Cementless Total Hip Replacement for Non United Femoral Neck Fractures

Thesis submitted For Partial Fulfillment
Of MD Degree in Orthopaedic Surgery

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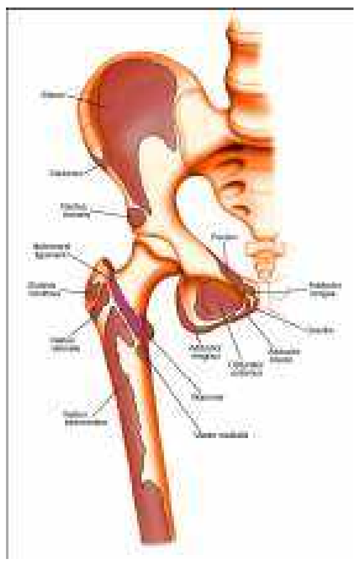

Introduction

The hip is a ball-and-socket joint formed by the head of the femur and the acetabulum of the pelvis. It has 3 rotational degrees of freedom (flexion/extension, abduction/adduction, internal/external rotation). The articular surfaces are formed of hyaline cartilage which has a very low coefficient of friction. The hip joint supports the weight of the body in both static and dynamic postures. Stability is conferred by high surface conformity 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 **(McCarthy et al, 2005)**

Osteology

The Proximal Femur

The form of the femur is relatively complex, with bows and twists that distort its basically tubular structure. The anterior bow of the midportion of the femur is well recognized and has even been built into some current prostheses. This is commonly envisioned as an anterior bow because of the position that the separate femur assumes when it is placed on a horizontal surface, resting on the posterior margin of the trochanter and the posterior aspects of the condyle (Figure 1.1A). However, in vivo the orientation is somewhat different. In the erect position, the central portion of the femur is more in the coronal plane of the body, with the distal portion inclined posteriorly to the knee and the proximal portion inclined anteriorly to the acetabulum (Figure 1.1B).

The posterior bow of the proximal femur is just as constant as the midportion anterior bow, but it seems to have been unrecognized or considered of no importance by most designers of femoral stems. The central portion of the proximal posterior bow is opposite the level of the lesser trochanter. This bow is constant. It is also noteworthy that the radius of curvature does not seem to change dramatically with the size of the femur. The length of the curve increases with increasing femur size from the base of the neck until the curve reverses distal to the lesser trochanter, but the radius of the curve is relatively constant, **(Noble et al 1995)**

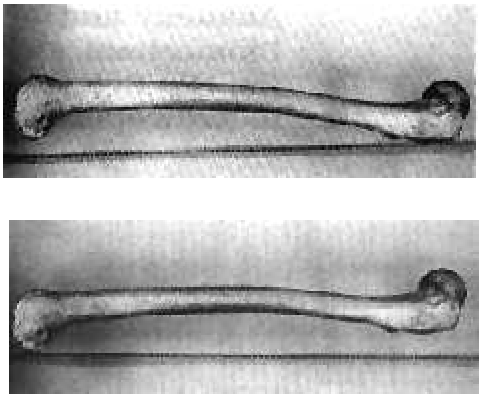

Figure 1.1 A, Photo of skeletal femur resting on table top;

B, same femur positioned in the neutral plane, as it is in the body,

(Radin 1980)

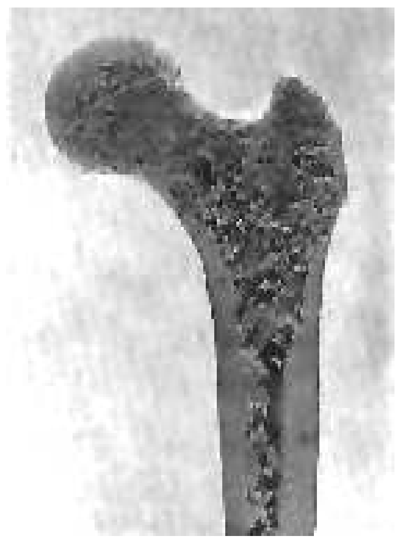

Figure 1.2 Coronal cut through the proximal femur showing the distribution of cancellous bone and particularly the striking diminution distal to the lesser trochanter.***(Noble et al 1988)***

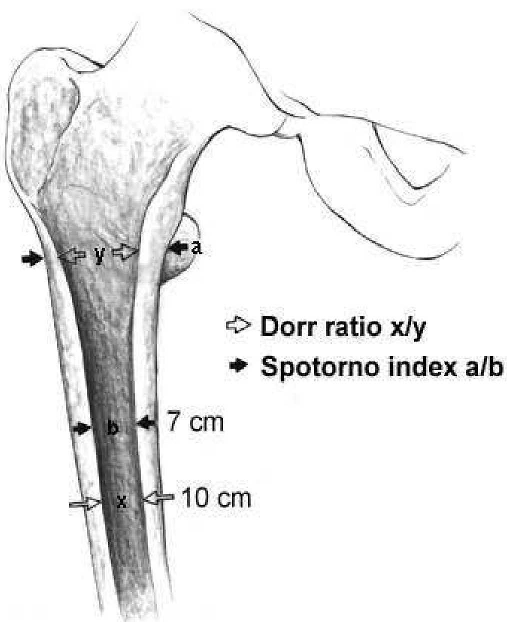

Figure1.3: Schematic diagram of the proximal femur, demonstrating the Dorr and Spotorno indexes for evaluating bone configuration ***(Spotorno et al., 1987)***

The Neck-Shaft Angle

The head of the femur considerably overhangs the femoral shaft. This occurs because the neck makes an oblique angle with the shaft of an average of 135°. Although there is considerable variability in both the neck-shaft angle and neck length, in general the center of the femoral head is extended medially and proximally by the femoral neck so that the center of the femoral head is at the level of the tip of the trochanter. The effect of the overhanging head and neck is to lateralize the abductors, which attach to the greater trochanter, from the center of rotation (center of the femoral head). This increases the torque generated by the abductors and reduces the overall force necessary to balance the pelvis during single leg stance. Reducing this lever arm (coxa valga) increases total load across the hip, and coxa vara reduces it to the extent it increases the lever arm. (Coxa vara with a short neck would have a negative affect.), **(Hoagland et al 1980)**

The distance between the center of the femoral head and the lateral aspect of the trochanter can vary independent of neck-shaft angle (although patients with increased valgus tend to have less offset, Whereas patients with increased varus have more offset), these variants are important because if they are anatomically normal, they need to be reconstructed with the use of femoral components with similar offset and angulation. If the variant is pathological, it is necessary to reestablish Normal hip joint kinematics and leg length **(Wasielewski 2007).**

Femoral Anteversion

The coronal plane of the femur is generally referenced to the posterior distal femoral condyles. When oriented in this plane, it can be seen that the proximal femur, including the femoral head and neck, are rotated anteriorly. This is commonly referred to as femoral head-neck anteversion. However, it is really a combination of a torsional change in the intertrochanteric part of the femur and a further anteversion of the femoral neck based upon this torsion. The sum of this change is that the adult femoral head and neck are in a plane 10-15° anteriorly oriented to the coronal plane

This can be very different in pathologic cases, particularly hip dysplasia and congenital hip displacement where torsional changes can be as much as 80°. Such abnormal relationships are much more frequently a true torsion rather than an abnormal relationship between the femoral head, neck, and greater and lesser trochanters. This is an important distinction when considering what changes may be indicated in handling such patients who present for total hip replacement. For prostheses intended to achieve maximal purchase in the proximal femur, it may be necessary to first change the relationship between the proximal and the distal femur, **(Radin, 1980)**

It is important to view the hip three dimensionally in order to establish criteria for forming prosthesis geometry that is anatomical. Both CAT scans of the proximal femur in normal patients and transection of properly oriented, referenced, and marked cadaver femurs can assist in this understanding. The intertrochanteric region of the hip is important for long-term fixation and stability, while the diaphyseal region distal to the lesser trochanter is principally important for initial fixation and stability of the components, **(Noble et al 1988)**

Distribution of Cancellous Bone in the Proximal Femur

It appears to be a characteristic of the articulating ends of long bones that the broad ends, covered with articular cartilage, are supported principally by cancellous bone and a very rudimentary cortex in the form of a subchondral plate. The forces applied to the articular surfaces are carried by the cancellous bone out to the cortex. It does not appear to be a coincidence that where the cortex reaches its full thickness, the cancellous bone essentially stops. The distribution of cancellous bone that is suggested in the x-ray is vividly illustrated in the coronal cut through a dessicated femur (Figure 1.2).

Dorr, 1985 and **Spotorno, 1987** have developed indices to characterize proximal femoral configuration. The Dorr index is a ratio of the canal diameter at the level of lesser trochanter to canal diameter at a point 10 centimeter distal (Fig. 1.3). The Spotorno index is the ratio of the outer bone diameter at the middle of the lesser trochanter to the canal diameter 7 cm distal to this point.

As the canal calcar isthmus ratio (the Dorr index) approaches 1, prosthesis fill proximally and distally is compromised. Young patients with a champagne - fluted configurations may require more porous surface on their femoral implants to adequately contact the endosteal femoral surface or a cemented implant should be considered **(Wasielewski 2007).**

Cross-Sectional Analysis

As a part of the development of the shape and sizes for the PCA hip stem, 86 North American cadaver femurs were x-rayed in the A-P and true lateral position to determine the form of the proximal femur and distribution of cancellous bone. A detailed examination of one of those normal bones is representative for the shape of the normal human femur. Particularly on the lateral x-ray, the posterior bow of the proximal femur can be seen with its apex opposite the lesser trochanter (Figure 1.4).

The three aspects of the anatomy of the femur that limit the access of stems that are straight in the lateral plane are the posterior margin of the femoral neck, the anterior margin of the cortex opposite the lesser trochanter, which represents the apex of the posterior bow of the femur, and the posterior cortex of the shaft where the bow of the femur is reversing into an anterior bow.

By superimposing the cross sections from the proximal base of the neck, the level of the lesser trochanter, and the level of the tip of a typical prosthesis, the limit to the window of common opening for a straight stem prosthesis can be seen (Figure 1.5). The straight stem would bind proximally at the posterior margin of the neck, in the mid-portion at the anterior cortex, and distally at the posterior cortex. A larger stem prosthesis would have the tendency to blow out the posterior neck as the stem follows the anterior bow of the mid femur or to punch through the posterior cortex 5-6 in. down the shaft, **(Hoagland et al 1980)**

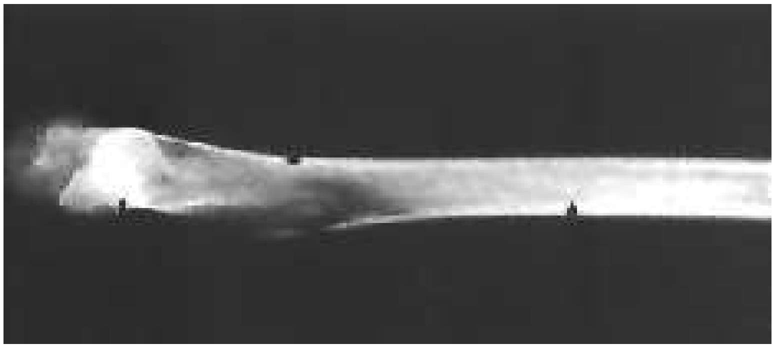

Figure 1.4. Direct lateral x-ray of the femur. Arrows mark the structures that limit the windows of access for a straight-stem prosthesis, ***(Hoagland et al 1980)***

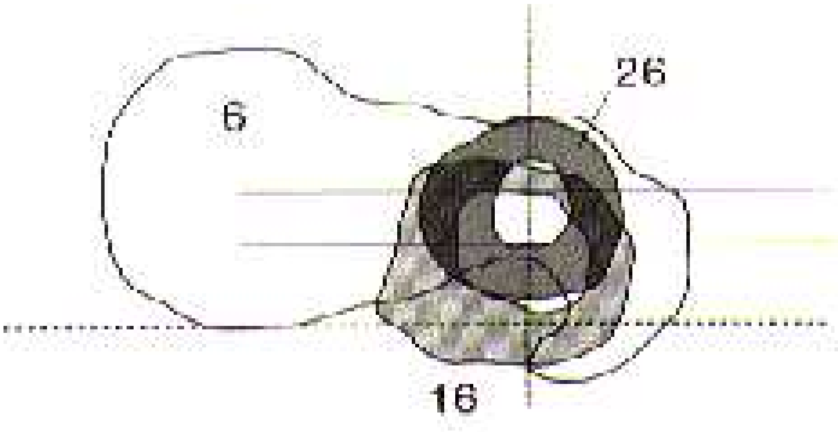

Figure 1.5. Superimposition of slices 6, 15 and 26 give an end-on view of the proximal femur. The common A-P window for a straight stem prosthesis is narrowed by the posterior margin of the neck (slice 6), the anterior cortex of slice 15, the posterior cortex of slice 26. The slices have been oriented against a common coronal plane reference, ***(Hoagland et al 1980)***

Acetabulum

The acetabulum is formed by the confluence of the ilium, pubis, and ischium at the triradiate cartilage. With the fusion of this cartilage at the completion of growth, the form and orientation of the acetabulum are fixed. The normal bony acetabulum is slightly less than a hemisphere, but its functional dimensions are extended by the tough fibrocartilaginous labrum. There is some controversy in the literature concerning the orientation of the acetabulum. Getz , Steindler , and von Lanz all give figures for acetabular anteversion of around 4O° (38- 42°). They made their measurements with the pelvic brim approximately horizontal, where it can be seen that the acetabula are obviously facing forwards (Figure 1.6). However, in the erect position, the anterior-superior iliac spines and pubic symphysis are in the same plane and the acetabulae are not as obviously anteverted (Figure 1.7). McKibbin measured 30 each adult male and female pelvises, oriented this position, and recorded an average anteversion of 14° (5-19°) for men and 19° (10-24°) for women. When the pelvis is flexed, as it is in sitting, the forward facing of the acetabulum is accentuated. In the erect position, the anterior-superior iliac spines and the symphysis pubis lie in the coronal plane. In this position, the acetabulum opening is directed approximately 45° laterally and 15° forward. Flexion of the pelvis on the lumbar spine increases the apparent anteversion without greatly changing the apparent lateral opening, whereas lumbar lordosis does the opposite,**(Murray , 1993)**

The non - articulating surface, known as the acetabular fossa contains some fibro fatty tissue (Haversian Fat Pad) and opens below toward the obturator foramen at the acetabular notch. The acetabular fossa is a rough area at the center of the acetabulum. It is the thinnest portion of the floor and a zone that may transilluminate on a dry specimen since the inner and the outer tables of cortical bones are fused without interposioned cancellous bone.

It is of paramount importance to avoid deepening the socket beyond this zone or breaking through this area; this could lead to failure of fixation and complete medial migration of the prosthetic device. It is a fortunate coincidence that in most of osteoarthritic hips, especially following congenital dysplasia, marked thickening of the floor has taken place, which allows further deepening at this level but this is usually evidenced by radiological teardrop **(Eftakhar 1978).**

The teardrop is a u- shaped shadow medial to the hip joint that has been utilized to detect abnormalities of acetabular depth, thereby establishing a diagnosis of acetabular protrusion. The lateral aspect of the tear drop is the wall of the acetabular fossa, and the medial aspect is the anteroinferior margin of the quadrilateral surface (Fig. 1.8).

In the usual anteroposterior radiograph of the pelvis, the lateral surface is parallel to the x- ray beam and is thereby projected as typical teardrop. The configuration of the teardrop varies in normal persons, however. Furthermore , it is affected significantly by patient positioning **.**

The peripheral articulating margin (lunate surface), covered by articular cartilage, carries the full body weight but absent Inferiorly, at the acetabular notch. Thickness of acetabular cartilage ranges from 1 mm peripherally, where it blends with the labrum, to 2 or 2.5 mm in the posterosuperior segment, where it is exposed to the maximal head pressures **(Wasielewski 2007).**

The optimum acetabular alignment is about 45^o to the horizontal and 15^o of anteversion. The normal bony acetabular angle of about 55^o is reduced to 45^o by the presence of the acetabular labrum. This means that if inserted at 45^o the superior lip of the cup tends to hang out or be uncovered. The advent of a non cemented cups with offset plastic liners suggests that these cups can be inserted for the maximum bony angle , i.e., at 55^o, the plastic overhang serving as the labrum. If the cup is anteverted 15^o or more, then the chances of posterior dislocation are reduced, and the anterior lip of the cup does not contact the patient's femoral neck in flexion and adduction. The cup anteversion, however must not be so great to allow femoral neck contact with the cup in extension and external rotation because this can lead to anterior dislocation **(Cameron 1992)**