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Subtrochanteric Fractures- Current Management Options

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Abstract

INTRODUCTION

The Subtrochanteric fractures account for 10-34% of all hip fractures (David G Lavelle 2003).These fractures have long been recognized as the most difficult of femoral fractures in terms of treatment (Delong William G. 2001). These are the fractures between lesser trochanter and 5cm distally. They may occur as singly but sometimes extension of intertrochanteric fractures. Prior to twentieth century these fractures were less common but more complicating to the patient. As the treatment options were few therefore, the situation used to be life threatening (Delong William G. 2001).

The treatment of these fractures continues to present a challenge to an Orthopaedic surgeon. This challenge stems from a combination of anatomical and biomechanical features pertinent to this area. (Fielding. clinic orthop 192;86,1973.,Heiple. JBJS 61A; 730, 1979)

ANATOMICAL FEATURES

The subtrochanteric region has been defined in various ways, but most commonly the area between the inferior border of the lesser trochanter and the isthmus of the femoral shaft or the inferior border of the lesser trochanter to the junction of proximal and middle one third of the femur is taken as subtrochanteric region (Stephen H. Sims 2002). The area is mainly cortical due to which the area of healing as well as the vascularity are less. This prolongs the healing time. Moreover the Proximal fragment is short and medullary canal wide leading to less than optimal fixation. The attachment of muscles across the fracture is such that the proximal fragment is flexed, abducted and externally rotated and the distal fragment adducted causing a shear at the fracture site so closed reduction and holding is not possible in these fractures.

In the late teens and early adult life the proximal femoral metaphysis and the femoral neck are filled with dense cancellous bone. Because this cancellous bone becomes increasingly sparse with advancing age, contact and purchase for any intramedullary nail type of fixation are poor. The trabecular structure of the femoral head also thins, this result in a relative void of the trabeculae deep to the subchondral bone. Only the centre of the femoral head where the tension and compression trabecular systems cross contains a relatively dense trabecular network that can give adequate purchase for any fixation device.

BIOMECHANICAL FEATURES

Because of its shape the femur is subjected to eccentric loading The proximal end of the femur has been likened to a cantilevered arch that transfers the force of weight bearing to the hip and pelvis. In vivo this bending force loads the medial cortex in compression and lateral cortex in tension, the forces are not in equilibrium. There are high stresses acting in Subtrochanteric area, up to 1200lb/sq inch. There is high compressive stress on the medial side and high tensile stress on the lateral side (Kock am J orthop. 21; 177-193, 1917). Although lateral muscles partly compensate for the high compressive medial forces, proximal femur is still eccentrically loaded as the compressive medial forces are considerably greater than the lateral tensile forces (Rybicki etal J. Biomech. 5; 2003,1972). Major compressive stresses in the femur are greatest in the medial cortex 1-3 inches below lesser trochanter. If the medial buttress is not intact or can not be re-established, the internal fixation devices are subjected mainly to bending stresses and the loads are concentrated in this high stress area resulting in implant failure or loss of fixation. This is the most highly stressed region in the body.

This dissimilar loading pattern is of great importance in selecting internal fixation devices and in understanding the causes and prevention of failure of internal fixation devices.

The loading pattern further emphasizes the importance of integrity of medial half of the column as well as the importance of prestressing of the implant in tension. This in turn increases axial compression, which increases the stability of the fixation and restores the fractured fragment as functional unit. If the medial cortex can be reconstituted at the time of surgery, a plate placed laterally acts as a tension band, allowing impaction with protected weight bearing. If the medial cortical contact is not restored, bending stresses are concentrated in one small area of the plate, which often results in mechanical failure of the internal fixation device with delayed union, nonunion, or malunion of the fracture. Until recently, restoration of the continuity of the medial cortex of the proximal femur has been the key to success.

The proximal femur is surrounded by large and powerful muscles. These together with the interplay of gravity result in characteristic deformities in the case of subtrochanteric fractures. The iliopsoas flexes, abducts, and externally rotates the proximal fragment. The adductors lead to adduction of the shaft. This deformity complicates attempts at closed reduction. Shortening, of, course, occurs as a result of the contraction of all the long muscles that span the length of the shaft. Thus the characteristic deformity is an anterior and lateral bowing of the femoral shaft combined with considerable shortening.

The angle formed by the axis of femoral neck and femoral shaft is130±7. If the angle is reduced as would occur with varus reduction of fracture, the distance between the head and shaft is increased, with the increased moment arm and the bending forces across the fracture and may produce varus collapse.

Management problems- these may be either patient related or fracture related pertinent to this area.

PATIENT RELATED:

Subtrochanteric fractures have a bimodal age distribution but different mechanisms of injury. The older people typically sustain low velocity trauma as do pathologic injuries in metastatic or primary bone disease. Usually they fall on the slippery surfaces or after a mis step. These fractures usually have less comminution and of long spiral configuration. In some elderly individuals fracture is caused by the twist where dissolution of the continuity has already occurred before the patient falls to the ground. Such individuals get fracture first and a consequent fall rather than the other way round. The main contributing factor of this injury in the elderly persons lies in their inherent instability while erect, slow reflex proprioceptive response and osteoporosis. Also the possibility of pathological fracture because of metastasis is to be kept in mind and the very high risk due to antecedent medical conditions also has a bearing in the treatment of these difficult fractures in elderly patients.

The younger patients get these fractures from high energy trauma and often have significant comminution. These fractures most commonly result from motor vehicle accidents or falls from a height. Penetrating trauma secondary to gunshot wounds is another common mechanism of fractures in young patients. With these mechanisms of injury, severe injuries to other organ systems are frequent and often are associated with other fractures and injuries.

FRACTURE RELATED:

There are various fracture related problems like the presence of numerous classifications for these fractures, moreover because of shear across the fracture , close reduction and maintainance is not applicable. The presence of medial cortical comminution hinders in achieving stability. Malunion leading to varus, shortening and external rotation is not uncommon even after operative management. Delayed union and non union are the other problems encountered during the management of Subtrochanteric fracture. The incidence of implant failure approximates 20%.

CLASSIFICATION:

Fieldings: difficult to apply because it doesn’t take into account spiral and oblique fractures, secondly no comment on comminution is there.

Seinsheimer’s : this classification comments on shape of fracture line, its location and degree of comminution.

Russel Taylor : tells about the involvement of piriform fossa and lesser trochanter an guides to use appropriate implant for a particular fracture pattern.

A.O Muller etal: widely used classification , takes into consideration shape of fracture line and degree of comminution and some complex fractures which are not included in the above classification system.

A.O classification system

Figure 1

Type A: Simple fracture (two part fracture)

A1 Spiral

A2 Oblique

A3 Transverse

Type B: Wedge fracture (fracture with butterfly fragment)

B1 Spiral Wedge

B2 Bending Wedge

B3 Comminuted Wedge (fragmented wedge)

Type C: Complex comminuted fractures

C1 Complex Spiral

C2 Complex Segmental

C3 Complex Irregular

Fracture reduction and stability

In subtrochanetric fractures the deforming forces because of the the attached muscles across the fracture is such that the proximal fragment is flexed, abducted and externally rotated and the distal fragment adducted causing a shear at the fracture site. It is because of these deforming forces plus unstable fracture patterns and comminution the fracture reduction and maintenance is difficult.

MEDIAL CORTICAL COMMINUTION

As the proximal femur is eccentrically loaded, so this subtrochanteric area is subjected to high stress so medial cortical comminution is not uncommon thus making these fractures unstable. These fractures occurs in young adults because of high velocity trauma or gun shot wounds, in elderly these fractures complicate osteoporosis and comminution is the end result in both situations.

MALUNION , DELAYED AND NON UNION

Malunion is seen in these fractures leading to varus, valgus, external rotation, anterior angulation and shortening. The reason for these complications include inadequate reduction, loss of reduction , inappropriate implant selection along with certain anatomic and biomechanical features pertinent to subtrochanteric area that hinders the intraoperative reduction and its maintainance . Medial cortical comminution and unstable fracture pattern are the additive factors in these malunions.

Delayed union and nonunion is not less common in these fractures. As the bone is mainly cortical so the vascularity is less and less surface area is available for healing. Moreover medial cortical comminution leads to avasularity of the fracture fragments and subsequent delayed or nonunion . Other reasons include open reduction making fracture fragments avascular, inappropriate reduction and internal fixation leading to non union and implant failure.

IMPLANT FAILURE

The compressive medial forces are considerably greater than the lateral tensile forces. Major compressive stresses in the femur are greatest in the medial cortex 1-3 inches below lesser trochanter. If the medial buttress is broken or can not be re-established, the implants are subjected mainly to bending stresses and the loads are concentrated in this high stress area resulting in implant failure. Other causes of implant failure include wrong choice of implant, osteoporosis and premature weight bearing.

MANAGEMENT

The successful management of these fractures begins from thorough clinical and radiological evaluaton, careful preoperative planning. Consideration should be given to the reduction technique and implant selection. Postoperative care and follow up should be very careful and precise with strict adherence to weight bearing protocols.

RADIOGRAPHIC EVALUATION

X-Rays AP and Lateral views of involved and contralateral side were taken for comparison and preoperative planning. Fracture topography and quality of bone is assessed meticulously with special note to piriform fossa, greater and lesser trochanter as has the baring on the use of proper implant. Pathological fractures and the injuries to hip should not be overlooked.

TREATMENT OPTIONS

In these fractures widest clinical experience, the greatest wisdom and the most judicious decision is required to choose the most appropriate treatment for a particular fracture pattern.

Prior to twentieth century these fractures were less common but more complicating to the patient. As the treatment options were few therefore, the situation used to be life threatening (Delong William G. 2001).

NON OPERATIVE TREATMENT

Conservative option has produced consistently poor results although this method eliminates many complications inherent to surgery e.g. anesthetic complication, blood loss and infection. Prolonged costly hospitalization is necessary and acceptable alignment is difficult to obtain and maintain. Various methods of conservative treatment ranges from 90-90 skeletal traction; modified cast brace, pin and plaster, but has high rates of morbidityan mortality and also high rates of local complications.(cech and sosna OCNA 5;651-662,1974.) During the past 50 years, there has been a near complete elimination of non operative treatment in adults and a corresponding increase in operative treatment of subtrochanteric fractures (Wadell J. P 1979)

OPERATIVE TREATMENT

Subtrochanteric fractures are best treated surgically and open reduction internal fixation has produced favorable results in a majority of cases. The combination of properly engineered implants, better understanding of soft tissue, perioperative antibiotics and improved anesthetic methods have made internal fixation safe and effective (Wadell J. P.1979, Warwick D. J 1995, Radford P. J &C.J Howell 1992, Nungu K. S 1993, Stephen H. Sims 2002).

The aim of any surgical intervention in this area is to obtain anatomic alignment, stable fixation, rapid mobilization and early functional rehabilitation. Having said thus, the surgical technique continues to remain complex.

Currently two broad categories of internal fixation devices are commonly used for Subtrochanteric fractures.

1. Extramedullary side plate devices like

    1. a) Sliding compression hip screws
    2. b) Condylar blade plate
    3. c) Medoff's sliding plate

Extramedullary implants are load bearing devices. Here the implant is pre-stressed and put on the tension side of the fracture and thus functions as tension device. With the use of theses extramedullary implants restoration of the medial cortical continuity is essential to reduce the concentration of stresses on the implant otherwise implant failure is the result. Restoration of the medial cortex can be done by autologous cancellous bone grafting or by biological (indirect)reduction method . With biological reduction bone grafting is no longer needed.

DYNAMIC HIP SCREW(DHS);

The favorable experience with locked nailing for comminuted subtrochanteric fractures gave the surgeon the opportunity to treat difficult fractures with much less soft tissue dissection. However, the problems continue in cases of fractures with intertrochanteric extension. Radiation exposure continues to plague locking methods (Stephen H. Sims 2002).

The DHS is a popular implant for these Subtrochanteric fractures with trochanteric extension. The mechanism of screw haft and barrel allows impaction which however is not needed in Subtrochanteric fractures. The screw is cannulated and has blunt nose so less chances of impaction.

The DHS in subtrochanteric fractures does not correct the saggitall plane deformities, the head spins on the screw and flexion of proximal fragment occurs.

DYNAMIC CONDYLAR SCREW(DCS);

The DCS is a new device introduced by the AO group for supracondylar fractures of the femur. It has been adopted for use in the proximal femur.

Proximal fragment can be fixed with two or more screws as additional 3cms of proximal femur is available for fixation and thus gives more stable construct and secure fixation (Radford P. J & Howell C.J 1992). Varus angulation and spin of proximal fragment into flexion is least as proximal fragment is more securely fixed (Kulkarni G. S). In comminuted fractures Dynamic Condylar Screw can be used with biological reduction techniques, thereby maintaining blood supply of fracture fragments and their vitality enhance early callus formation and less rates of non-union (Shrinand V. Vaidya, Devesh B. Dholakia, and Anirban Chatterjee 2003)

Figure 2

95° CONDYLAR BLADE PLATE;

95°Condylar Blade Plate for Subtrochanteric fractures is exacting surgical technique, as being a one piece design, there is difficulty in correct placement of the blade and mal-alignment is not easily corrected after blade insertion.

Medoff's sliding plate is technically demanding procedure for subtrochanteric fracture fixation (Lunsjo Karl 1999).

2. Intramedullary fixation devices

1. A) K-nail
2. B) Ender's nails
3. C) Centromedullary nails
4. D) Cephalomedullary nails
5. E) Third generation Gamma nails
6. F) Proximal femoral nails

These intramedullary implants are load sharing devices and offers several advantages than those of load bearing implants. Being load sharing the weight bearing can be commenced early. Disuse osteoporosis from stress shielding is lessened. As the bending arm being smaller there is less stress on the implant and lesser chances of implant failure. Moreover fractures can be reduced closely with less surgical trauma and blood loss. Another advantage with these intrameduulary implants is reaming product acts as graft and activates periosteal reaction and vasculaity thus aids in union. However, the problems continue in cases of fractures with intertrochanteric extension. Radiation exposure continues to plague locking methods (Stephen H. Sims 2002).

K-NAIL

K-Nail is no longer used in Subtrochanteric fractures as it does not provide adequate fixation in these fractures.

ENDERS NAIL(FLEXIBLE CONDYLO-CEPHALIC NAILS);

Using Ender's nail for Subtrochanteric fracture is complicated by shortening, and secondary perforation of the head of femur (Kudrena Heinz 1976). It may be indicated in selected cases like comminuted fractures in elderly patients and In presence of severe softtissue trauma proximally.

Other problems includeknee irritation and need for adjunctive internal fixation.(Dobozzi etal Clin Orthop 1986;212:68-72)

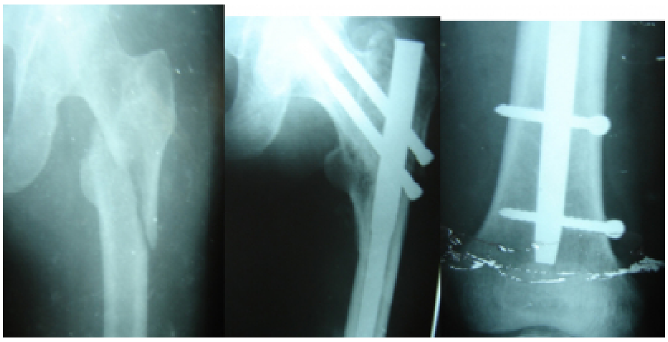
CENTROMEDULLARY NAILS(IST GENERATION INTERLOCKING NAIL);

These interlocking devices have biomechanical, biological and technical advantages. Technically can be used for all fracturesbelow lesser trochanter. Intactness of the piriformis fossa is prerequisite in using these implants. With the use of these locking devices weight bearing is commenced early and chances of nonunion and implant failure are lessened.

CEPHALOMEDULLARY NAILS(RECON, ZICKEL, PFN, GAMMA)

Russel Taylor Recon. Nail(2nd generation interlocking nail); the placement of screws in the femoral head leads to better rotational control. Recon Nail is the gold standard among 2nd generation nails. It can not be used in situations where entry site for an intramedullary is essentially destroyed (Kulkarni Sushrut S., Christopher G. Morand 2003). The procedure is technically demanding with high intraop complications(Frenc and Tometta.Clin Orthop 1998;70A: 239-243).

Figure 3



ZICKEL NAIL;

This nail provide adequate proximal fragment fixation however implant insertion is difficult . Removal of implant is also difficult as refracures occurs during their removel(Ovadia and ChessJBJS 1988;70A: 239-243).

GAMMA NAIL;

As the implant is thicker, provides efficient fixation for subtrochaneric fractures. More bone is removed during inserton so risk of shaft ractures is there and abductor mechanism damage has been reported in 27% cases.(Mc Connel etal Clin orthop 2003;407:199-202).

Proximal Femoral Nail(PFN)

This biocompatible titanium implant is used in unstable fracture configuration with less failure rates. Simmermacher etal Injury 1999;30: 327-332)

THIRD GENERATION NAIL;

It is a titanium nail with retrograde spiral blade plate, there ie greater distribution of load so less potential for cutout. The implant is designed such that can be inserted through a small incision.(Bruise and Reynder. J. Orthop trauma 2002;16:150-154).

SUMMARY

Despite the advances in surgical techniques and fixation devices subtrochanteric fractures of the femur continue to be a treatment challenge to the orthopaedic surgeon in view of the extreme sresses and the manfest shear across the fracture site various implants have been used and studied as a treatment measure for these fractures, yet a panacea has not been discoursed. The primary goal of open reduction and internal fixation of subtrochanteric fractures is to encourage sound union without deformity and at the same time allowing early mobilization.

Operative treatment is a step in a continuously evolving spectrum whereby problems that plagued conservative management are either overcome or minimized. Closed or indirect(biological) reduction is preferable while using extramedullary implants .

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