physeal scar formation from late or eccentric closure of the lateral capital epiphysis (7, 13). These nonspherical areas of the femoral head-neck junction occur nearly exclusively in the anterosuperior portion of the femoral neck (30).

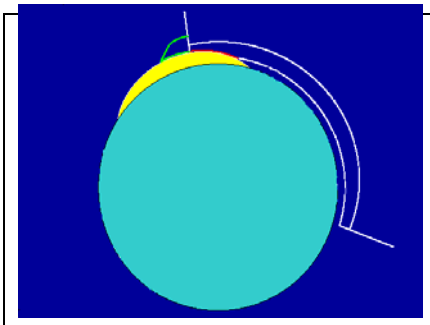


Figure5: Cam Impingement Courtesy Martin Beck Bern, Switzerland

This alteration in the femoral head-neck junction results in an abnormally shaped femoral head with increasing radius that enters into the acetabulum during forceful motion especially with flexion. The shearing forces result in an outside-in abrasion of the acetabular cartilage and avulsion of the labrum (7).

Pincer Impingement

Pincer Impingement is the result of contact between the acetabular rim and femoral head neck junction. The femoral head may be normal and the abutment is secondary to anterior over coverage seen with acetabular retroversion or a deep acetabular socket.

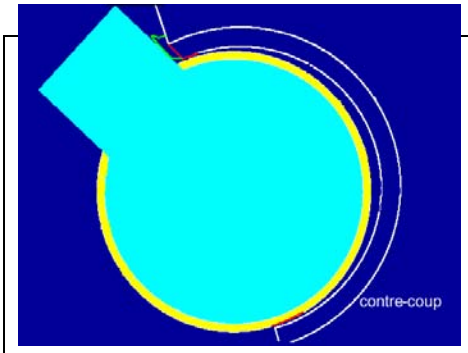


Figure 6: Pincer Impingement Courtesy Martin Beck , Bern, Switzerland

The continued abutment with crushing of the labrum between the acetabulum and the femoral neck leads to degeneration of the labrum with ossification of the acetabular rim resulting in further deepening of the socket and worsening of the over coverage. Cartilage damage is along the acetabular rim circumferentially involving a narrow strip. This chronic leverage results in a contre coup posterior acetabular injury with cartilage damage and rim ossification (7).

Pincer Impingement is seen in acetabular retroversion, coxa profunda, and protrusio acetabuli. Acetabular retroversion is best seen on AP radiographs with the “Cross-Over Sign” described by Reynolds*. Coxa Profunda is defined as the fossa acetabularis meets or lies medial to the ilioischial line. Protrusio Acetabuli is defined as the femoral head being medial to the ilioischial line.

Although Cam Impingement has been described as more common in young males and Pincer Impingement as more common in older women, they are less commonly seen as isolated lesions (2).

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