Introduction

The term developmental hip dysplasia covers a wide range of deformities, from simple acetabular dysplasia to high dislocation of the hip. Total hip arthroplasty (THA) is one of the treatment options for these deformities. [1]

Total hip replacement for the patient with a dysplastic hip is challenging. The normal anatomy about the hip joint is distorted in the presence of congenital hip dislocation and proximal migration of the femur. [2] It is a technically demanding procedure in which several problems and complications can be encountered. [1]

Congenital hip dysplasia or dislocation, juvenile rheumatoid arthritis, epiphyseal dysplasia and dwarfism are examples of diseases leading to dysplastic hips. [3]

In complete congenital dislocation of the hip, the femoral head is located entirely outside the original acetabulum, whether the hip has been treated during childhood or not. In this condition, the femoral head articulates with the iliac wing, superior to the true acetabulum or superiorly and posteriorly. [4]

Total hip arthroplasty (THA), performed for developmental dysplasia of the hip, aims at providing the patient with a pain-free, stable, and mobile hip, while equalizing leg length and decreasing low back and knee pain through the improvement of static body balance. (4)

Problems during total hip replacement in hip dysplasia are related to:

1. Placement and coverage of the cup.
2. The need for small femoral and acetabular components,
3. The surgical technique.
4. Soft tissues problems
5. Limb-length discrepancy
6. Proximal femoral migration

These are problems that should be solved in hip replacement of dysplastic cases. (2)

Proximal displacement of the femoral head leads to a more horizontal direction of the abductor muscles and an elongated, hourglass like joint capsule. Bone stock at the location of the original and secondary acetabulum as well as the iliac wing is deficient and thinned. (5)

One of the most commonly used classifications for hip dysplasia is crowe classification. Crowe et al. found the distance of the medial head-neck junction to the inter-teardrop line to be close to zero and the height of the femoral head to be one-fifth of the pelvic height in normal hip joints. Cranial displacement of femoral heads in dysplastic hips was therefore measured as cranial displacement of the medial head-neck junction from the inter-teardrop line, and 100% subluxation of the femoral head was defined as cranial displacement of one-fifth of the pelvic height. Crowe group I was defined as less than 50% subluxation, group II 50%–75%, group III 75%–100%, and group IV more than 100% subluxation of the femoral head. (5)

There are important technical considerations involving the femoral part of the arthroplasty. The femora in these patients frequently are dysplastic, proximaly migrated and the medullary canal is narrow, and it may be deformed by previous operations, and the femoral head articulates high on the ilium. (6)

Soft tissues surrounding the hip joint are frequently contracted because of the chronicity of dislocation. (7)

The durability of the arthroplasty in these patients is better with restoration of an anatomic hip center. [8] When the cup is implanted at the anatomic height, reduction of the prosthesis to this level is sometimes impossible and bears the danger of sciatic or femoral nerve stretching. [5]

Therefore restoration of the hip center typically requires some form of femoral shortening to allow hip reduction and to avoid excessive limb lengthening. One option for restoring the anatomic hip center at the time of total hip arthroplasty is a subtrochanteric femoral shortening osteotomy, which facilitates reduction, can help to equalize limb lengths, and protects the sciatic nerve. [8]

The surgical technique used for high-riding dislocation of the hip is different from that for simple acetabular dysplasia. Femoral-shortening osteotomy, although seldom required for acetabular dysplasias without dislocation or with low dislocation, is frequently required for high dislocations. [1]

Proximal femoral anteversion may be corrected by rotating the femoral fragments, which places the greater trochanter and the abductors in an anatomic lateral position and restores the abductor lever arm to minimize instability and limping. [8]

Severe acetabular deficiency represents a major challenge to surgeons who perform reconstructive procedures on the dysplastic hip. [9] The surgeon faces an excessively anteverted shallow true acetabulum with segmental defects and poor bone stock. [10]

There are many techniques for coverage of the acetabular component during a total hip arthroplasty for a dysplastic hip including cotyloplasty technique that involves medial advancement of the acetbular floor by the creation of a controlled comminuted fracture of its medial wall, autogenous bone grafting and the implantation of a small acetabular component, doing chiari osteotomy, use of acetabular augments or creation of a higher hip center. [9,10]

Cementless total hip arthroplasty combined with a subtrochanteric femoral shortening osteotomy in patients with a high hip dislocation secondary to developmental dysplasia was associated with high rates of successful fixation of the implants and healing of the osteotomy site and postoperative improvement of Harris hip score. [8]

Aim of work

A prospective study for evaluation of the results of single stage total hip arthroplasty in treatment of patients with advanced developmental dysplasia of the hip (Crowe types lll, lV).

Chapter (1)
Anatomy of the hip joint

The hip joint is a ball and socket synovial joint consisting of 2 components: the femoral head and the acetabulum. It has three rotational degrees of freedom (flexion/extension, abduction/adduction, internal/external rotation). The articular surfaces of the hip are formed of hyaline cartilage which has a very low friction coefficient. The hip joint supports the body weight in both static and dynamic postures. [11]

Stability is achieved by high conformity of articular surface that restricts translation (bony factors), and by strong ligaments and powerful muscles that provide rotational stability (soft tissue factors) which allows humans to be bipedal. [11]

Femur

The head of femur forms 2/3 of a sphere. It is attached to the metaphysis by the neck. There are 3 anatomical considerations of the femoral neck which influence the biomechanics of the hip joint:

1) Femoral neck anteversion: the anterior rotation of the femoral neck in relation to the anatomical axis of the shaft.

2) Femoral offset: the distance between the centre of rotation of the femoral head and the anatomical axis of the shaft. (Fig. 1)

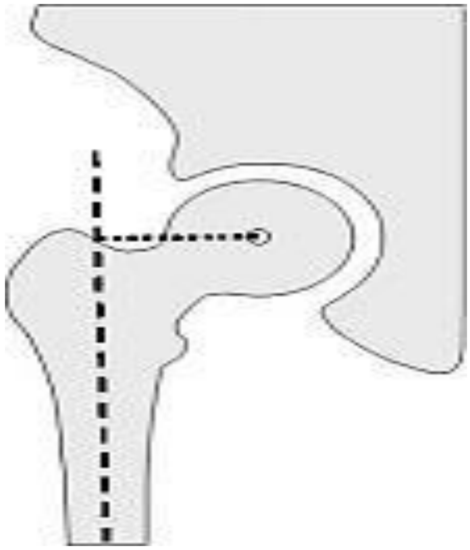

Figure (1): Lateral femoral offset. [11]

3) Head Neck ratio: the difference between the femoral head circumference and the femoral neck, which permits joint movements to occur before the impingement of the neck on the acetabular rim. [12]

Acetabulum:

Understanding acetabular orientation is of much importance in many orthopedic considerations including: periacetabular osteotomies, hip joint osteoarthritis, managing acetabular trauma, development of acetabular implants and in planning, and evaluation of total hip arthroplasty (THA). Acetabular orientation is generally defined by two angles: abduction (inclination) and anteversion (opening angle). (13)

The average functional and anatomic abduction and anteversion angles ranges from 32◦–58◦ and 22◦–31◦, respectively. (14)

The acetabulum has a nearly circular contour in its superior margin, but it has only enough hemispherical depth to allow for 170^{o} 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) This labrum increases the depth of the acetabulum and thus increases the hip joint stability. (16)

The three ligaments surrounding the hip (ilio-femoral, pubo-femoral and ischio-femoral ligaments) restrict movement in their corresponding directions and contribute to the stability of the normal hip. [16]

Musculature:

Twenty seven muscles cross and therefore act on the hip joint. They act to produce movement, and improve stability. The most important group of muscles for stability of the hip joint is the hip abductors, specifically gluteus medius, that extends from the lateral aspect of the ilium to the greater trochanter. It acts to perform single leg stance. The produced torque by this muscle around the hip center of rotation is influenced directly by the femoral offset which determine the magnitude of the lever arm. [17]

Biomechanics of the hip joint

The biomechanics of the hip will be discussed in the following items:

***1) Kinematics**:*

A) Surface joint motion and Center of rotation.

B) Range of motion.

2) Kinetics:

A) Statics.

B) Dynamics.

1) **Kinematics:** Joint kinematics is defined as the description of angular or translational motion of the joint in response to applied forces. [18]

A) Surface joint motion and center of rotation:

Surface motion of the hip joint is considered as the sliding of the head of femur on the acetabulum. The pivoting of the ball and socket in three differant planes around the center of rotation of the head of femur produces this sliding of the hip joint surfaces. If the femoral head is incongruent, sliding may not be parallel or tangential to the surface, and the cartilage of the joint may be abnormally distracted or compressed. Shear forces (i.e. forces parallel to the surface) are very small in sound joints because of the very low friction coefficient. (19)

The center of rotation of the hip joint is the geometrical center of the head of femur. good preoperative planning, templating and selection of used implant should help to ensure that after total hip replacement the hip center of rotation is restored to its original sound position. (Fig. 2) (19)

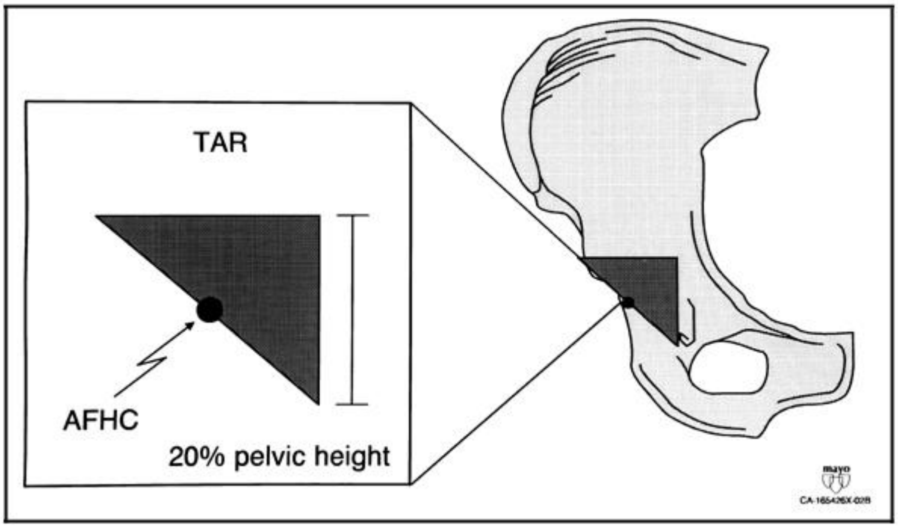

Figure (2): this Diagram showes the true acetabular region (TAR) which is the area enclosed by an isosceles triangle, where the height and width are equal to 20% of the pelvic height. The inferomedial corner of the true acetabular region is five millimeters lateral to the intersection of radiographic teardrop and the kohler line. The mid point of the triangle's hypotenuse is defined as the approximate femoral head center (AFHC) and represents the normal center of rotation of the hip joint. (19)

In the condition of developmental dysplasia of the hip joint the centre of rotation is usually displaced proximally with varying degrees. Restoration of the centre of rotation to the true acetabulum during hip replacement provide both anatomical and biomechanical advantages and also the best bone stock of the acetabulum is usually found at the site of the true acetabulum, which allows proper medialisation and adequate coverage of the implanted cup. [20]

Positioning of the cup at the site of the true acetabulum also raises the lever arm for the abductor muscles, thus helps to restore biomechanics and maximizes the moment generating capacity of the abductors. [20]

Many investigators developed mathematical models to calculate the effect of alterations in the anatomic position of the hip joint center on the moment generating capacity of muscles crossing the hip joint. These analyses demonestrate that the joint reaction force may be minimized when the hip joint center is displaced medially, inferiorly and anteriorly. This position maximizes the moment generating capacity of the abductor muscles and brings the joint center of rotation closer to the line of action of the foot floor reaction force, therefore minimizing the external moment that must be balanced by the muscle forces acting across the hip joint. [21]

This analysis also demonestrate that superior displacement of the hip joint center will reduce the moment generating capacity of the abductors, adductors, flexors, and extensors due to alterations in the resting lengths and moment arm of each muscle. So, cup lateralization and higher hip centre are both considered cause of early failure. [21]

Anteversion:

The combined anteversion of the femoral stem and the acetabular cup helped by some anatomical landmarks as the transverse acetabular ligament should help to reflect patients normal anatomy. This provides adequate range of movement before implant impingement occurs. Retroversion or decreased anteversion of the acetabular cup leads to higher risk of dislocation, especially with posterior approach. This is caused by relative weakness of the posterior structures after surgery and also because of anterior impingement with internal rotation of the lower limb. [22]

The Offset:

The femoral offset can be defined as the perpendicular distance between the neutral long axis of the femur and the center of rotation of the hip joint. Restoring the normal degree of the femoral offset is considered a primary goal of total hip replacement, thus making this measurement valuable. Because the offset is affected by the hip degenerative process, it is useful to measure the offset on the contralateral normal hip. This offset can be influenced by each of cup positioning, choice of suitable femoral stem and position of the stem. (Fig. 3) [(18)]

Decreasing the femoral offset has a number of disadvantages. The decrease in abductor muscles moment arm decreases abductor strength. Decreasing the abductor moment arm increases the joint reaction forces, which could cause higher rates of acetabular cup loosening or higher rates of polyethylene wear. Finally, decreasing the offset leads to abductor muscles laxity, which may lead to a higher incidence of implant instability. [(18)]

Increased offset leads to greater stresses on the femoral stem and the femur due to the higher bending moment. Over tightness of the ligaments can also have a negative effect on