INTRODUCTION

The subtrochanteric region of the femur extends from the upper border of the lesser trochanter to 5 cm distal to it. It represents the transition zone from cancellous bone of trochanteric area to cortical bone of femoral shaft. The incidence of the subtrochanteric fractures varies from 7% to 2% of fractures of proximal femur(17).

There are several classification systems but the most widely accepted is the one proposed by Seinsheimer in 1978. the intense concentration of compression, tensile and torsional stresses and decreased vascularity of this region has challenged orthopaedic surgeons in cases of fractures of this region(34,72).

There is a high rate of complications associated with their management as malunion, delayed union, non union and implant failure(34).

Biological fixation preserves fracture haematoma, avoids extensive bone exposure and thus reduces surgical trauma to both bone and surrounding soft tissues. It also aims to achieve optimal biological conditions for fracture healing rather than absolute stability of the fracture fixation. In subtrochanteric fractures with posteromedial comminution restoration of the medial cortex is often difficult to achieve. In these kinds of fractures, biological fixation helps to solve major problems(31).

There are many different methods of biological fixation used in management of subtrochanteric fractures especially the comminuted and unstable fractures.

Biological fixation divided into external fixation and internal fixation.

Biological external fixation may be of value for open fractures or problem fractures in children. Problems that can be encountered are pin tract sepsis, malnunion of fracture or nonunion[72].

Biological internal fixation is a developing concept. It aims principally to cause minimal biological harm to the bone and surrounding soft tissues. In particular, the technique does not aim at the reduction of intermediate fragments and takes advantage of indirect reduction to achieve only a proper alignment of the main fragments. They perform indirect reduction and biological fixation in only communited fractures[31].

The implants used in biological internal fixation are broadly divided into extra medullary implants and intra medullary implants [31].

The extra medullary implants include dynamic hip screw plate, dynamic condylar screw plate, and condylar blade plate 95^{o}C [17,72].

Intra medullary implants include Gamma nail, Russel-Taylor reconstruction nail and interlocking intramedullary nail[72].

AIM OF THE ESSAY

The aim is to review the literature regarding the various methods of biological fixation of subtrochanteric fractures especially comminuted and unstable fractures, stressing on advantages and disadvantages.

Chapter (1)

APPLIED ANATOMY OF SUBTROCHANTERIC AREA

It is the area between the lesser trochanter and 5 cm distal to it and shaft region, the femur is covered circumferentially by well - vascularized muscle groups. Direct surgical exposure of the subtrochanteric region involves either splitting the vastus lateralis muscle or reflecting it anteriorly from the lateral intermuscular septum. Profuse bleeding from perforating branches of profounda femoris artery can complicate this exposure. The attachment of hip muscles (iliacus and psoas, gluteus meduis and minimus, glutens maxmius and adductors) all contribute to the powerful forces that act on the individual fragment in subtrochanteric factures[1].

Internal skeletal Anatomy of upper end of femur

In 1838, Ward first described the internal trabecular system of the proximal end of the femur. He identified three groups, the compressive, the tensile, and the secondary compressive groups. A triangular area of loosened density known as the trigonum internum femoris or Ward's triangle.

Singh et al. (1970) divided the trabecular pattern of the proximal femur into five groups as follows.

1) Principal compressive group:

This forms the thickest and the most closely packed trabeculae-in the proximal femur. They extend from the medial cortex of the upper femoral shaft to the weight-bearing dome of the femoral head.

2) Secondary compressive group:

It is rest of the compression trabeculae, which arises just below the principal compressive group and curved upward and laterally. It ends into the greater trochanter and the upper portion of the neck. This group is thin & widely spaced.

3) Greater trochanter group:

It is a poorly defined and slender tensile group of trabeculae that arises from the lateral cortex just below the greater trochanter and sweeps upward to end near its superior surface.

4) Principal tensile groups:

This is the thickest tensile group and it springs from the lateral cortex just below the greater trochanter group. It curves upward and medially across the neck to end in inferior portion of the femoral head below the foveal area.

5) Secondary tensile group:

This group of trabeculae arises from the lateral cortex-below the principal tensile trabeculae and arches upwards and medially crossing the upper end of the femur. It ends irregularly after crossing the mid-line. In normal hip radiograph, all the trabecular groups described above are clearly demarcated.[(2)]

Ward's triangle (Trigonum internum femoris)

It is an area containing some thin and loosely arranged trabeculae enclosed between the principle compressive, the secondary compressive and the tensile trabeculae in the neck of the femur. Its importance is that it is a basically weak area which gets weaker with osteoporosis and through it the majority of femoral neck fractures occur. This probably occurs due to little demand exerted on this area from either the static or dynamic point of view[(3)].

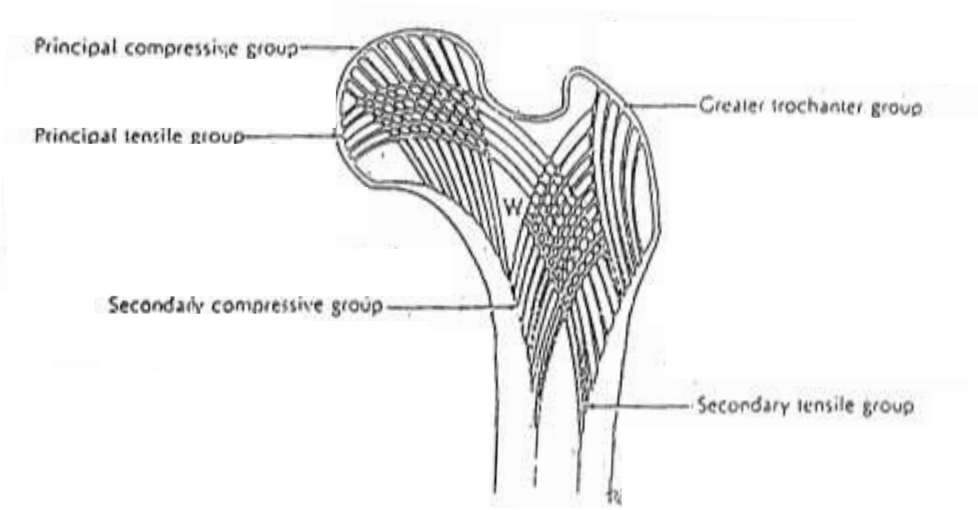

Figure (1): Bony trabeculae in the proximal end of femur.
(W) is the ward's triangle[(4)]

Calcar femoral

It is a dense vertical plate of bone. It springs from the posterior medial portion of the femoral shaft under the lesser trochanter and radiating laterally to the greater trochanter. It reinforces the femoral neck posteromedially as it joins the inner surface of the posterior wall of the femoral neck. It represents a lateral extension of the posterior wall of the femoral neck anterior to the trochanteric crest. The calcar femorale is thickest medially & gradually thin as it passes laterally. The calcar femorale represents the upward extension of the original cylindrical shaft and is considered transitional from the tubular outline to the metaphyseal trochanteric area. It counteracts the postero-inferior compressive forces of the femoral external rotators. This helps in evaluating and designing a more proper internal fixation and prosthetic replacement,, also for choosing a good site for nail placing.

So, the centrally placed nail is along the neutral or anatomical axis, which is mechanically unsound for supporting a stress load. From this point of view of bone architecture and engineering the position of choice is a low placed nail in valgus position, actually resting on the calcar femorale, which offers the best support in the neck of the femur(5).

Abnormal bone quality in the upper end of femur

Singh et al., 1970, introduced a method of determining the degree of osteoporosis by radiological evaluation of trabecular patterns of the proximal femur They graded the degree of osteoporosis into six grades in which grade I is severely osteoporotic while grade six is normal bone. The radiological findings were correlated with clinical and histological data of these patients. This correlation was found highly significant[(2)].

1- **Grade six:** all the normal trabecular groups are visible and upper end of femur seems to be completely occupied by cancellouls bone. The compression and tensile trabeculae cross each other. Even Ward's triangle shows some thin trabeculae and is not clearly delineated. The all five-trabecular groups are clearly apparent clinically it is found in young individuals histologically their bones are normal.

2- **Grade five:** the structure of the principal tensile and principal compressive trabeculae is accentuated. Ward's triangle appears prominent. This is because the secondary compressive trabeculae are no longer clearly demarcated. Histologically, bone biosy is still shown normal bone pattern.

3- **Grade four:** the principal tensile trabeculae are markedly reduced by still can be traced from the lateral cortex to the upper part of the femoral neck. Resorption seems to be proceeding outward from the center of bone. The principal tensile trabeculae in the outer portion of the bone can still be traced in the continuity from the lateral cortex to the upper part of the femoral neck. Ward's triangle is opened up laterally as the secondary compressive trabeculae are completely resorped. This stage represents transition from the normal to osteoporosis bone.

4- **Grade three:** there is the a break in the continuity of the principal tensile trabeculae opposite the greater trochanter. This grade indicates definite osteoporosis both radiologically and histologically.

5- **Grade two:** only the principal compressive trabeculae is the prominent one. All the other groups are more or less completely resorped. This stage represents a moderately advanced osteoporosis.

6- **Grade one:** even the principal compressive strabeculae are markedly reduced in number and are no longer prominent. Radiological there is an impression of badly taken radiograph. There is only little difference in the density between bone and the surrounding soft tissue. Histologically also the bone is in the most severe degree of osteoporosis.

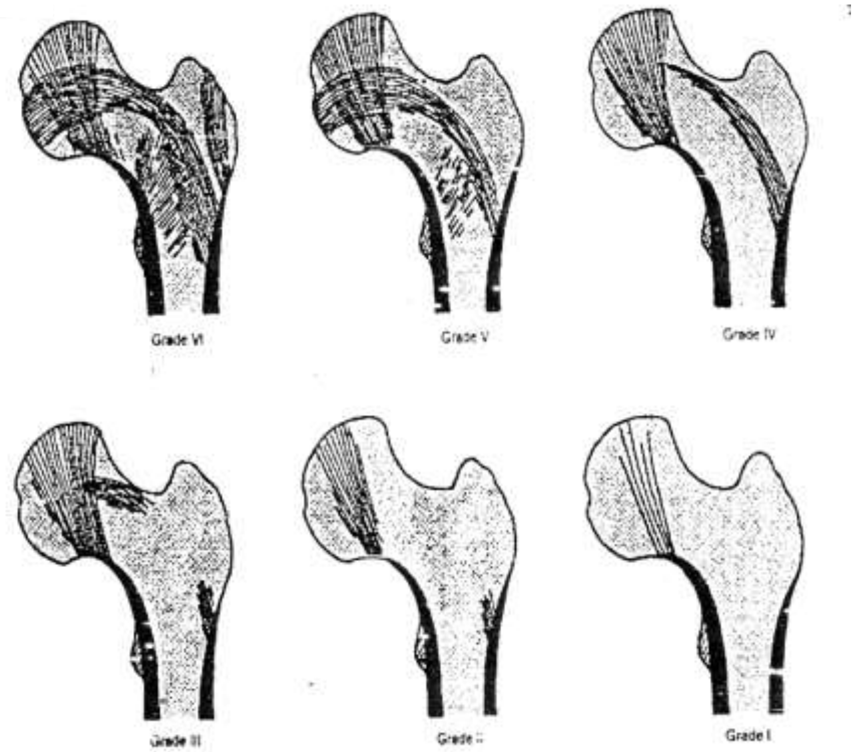

Figure (2): The Singh index of proximal femoral osteopenia. Progression is form normal grade VI with well defined primary and secondary tension and compression trabeculae to severely osteopenic grade I with only a few residual primary compression trabeculae. Although this scheme is extremely useful in determining suitability for reduction and internal fixation, it has limited application as a research tool because of interobserver variability and difficulty in interpreting many radiographs[6].

Muscles acting on the proximal femur:

The proximal femur is surrounded by thick broad muscle groups which play a vital role in its displacement after fractures.

Anteriorly the flexors are innervated by the lumbar nerve roots, posteriorly the extensors and abductors get their nerve supply from the lumbo-sacral plexus, and medially the adductors are innervated by the obturator nerve[7,8,9].

Abductor muscles:

The glutei medius and minius, passing from the dorsum ilii to the greater trochanter, cover the superior and lateral aspect of the joint. These two muscles together with the tensor fascia lata are innervated by the superior gluteal nerve.

In walking the thigh is fixed and the contraction of the abductors prevents sagging of the pelvis to the opposite side i.e. the side of the swinging limb and the pelvis is maintained in a relatively level plane during locomotion. To prevent contralateral pelvic drop while bearing weight on one limb as in walking two factors are indispensable:

- A stable hip joint which provides a painless fulcrum.
- Adequate and efficient hip abductors.

Loss of the fulcrum or incompetence of the abductor mechanism leads to contralateral pelvic sagging when standing on one limb (positive Trendelenburg's test)

In maintaining a leveled pelvis during weight bearing, the hip abductors gain additional aid from contraction of the contralateral quadratus lumborum and sacrospinalis groups[7,8,9].

The adductor muscles:

Arising from the pubic bone, they are the adductor longus and brevis with parts of the adductor magnus and obturator externus all are innervated by the obturartor nerve. They adduct and help in flexing the thigh. The ischial component of the adductor magnus reaches distally to the adductor tubercle, it is innervated by the sciatic nerve and adducts but also extends the thigh[8].

The flexor muscles:

The main flexors are the psoas major and the iliacus. They are assisted by the pectinius, the rectus femoris and the sartorius muscles. The adductor longus participates in the movement specially in its early stages[8].

The extensor muscles:

The main extensor muscle is the gluteus maximus. It is the true antagonist of the psoas major and iliacus. The hamstring muscles share in producing movement, also the ischial part of the adductor magnus, when strong resistance is encountered[8].

The internal rotators:

The internal rotators are the tensor fascia late and the anterior fibres of the gluteus medius and minimus. The movement is limited by the tension of the external rotators, the ischiofemoral ligament and the posterior part of the fibrous capsule.

Internal rotation is weak in full extension, for more effective medial rotation, some hip flexion is always utilized[7].

The external rotator muscles:

They are the obturators, the gemelli and the quadratus femoris assisted by the piriformis, the gluteus maximus and to a slight extent by the sartorius and the adductors.

The movement is limited by tension of the medial rotators and the lateral band of the ilio-femoral ligament. The external rotators are three times more powerful than the internal rotators, but internal rotation is reinforced by hip flexion[7].

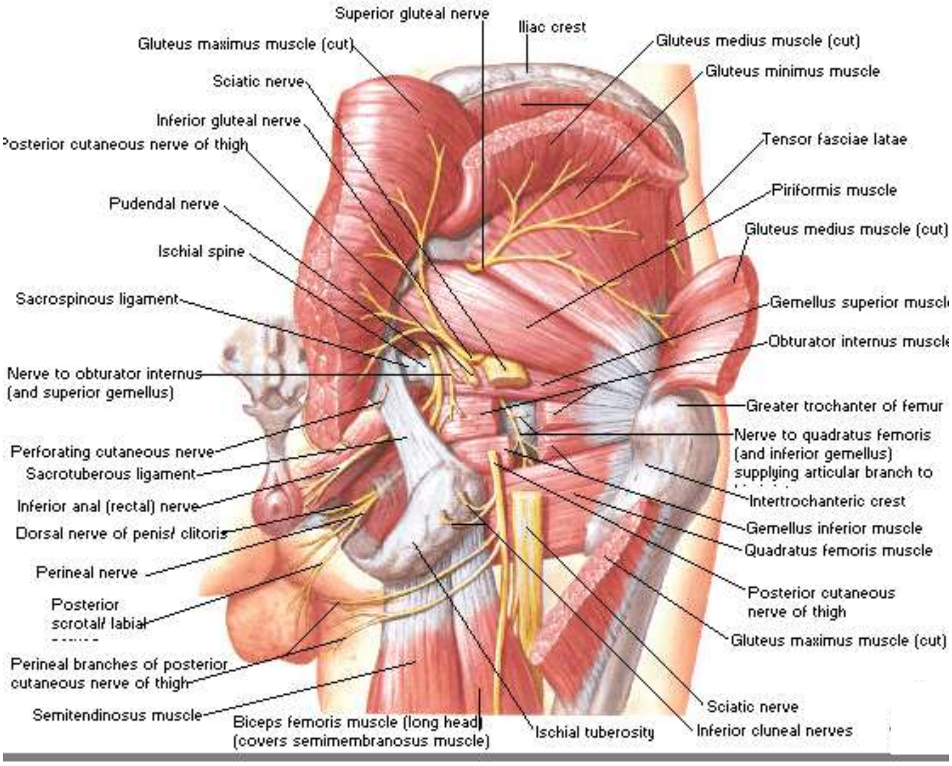

Figure (3): Muscles and nerves of the hip and buttock[73].

Arterial supply of the proximal end of the femur:

Crock (1980) divided the arteries of the proximal end of the femur into three groups:

1- An extracapsular arterial ring located at the base of the femoral neck.

2- Ascending cervical branches of the extracapsular arterial ring on the surface of the femoral-neck.

3- The arteries of the round ligament.

The extracapsular arterial ring is formed posteriorly by a large branch of the medial femoral circumflex artery, and anteriorly by branches of the lateral circumflex artery. The superior and inferior gluteal arteries also have minor contributions to this ring.

The ascending cervical branches arise from the extracapsular arterial ring. Anteriorly, they penetrate the capsule of the hip joint at the intertrochanteric line; and posteriorly, they pass beneath the orbicular fibers of the capsule. The ascending cervical branches pass upward under synovial reflections and fibrous prolongations of the capsule toward the articular cartilage that demarcates the femoral head from its neck.

These arteries are known as retinacular arteries, described initially by Weitbrecht This close proximity of the retinacular arteries to bone puts them at risk of injury in any fracture of the femoral neck(10).

As the ascending cervical arteries traverse the superficial surface of the neck of the femur, they send many small branches into the metaphysis of the femoral neck. Additional blood supply to the metaphyeal arteries from the extracapsular arterial ring and may include anastomosis with intramedullary branches of the superior nutrient artery system, branches of the ascending cervical arteries and the subsynovial intra-articular ring. In adults