DEPARTMENT OF ORTHOPAEDICS

USAIM M.Ch. (Ortho)

"Comparison of Cutout Resistance of Dynamic Condylar Screw and Proximal Femoral Nail in Reverse Trochantric Fractures"

A Dissertation submitted to the University of Seychelles, in partial fulfillment of the requirements for the award of M.Ch. in orthopaedics

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INTRODUCTION

, the number of hip fracture will be expected to increase exponentially. Despite improvement in patients care and operative technique, hip fractures account for significant amount of health care expenditures and hence posses an important economic and social impact.The incidence of intertrochanteric femoral fracture has been estimated to occur in more than 250,000 patients each year in the United States, with 90% occurring in patients over the age of 50 years, with reported mortality rates ranging from 15% to 20%. With the aging of the population, the annual number of hip fractures is projected to double by the year 2040.

Reverse oblique trochanteric fractures accounts for 2% of all the hip fractures and 5% of all the intertrochanteric and subtrochanteric fractures.

The estimated incidence of hip fractures in the United States in 80 per 100,000 population. The incidence increases with age, doubling for each decade after 50 years, and is two to three times higher in women than in men. The incidence is two to three times higher in white women than in nonwhite women. Other risk factors for hip fracture include a maternal history of hip fracture, excessive consumption of alcohol and caffeine, physical inactivity, low body weight, tall stature, previous hip fracture, use of certain psychotropic medications, residence in an institution, visual impairment, and dementia. Osteoporosis is an important contributing factor, because it decreases the skeleton's resistance to injury, and approximately 90 percent of hip fractures in the elderly result from a simple fall.

These fractures may be treated conservatively by reduction and simple traction for maintenance of alignment. As this region consists predominantly of spongy bone with an adequate blood supply, therefore, unlike fracture neck of femur, non union or vascular necrosis is rare.

Unfortunately elderly patients with these fractures treated by this conservative method frequently succumb to the complications of the bed rest and hospitalization, namely, decubitus ulceration, pneumonia, thromboembolic disease etc. For these reasons, early surgical fixation of these fractures is recommended in elderly.

Reverse oblique trochanteric fracture of proximal part of femur is a distinct fracture pattern that mechanically differs from intertrochanteric fractures.

A sliding hip-screw is not indicated for stabilization of these fractures. The problem with use of the sliding hip-screw is that the large diameter lag screw does not cross the primary fracture line. A less than perfect reduction of a gap from fracture line resorption is compensated for by telescoping of hip-screw. In fact, telescoping of implant can promote fracture separation rather than impaction. There are fracture impaction results in displacement secondary to the orientation of the fracture line. This leads to an unacceptable high failure rate when a conventional sliding hip-screw is used to treat this fracture pattern.

For surgeons who prefer open plating techniques, the 95^{o} angled plate is indicated for these fractures. Compared with a 135^{o} angled hip-screw, these devices provide more cortical purchase on proximal fragment and eliminate the potential for rotational instability.

Though its usually involves a relatively simple operative procedure, various modes of failure were noted including- cutting out of screw, breakage of the plate and screw or plate pull off from the bone. These fixation failures had a basis in the biomechanics of the DCS which puts a large amount of strain at the screw and side plate junction. Also being an open procedure it requires a wide exposure at the fracture site leading to drainage of the fracture hematoma, which is vital for early union. With extensive dissection there is always a possibility of significant blood loss and increased incidence of post operative infection.

In intramedullary devices, the shaft fixation is nearer to the centre of rotation of the hip; giving a shorter lever arm and a lower sliding moment or tensile strain on the implant. The Gamma nail had been available since 1988 and was designed specifically to obviate the disadvantages of DHS by combining the advantages of semi-closed intramedullary nailing a dynamic femoral neck screw and early post operative weight bearing. However, these advantages of intramedullary devices have not been realized so for; rather serious implant related complication have been described, such as fracture of the femoral shaft in upto 17%, failures of fixation in upto 7%, complication of distal locking in upto 10% requiring re-operation with subsequent morbidity and severe thigh pain in post operative follow up. Because of these well described and persistent problems, the current generation of intramedullary device i.e. proximal femoral nail was developed in Europe in 1997 with the aim to improve the rotational stability of the proximal femoral fragment combining the features of an unreamed intramedullary femoral nail with a sliding load bearing femoral neck screw. Furthermore, the tip of the nail was redesigned to decrease the risk of intra and post-operative fractures of the femoral shaft by a significant reduction in bone stress.

Reverse oblique trochanteric fractures are highly unstable fractures, are best stabilized with Cephalo medullary nail. The intramedullary location provides Buttress against lateral displacement and it decreases bending strain on the implant.

The clinical relevance of these presumed bio-mechanical advantages and lower complication rate of Proximal Femoral Nail are still to be established.

This study is to evaluate the effectiveness of implants of different design to resist migration and cutout failure under such critical operating conditions. After model validation by direct correlation to human cadaver specimens, Dynamic Condylar Screw and Proximal

Femoral Nail were tested in surrogate specimens to determine differences in cutout resistance.

REVIEW OF LITERATURE

The estimated incident of hip fractures in United States is 80 per 100,000 population[1,2]. The incidence increases with age, doubling for each decade after 50years, and two to three times higher in women then men[2,3].

These fractures may be treated conservatively by reduction and simple traction for maintenance of alignement. As this region consists predominantly of spongy bone with adequate blood supply, therefore non union or avascular necrosis is rare.

Reverse oblique trochanteric fractures accounts for 2% of hip fractures and 5%of all the intertrochanteric and subtrochanteric fractures.

Mechanism of Injury

Intertrochanteric fractures in younger individuals are usually the result of a high-energy injury, such as a motor vehicle accident (MVA) or fall from a height. Ninety percent of intertrochanteric fractures in the elderly result from a simple fall. The tendency to fall increases with patient age and is exacerbated by several factors, including poor vision, decreased muscle power, labile blood pressure, decreased reflexes, vascular disease, and coexisting musculoskeletal pathology. Laboratory research indicates that the fall of an elderly individual from an erect position typically generates at least 16 times the energy necessary to fracture the proximal femur[4]. According to Cummings[5], four factors contribute to determining whether a particular fall results in a fracture of the hip: (a) the fall must be oriented so the person lands on or near the hip, (b) protective reflexes must be inadequate to reduce the energy of the fall below a certain critical threshold, (c) local shock absorbers (e.g., muscle and fat around the hip) must be inadequate; and (d) bone strength at the hip must be insufficient. A person must land on or near the hip in order for the energy of the fall to be transmitted to the proximal femur; falling onto the lateral thigh or buttock near the greater trochanter is much more likely to cause hip fracture than impacts elsewhere[6]. Such falls are also much more likely when there is little or no forward momentum, as when the person is standing still or walking slowly another factor that helps explains why the elderly sustain a greater proportion of fractures in these incidents. Furthermore, because their reaction times are longer and muscle strength less, older persons' protective responses tend to be too little and too late. Skin, fat, and muscles surrounding the hip can absorb large amounts of energy from an impact. The age-related decline in muscle mass around the hip may help account for the increased incidence of hip fractures with aging. Although the muscles surrounding the hip can provide protection, contraction of these muscles during a fall may actually lead to increased rates of hip fracture. In a laboratory study, Hayes[7] found that muscle relaxed falls resulted in a significant (7%) decrease in hip impact

APPLIED ANATOMY

The intertrochanteric region of the hip, consisting of the area between the greater and lesser trochanters, represents a zone of transition from the femoral neck to the femoral shaft. This area is characterized primarily by dense trabecular bone that serves to transmit and distribute stress, similar to the cancellous bone of the femoral neck. The greater and lesser trochanters are the sites of insertion of the major muscles of the gluteal region: the gluteus medius and minimus, the iliopsoas, and short external rotators. The calcar femorale, a vertical wall of dense bone extending from the posteromedial aspect of the femoral shaft to the posterior portion of the femoral neck, forms an internal trabecular strut within the inferior portion of the femoral neck and intertrochanteric region and acts as a strong conduit for stress transfer[9]. The musculature of the hip region can be grouped according to function and location[10]. The abductors of the gluteal region, the gluteus medius and gluteus minimus, which originate from the outer table of the ilium and insert onto the greater trochanter, function to control pelvic tilt in the frontal plane. The gluteus medius and gluteus minimus, along with the tensor fascia lata, are also internal rotators of the hip. The hip flexors are located in the anterior aspect of the thigh and include the sartorius, pectineus, iliopsoas, and rectus femoris. The *iliopsoas* inserts onto the lesser trochanter. The *gracilis* and the *adductor* muscles (longus, brevis, and magnus) are located in the medial aspect of the thigh. The short external rotators, the *piriformis, obturator internus, obturator externus, superior* and *inferior gemelli*, and *quadratus femoris,* all insert onto the posterior aspect of the greater trochanter. The *gluteus maximus*, originating from the ilium, sacrum, and coccyx, inserts onto the gluteal tuberosity along the linea aspera in the subtrochanteric region of the femur and the iliotibial tract. The gluteus maximus serves as an extensor and external rotator of the hip. The *semitendinosus, semimembranosus,* and *biceps femoris,* which originate from the ischium to form the hamstring muscles of the thigh, are responsible for knee flexion as well as hip extension.

BIOMECHANICS

Reverse oblique trochanteric fractures of the femur are recoganised as mechanically different from standard intertrochanteric fractures, are difficult fractures to treat, being unstable reduction due to their unique muscle pull, which tend to displace further these fractures.

Extracapsular fractures (intertrochanteric and subtrochanteric fractures) primarily involve cortical and compact cancellous bone. Because of the complex stress configuration in this region and its nonhomogeneous osseous structure and geometry, fractures occur along the path of least resistance through the proximal femur[11]. The amount of energy absorbed by the bone determines whether the fracture is a simple (two-part) fracture or is characterized by a more extensive comminuted pattern. Bone is stronger in compression than in tension[12].

Cyclic or repetitive loading of bone at loads lower than its tensile strength can cause a fatigue fracture. Each load causes microscopic damage to the osseous structure, essentially forming microscopic cracks that can coalesce into a single macroscopic crack, which in turn functions as a stress riser. Failure can thus occur if healing of these microfractures does not take place. In repetitive loading, the fatigue process is affected by the frequency of loading as well by as the magnitude of the load and the number of repetitions.

Muscle forces play a major role in the biomechanics of the hip joint(13). During gait or stance, bending moments are applied to the femoral neck by the weight of the body, resulting in tensile stress and strain on the superior cortex(14). The contraction of the gluteus medius, however, generates an axial compressive stress and strain in the femoral neck that acts as a counterbalance to the tensile stress and strain. When the gluteus medius is fatigued, unopposed tensile stress arises in the femoral neck(14). Stress fractures are usually sustained as a result of continuous strenuous physical activity that causes the muscles gradually to fatigue and lose their ability to contract and neutralize stress on the bone.

Classification:

Evans(1949) classification based on the stability of the fracture pattern and the potential to convert an unstable fractures pattern to a stable reduction. Evans observed that the key to a stable reduction is restoration of postero-medial cortical continuity. He divided fractures into two types differentiated by the status of this anatomic area.

Type I: Undisplaced 2-fragment fracture

Type II: Displaced 2-fragment fracture

Type III: 3-fragment fracture without posterolateral support, owing to displacement of greater trochanter fragment

Type IV: 3-fragment fracture without medial support, owing to displaced lesser trochanter or femoral arch fragment

Type V: 4-fragment fracture without posterolateral and medial support (combination of type III and type IV)

R: Reversed obliquity fracture

Jensen and Michaelson et al (1975) proposed some modification in Evans' classification to improve the predictive value; to indicate which fractures could be reduced anatomically and which were at risk of secondary displacement after fixation.

Class I: Includes 2-fragment fractures, which are considered stable. These fractures could be reduced both in the coronal and sagittal view.

Class II: Contains Evans type III and type IV fractures which are difficult to reduce in either the coronal or the sagittal plane.

Class III: Contains Evans type V fracture consists of very unstable fracture which are difficult to reduce in both planes

Boyd and Griffin Classification: peritrochanteric injuries divided into four categories:

Type I: Fractures that extend along the intertrochanteric line from the greater to the lesser trochanter

Type II: Communited fractures, the main fracture being along the intertrochanteric line but with multiple fractures in the cortex.

Type III: Fractures that are basically subtrochanteric with at least one fracture line passing across the proximal end of the shaft just distal to or at the lesser trochanter.

Type IV: Fractures of the trochanteric region and the proximal shaft, with fracture in atleast two planes one of which usually is the sagittal plane and may be difficult to see on routine anteroposterior roentgenograms.

RusseI-Taylor's Classification:

Based on continuity of the lesser trochanter and extension of fracture line into the greater trocahtner or posteriorly to the pyriformis fossa. When the greater trochanter is involved in the fracture, an intramedullary device can be safely used as long as the piriform fossa is not violated.

Type IA: The fractures in exclusively below the lesser trochanter that extends further down the shaft towards the isthmus.

Type IB: The fracture includes the lesser trochanter and extends distally but has no involvement of the greater trochanter or the pyriformis fossa.

Type IIA: The fracture extends into the pyriformis fossa with the lesser trochanter remaining intact.

Type IIB: The fractures extends into the pyriformis fossa with disruption of medial column above the lesser trochanter

AO/OAT Classification:

ORTHOPAEDICS TRAUMA ASSOCIATION CLASSIFICATION

The AO classification, proposed by Muller et al in 1980-1987, attempts to be descriptive and to provide prognostic information, in the light of what can be done with present day fixation techniques. Type A fractures are fractures of the trochanteric area. These fractures are divided into three groups.

Group A1:

Contains the simple (two fragment) pertrochanteric fractures whose fracture line runs from the greater trochanter to the medial cortex; this cortex is interrupted in only one place. There are three subgroups, reflecting the pattern of the medial fracture line: Al. 1: Fractures run above the lesser trochanter; A1.2: Fractures have calcar impaction in the metaphysis; while A1.3 fractures are trochantero-diaphyseal fractures that finish up distal to the lesser trochanter.

Group A2:

The fractures of group A2 have a fracture line pattern identical to that of Group Al fractures; however, the medial cortex is comminuted. They are subdivided into A2.1 fractures, with one intermediate fragment; A2.2 fractures, with two fragments; and A2.3 fractures; with more than two intermediate fragments.

Group A3:

Fractures are characterized by a line that passes from the lateral femoral cortex below the greater trochanter to the proximal border of the lesser trochanter; often there is also an undisplaced fracture separating the greater trochanter. A3.1 fractures are reverse intertrochanteric fractures (with an oblique fracture line); while A3.2 fractures are transverse (intertrochanteric). A3.3 fractures involve the detachment of the lesser trochanter and are notoriously difficult to reduce and stabilize.

Classification:

A1: Simple (2-fragment) pertrochanteric area fractures

- A1.1: Fractures along the intertrochanteric line
- A1.2: Fractures through the greater trochanter
- A1.3: Fractures below the lesser trochanter

A2: Multifragmentary pertrochanteric fractures

- A2.1: With one intermediate fragment (lesser trochanter detachment)
- A2.2: With 2 intermediate fragments
- A2.3: With more than 2 intermediate fragments

A3: Intertrochanteric fractures

- A3.1: Simple, oblique
- A3.2: Simple, transverse
- A3.3: With a medial fragment

Two factors must be considered in the assessment of stability: loss of medial support, as a result of a separation of the lesser trochanter in association with a fracture of the medial arch, and comminution of the posterior cortex, which is frequently associated with a separation of the greater trochanter. The fracture must be reduced in internal rotation, to close the anterior gap and to replace the posterior cortical fragments.

TREATMENT OPTIONS

Non operative treatment

Before 1960s, treatment for intertrochanteric fractures was of necessity non operative treatment, consisting of prolonged bedrest in traction until fracture healing occurred (usually 10 to 12 weeks), followed by a lengthy program of ambulation training. In elderly patients, this approach was associated with high complication rates(15); typical problems included decubiti, urinary tract infection, joint contractures, pneumonia, and thromboembolic complications, resulting in a high mortality rate. In addition, fracture healing was generally accompanied by varus deformity and shortening because of the inability of traction to effectively counteract the deforming muscular forces[15].

Operative Treatment

. Operative management consisting of fracture reduction and stabilization, which permits early patient mobilization and minimizes many of the complications of prolonged bed rest, has consequently become the treatment of choice for fractures of intertrochanteric region.

Operative management, which allows early rehabilitation and offers the patient the best chance for functional recovery, is the treatment of choice for the vast majority of intertrochanteric fractures.

Evolution of Sliding Hip Screw Devices

Plate and Screw Devices

Although it is unnecessary to review each and every type of implant that has been used to stabilize the fractures in the trochanteric region . it is important to understand the principles behind their evolution. The first successful implants were fixed-angle nail-plate devices (e.g., Jewett nail, Holt nail) consisting of a triflanged nail fixed to a plate at an angle of 130^{o} to 150^{o}. While these devices provided stabilization of the femoral head and neck fragment to the femoral shaft, they did not allow fracture impaction. If significant impaction of the fracture site occurred, the implant would either penetrate into the hip joint or cut-out through the superior portion of the femoral head and neck. If, on the other hand, no impaction occurred, lack of bony contact could result in either plate breakage or separation of the plate and screws from the femoral shaft. These complications occurred much more frequently when these devices were used to treat unstable fractures.

Other theoretical advantages provided by the use of two smaller-diameter screws are preservation of the remaining lateral wall of the distal fragment. In unstable fracture patterns, it is the remaining lateral wall of the distal fragment that prevents excessive fracture collapse and subsequent fracture deformity. Placement of a large-diameter single lag screw creates a larger defect in the lateral wall of the distal fragment, which increases the risk of lateral wall fracture[26]. In addition, the plate has an extension proximal to the two lag screws, which acts like a buttress, similar to the lateral support plates, to limit fracture collapse.

DYNAMIC CONDYLARS SCREW (D.C.S.)

Reverse oblique trochanteric fractures are highly unstable types of fractures. The rate of failure of internal fixation for this pattern was higher than the rates in most reports of internal fixation of intertrochanteric fractures with use of internal fixation devices.

Sliding hip screw have proven to successful implants for treatment of intertrochanteric fractures of proximal part of femur .The key to success of these devices is controlled postoperative impaction of fracture to a stable configuration[30,31]. This concept requires that the direction of compression be perpendicular to the major fracture line, a condition present in most of intertrochanteric fracture pattern.

The application of this concept to reverse oblique fractures is suspect because sliding of proximal fragment and medialization of distal fragment can lead to fracture distraction. Under these circumstances, there is no medial buttress, the implant act as a load bearing device and subsequent loss of proximal fixation can occur. Treatment of these fractures with a sliding hip screw lead to high rate of failure and is reported upto 56%. The most common mode of failure was medialization of the distal fragment and loss of proximal fixation with nonunion or cutout of the lag screw superiorly This mode of failure predicted on the basis of the biomechanics of sliding hip screw and of unique fracture pattern.

On the basis of biomechanical argument against sliding hip screw, fixed angle device have been advocated for the treatment of reverse oblique fractures[(32,33)].

Fixed- angle device can be used to treat these fractures with high likelihood of success.

The blade plate have theoretical advantages over 95 dynamic condylar screws because blade-plate provides more resistance to rotation of the proximal fragment and also do not allow the proximal fragment to slide laterally.

Intramedullary Devices

Despite the general success of the sliding hip screw for stabilization of intertrochanteric fractures, there has been dissatisfaction with the resultant deformity associated with use of this type of device to stabilize unstable fracture patterns. Excessive sliding of the lag screw within the plate barrel results in limb shortening and medialization of the distal fragment. Jacobs et al[(36)] reported that the average fracture settling in stable patterns was 5.3 mm and in unstable patterns was 15.7 mm. Rha et al[(37)] reported that excessive sliding was the major factor causing fixation failure in unstable fracture patterns. Medialization of the femoral shaft greater than one-third of its diameter has been associated with a seven times increased rate of fixation failure[(38)]. Furthermore, since the two lag screws are smaller in diameter than those of the Gamma nail or IMHS, it is not necessary for the nail to be as stout proximally; the TAN’s 13 mm proximal diameter is therefore easier to insert and theoretically induces less comminution of the proximal segment. The smaller proximal diameter should also result in less disruption of the abductor insertion.

Comparison between plate and screw devices and intra-medullary nail and screw devices in the internal fixation of fractures of trochanteric region.

Hans Habimek et al[(42)] in their study of 51 patients of proximal femoral fractures resulting from sports accident treated by cither a gamma nail or a dynamic hip screw found that duration of return to work or sports and the time bone healing did not differ very much between the two treatments. Gamma nailing was good with regard to stability and time to full postoperative mobilization (4-5 day), but required 39 minutes to perform compared with insertion of a dynamic hip screw (27 minutes). According to them, stable pertrochanteric fractures may be treated with a dynamic hip screw but instable trochanteric or subtrochanteric fractures to be treated with a intramedullary devices like gamma nail.

Bridle et al[(43)] had prospectively compared the fixation of 100 fractures of trochanteric area of the proximal femur in elderly patients treated with either dynamic hip screw or gamma nail. They found no difference, in the operating time, blood loss, wound complication stay in hospital or patient's mobility at final review. There was no difference in failure of proximal fixation, however in four out of forty nine patients treated with gamma nail fractures of the femur occurred close to the nail requiring further major surgery. According to them, the central position of the screw is probably optimal for trochanteric fracture(44,45,46). Placement of the screw head close to the subchondral bone may improve fixation(47,48).

According to them simple measures of bone density (Singh grade) could not be demonstrated to influence the cut out rate. This contrast with the findings of others(53). They found out that cutting out was rare in stable fractures and that the cut out rate was determined by the quality of the fracture reduction as demonstrated by Jenson et al. Simmermacher RKJ et al(54) in their series of 152 patients with intertrochanteric fracture fixed with proximal femoral nail reported 93% primary full postoperative weight bearing possibility and showed fractures consolidation in 99%. Technical failures that occurred were poor reduction, malrotation, or wrong choice of screw in 4.6% of the cases. Cut out of the neck screw was observed in 0.6%. After 4 months, failure like breaking or bending of the implant were not seen. Local complication occurred in 12% of the cases. The absence of femoral shaft fractures at the tip of the devices in this study compares favorably to the number given for the gamma nail which reaches up to 18% in various studies(43,55,56,57,58,59). This may be attributed to the change in the design of the PFN i.e. an additional anti-rotational hip pin preventing rotation and collapse of the head neck fragment and the especially shaped tip with a smaller distal shaft diameter resulting in less stress concentration at the tip. Also, in case of PFN reaming of the shaft is not required while in gamma nail over reaming of the shaft 3 mm more than the nail diameter weakens the entire shaft leading to femoral shaft fracture (Friedl et al, 1994).

Comparison between 95^{o} screw-plate and devices and intra-medullary nail/screw devices in the internal fixation of fractures of reverse oblique trochanteric fractures.

A3 intertrochanteric fractures differ from A1 and A2 pertrochanteric fractures in that the fracture line extends through the lateral femoral cortex distal to the vastus ridge of the greater trochanter. While a sliding hip-screw device has been favored most often for the stabilization of A1 and A2 fractures(62-69), such an implant is not generally favored for A3 fractures(70-72).

In A1 and A2 fractures, axial loading leads to fracture impaction. In A3 fractures, such impaction does not occurs and medial displacement of the distal fragment with instability of the fracture is common. To eliminate the problem of medial displacement and loss of fixation, a fixed-angle implant has been recommended for these fractures(72).

In some studies, the A3 fracture has been called an unstable intertrochanteric fracture; in others, a subtrochanteric fracture; and in still others, a combination of intertrochanteric and subtrochanteric fracture(75-77). A few authors have specifically used the terms reverse oblique fracture and A3 fracture(70,72,73,75).

Wagner et al[88] prospectively reviewed the cases of 112 patients who were treated with one of two different intramedullary devices, both of which were found to be equally effective for the treatment of intertrochanteric fractures. In an earlier study Wagner et al[87] had reported on 119 patients with stable and unstable intertrochanteric fractures that had been treated with a dynamic hip screw. When they compared the results of their two studies, the authors favored the dynamic hip screw for stable pertrochanteric (A1 and A2) fractures and reserved the intramedullary device for unstable (A3) fractures. Baumgaertner et al[78] reported the results of a prospective, randomized study in which 135 patients were treated with either a sliding hip screw or an intramedullary hip screw. In the group of patients with unstable intertrochanteric fractures, the intramedullary device was associated with 23% less surgical time and 44% less blood loss. All of the intraoperative complications occurred in the group of patients who received the intramedullary hip screw, with two of three patients having distal propagation of the fracture. In addition, there were three late femoral-shaft fractures in the group of patients who received an intramedullary hip screw and two cases of hip screw cut-out in each group.

There were no differences between the two groups with regard to the rate of functional recovery. The authors did not recommend the intramedullary hip screw for the treatment of stable fractures, but because of decreased operating time and blood loss they believed that it might be the implant of choice for the treatment of unstable fractures by surgeons experienced in second-generation interlocked femoral nailing.

Christophi, Sadowski, et al[89] compared the intramedullary nail with 95^{o} screw plate device for the treatment of reverse oblique and transverse intratrochateric fractures.

They conduced a prospective study on 39 elderly patients with AO/OTA 31-A3 inter trochanteric fractures of the femur with minimum follow up of one year and they concluded that patients treated with an intramedullary nail had shorter operative times, fewer blood transfusion and shorter hospital stays compared with those treated with 95^{o} screw plate. Implant failure and/or nonunion was noted in seven of the nineteen patients who had been treated with 90^{o} screw plate. Only one of the twenty fractures that had been treated with an intramedullary nail not heal.

We were unable to find any report in which intramedullary fixation was specifically compared with a fixed-angle screw-plate device for the treatment of A3 fractures. In most reports in the literature, sliding hip screw devices have been compared with intramedullary nails for the treatment of all types of stable and unstable intertrochanteric fractures but A3 fractures have not been considered separately.

MATERIAL AND METHODS

Study was conducted on sixteen dry proximal femoral specimens, eight of them were implanted with Dynamic Condylar Screw (DCS) and the rest with Proximal Femoral Nail (PFN). The construct was made unstable to resemble a reverse oblique trochanteric fracture by removing a standard sized postero-medial wedge. These were tested on a cyclic physiological loading machine at one cycle per second (1 Hz) with a load of 200 kg (2 KN). The test was observed for 50,000 loading cycles or till failure, whichever occurred earlier.

Preparation of the construct

As mentioned, sixteen femoral specimens were obtained and were soaked in saline for four to six hours. Only the upper two thirds of the femoral specimen were used in every case. DCS and PFN were implanted in eight specimens each, all done under image intensification. Fresh implant, of the same make was used in every case. All implants used were made up of 316L stainless steel.

Procedure for Dynamic Condylar Screw

The bone specimen was mounted on screw clamp which was fixed to the table. Guide pin was introduced over the angled guide under image intensification. The position of the guide pin was kept in the central position in all the cases. The length of the lag screw to be used was then determined using the gauge. Tip Apex Distance (TAD) kept constant of 25mm and is determined under image intensifier, both in AP and lateral views. The specimen was then reamed over the guide pin with triple reamer after adjusting the measured length, with a powered drill. The reamed canal was tapped with guide pin in-situ upto to the required depth; a three to five millimeter wedge was removed from the postero-medial aspect which included whole of the calcar. The lag screw was then tightened with the driver and then a side plate was positioned. In all cases 95^{0} angled plate was used. The plate was then fixed with cortical screws in neutral position. A total of eight cortices were fixed in all cases. The compression screw was then tightened.

Procedure for Proximal Femoral Nail

The dry bone specimen was mounted as explained earlier; the entry portal was made on the tip of greater trochanter with a curved awl. Guide pin was passed through the portal into the medullary canal and the canal was reamed with flexible reamer up to the required diameter progressively. The Proximal Femoral Nail was mounted on the jig and. guide pin was passed in the proximal second screw slot and the position was ascertained on image intensifier in both anteroposterior and lateral projection. TAD kept constant at 25mm. The length of the lag screw to be used was measured with gauge and the guide pin was drilled over with 8 mm cannulated bit. The canal was reamed upto the measured depth; a three to five millimeter wedge was removed from the postero-medial aspect which included whole of the calcar. The lag screw was then tightened with 6.5 mm cannulated driver.

Creation of reverse oblique trochanteric fracture with posteromedial defect in the constructs

Appropriate fracture line is created from vastus ridge to the lateral femoral cortex using a bone saw, in either of the implanted proximal femoral specimens so as to resemble a reverse oblique trochanteric fracture. The objective was achieved by removing a three to five millimeter wedge from the postero-medial aspect of the proximal femur at the meta-diaphysis, which included the whole of the calcar.

Cyclic loading test of the implanted specimen

Fatigue test was then conducted using completely computer controlled servo hydraulic MTS testing machine (Model 810) of ±50KN capacity. The specimens to be tested were initially mounted on the base which was designed to fix the shaft of the femur which was done using cement to reinforce the construct. The upper portion of the MTS which was used to give cyclic load to the head of the femoral construct was modified in such a way that it was congruent with the femoral head so as to give an axial load. Tests were conducted under load control mode in compression at the frequency of I Hz using a triangular wave form.

The specimens were subjected to cyclic loading of 2KN, under observation for 50,000 cycles or till failure or cut out which ever occurred earlier.

Assessment

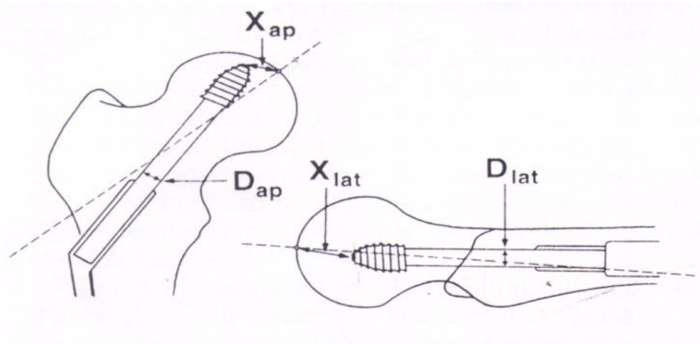
Migration of the implant in the femoral head was observed and measured in specimen in those which suffered failure of implant or cut out. In those specimen without observable failure or cut out, radiological comparison was made to look for any subtle changes. Groups were made with regard to implant type and implant placement to compare cut out resistance.

Definition of terms used in BMD measurements

1. **Bone mineral density (BMD, g cm^{-2}).** This is an 'areal' measurement and adjusts for the size of the bones measure.
2. **Bone mineral content (BMC, g).** This is the absolute measurement of bone mineral in the region measured.
3. **BMD expressed as a percentage** of the normal age-matched mean and the young adult mean.
4. **BMD compared with age and sex-matched controls (Z-scores)** or with young adult sex-matched controls (T-scores). These values may be expressed as percentiles or standard deviation scores (SD). The Z-score is a measure of the difference between the patient's BMD and the mean BMD of age and sex-matched peers. The T-score is a measure of the difference between the patient's BMD and the mean BMD of young normal adult. This information helps to provide and estimate of future fracture risk. The WHO classification of osteoporosis is based on DEXA T scores lot early post menopausal white Caucasian women and defines bone density levels as:
   - **Normal** - a BMD or BMC not more than 1 SD below young adult mean
   - **Osteopenia** (low bone mass) - BMD or BMC between 1 and 2.5 SD below young adult mean
   - **Osteoporosis** - BMD or BMC more than 2.5 SD below young adult mean.

- **Severe or established osteoporosis -** BMD or BMC more than 2.5 SD below young adult mean and the presence of one or more fragility fractures.

Tip Apex Distance (TAD)



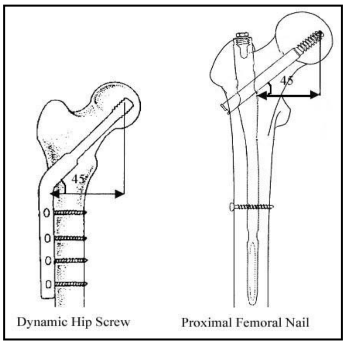
Technique for calculating the tip-apex index (TAD). For clarity, a peripherally placed screw is depicted in the anteroposterior (ap) view and a shallowly placed screw is depicted in the lateral (lat) view. (D_{true} = known diameter of the lag screw.)

B

Bending moment or the moment arm of a construct is the vector of force exerted at the confluence of the axial and the angular forces. In the present experiment it is considered as the distance between implant and shaft, and the femoral lag screw.

It was mathematically calculated using the formula:

$$\mathbf{F = P \times l \cos\theta}$$



F is bending moment force,

'P' is the load applied (200 kg),

'l' is the length of the lag screw from the base of barrel of DCS or medial edge of the PFN nail

For PFN

'θ' is the angle subtended to the normal which is 45° (135° - 90° = 45°)

For DCS

'θ' is the angle subtended to the normal which is 5° (95° - 90° = 5°)

OBSERVATIONS

All specimens were tested on MTS with 2 KN (200 kg) load at 1 Hz frequency for 50,000 cycles or till failure or cut out which ever occurred first.

Table 1: The observations were correlated with the number of cycles sustained and the DEXA for measure of osteoporosis; the values were tabulated in PFN group as follows:

Speci. No.	DEXA	TAD	Grouping	Cycles completed	Mode of failure	
					Macroscopic	**Microscopic**
1	0.890	25mm	B	36,000	Screw breakage	Screw breakage
2	0.878	25mm	B	50,000	stable	0 deg.
3	1.322	25mm	C	50,000	stable	2.5deg.
4	0.541	25mm	B	40,000	Screw bend	5deg.
5	0.865	25mm	B	50,000	stable	0deg.
6	1.265	25mm	C	50,000	Stable	0deg.
7	1.322	25mm	C	50,000	stable	0deg.
8	0.452	25mm	A	10,000	Screw bend	12.5deg.

Interpretation

- Total 4 failure out of 8 specimens
- 3 macroscopic failures out of 8 specimens.
- No failure in group C (Dexa >1.0)
- There was only one specimen from group A (Dexa <0.5). which failed at 10,000 cycles.
- Total 3 failure out of total 4 specimens from group B
- 5 out 8 specimens completed 50,000 cycles.
- There are 4 failure (3 macroscopic and 1 microscopic) out 8 specimens.

Table 2: The observations were correlated with the number of cycles sustained and the DEXA for measure of osteoporosis; the values were tabulated in DCS group as follows:

Speci. No.	DEXA	TAD	Grouping	Mode of failure (Bent)	
1	1.065	25mm	C 4,482	**a** = (-5^0 to 10^0) **b** **c**	= 15^0 = 2.5^0 = 1^0
2	0.408	25mm	A 1,962	**a** = (-5^0 to 5^0) **b** **c**	=10^0 = 0^0 =1^0
3	1.017	25mm	C 50,000	**a** **b** **c**	= 0^0 = 0^0 = 0^0
4	1.159	25mm	C 5,118	**a** = (-5^0 to 5^0)	= 10^0

				b **c**	= 2.5° =0°
5	1.144	25mm	C 2,508	**a** = (-5° to 5°) **b** **c**	= 10° = 5° =1°
6	0.598	25mm	B 564	**a** = (-5° to 10°) **b** **c**	=15° = 2.5° = 1°
7	0.752	25mm	B 50,000	**a** = (-5° to 5°) **b** **c**	=10° = 0° =1°
8	0.525	25mm	B 40,000	**a** = (-5° to 0°) **b** **c**	= 5° = 2.5° = 2°

a = Plate bending; b = Plate barrel angle deformation; c = Screw bending

Interpretation

- Failures in 7 out of 8 constructs.
- Only one specimen remained stable in this group with DEXA >I.0(group c)
- Only two specimens have completed 50,000 cycles.
- Six out of 8 failed within 5,000.cycles.
- one construct has shown microscopic failure
- six out of eight failed macroscopically.

Table 3: Correlation and calculation of bending moment with the mode of failure in PFN specimens:

Speci. No.	**Load (kg)**	**Length (meters)**	**Cos 45**	**Bending moment (kg-meter**	**Mode of failure**	
					Macroscopic	Microscopic
1	200	0.0685	0.7071	9.68	Screw breakage	Screw breakage
2	200	0.0845	0.7071	11.94	stable	0 deg.
3	200	0.0750	0.7071	10.60	stable	2.5deg.
4	200	0.0760	0.7071	11.70	Screw bend	5deg.
5	200	0.0660	0.7071	9.32	stable	0deg.
6	200	0.0610	0.7071	8.62	Stable	0deg.
7	200	0.0600	0.7071	8.48	stable	0deg.
8	200	0.0690	0.7071	9.74	Screw bend	12.5deg.

Interpretation:

- BM=F.L. cos θ
- Average bending moment of PFN specimen is = 10.01
- All the failures are associated with high bending moment.

Table 4: Correlation and calculation of bending moment with the mode of failure in DCS specimens:

Speci. No.	Load (kg)	Length (meters)	Cos 5	Bending moment (kg-meter)	Mode of failure	
					Macroscopic	Microscopic
1	200	0.0710	0.9962	14.14	a	b & c
2	200	0.0750	0.9962	14.94	a	c
3	200	0.0835	0.9962	16.62	construct is stable	construct is stable
4	200	0.0760	0.9962	15.14	a	b
5	200	0.0780	0.9962	15.54	a & b	c
6	200	0.0755	0.9962	15.44	a	b & c
7	200	0.0800	0.9962	15.92		a & c
8	200	0.0745	0.9962	14.84		a ,b& c

a = Plate bending; b = Plate barrel angle deformation; c = Screw bending

Interpretations:

- a=7, b=5 and c=6
- Average BM=15.32
- Average bending moment is 50% higher than PFN specimens

Table 5: Correlation of Bone quality and bending moment with mode of failure in PFN specimen

Speci. No.	BMD by DEXA	Bending Moment	Mode of failure	
			Macroscopic	Microscopic
1	0.890	9.68	Screw breakage	Screw breakage
2	0.878	11.94	stable	0 deg.
3	1.322	10.60	stable	2.5deg.
4	0.541	11.70	Screw bend	5deg.
5	0.865	9.32	stable	0deg.
6	1.265	8.62	Stable	0deg.
7	1.322	8.48	stable	0deg.
8	0.452	9.74	Screw bend	12.5deg.

Interpretations:

- Specimens having poor bone quality and higher bending moment are associated with higher failure rates.

Table 6: Correlation of Bone quality and bending moment with mode of failure in DCS specimen

Speci. No.	BMD by DEXA	Bending Moment	Mode of failure	
			Macroscopic	Microscopic
1	1.065	14.14	a	b & c
2	0.408	14.94	a	c
3	1.017	16.62	construct is stable	construct is stable

4	1.159	15.14	a	b
5	1.144	15.54	a & b	c
6	0.598	15.44	a	b & c
7	0.752	15.92		a, & c
8	0.525	14.84		a, b & c

Interpretation:

- Only one specimen remained stable out of eight DCS specimens.

Table 7: Correlation of BMD, Bending moment and number of cycles sustained with mode of failure in PFN specimens:

Speci. No.	TAD (mm)	BMD by DEXA	Bending Moment	Cycles Sustained	Mode of failure	
					Macroscopic	Microscopic
1	25mm	0.890	9.68	36,000	Screw breakage	Screw breakage
2	25mm	0.878	11.94	50,000	stable	0 deg.
3	25mm	1.322	10.60	50,000	stable	2.5deg.
4	25mm	0.541	11.70	40,000	Screw bend	5deg.
5	25mm	0.865	9.32	50,000	stable	0deg.
6	25mm	1.265	8.62	50,000	Stable	0deg.
7	25mm	1.322	8.48	50,000	stable	0deg.
8	25mm	0.452	9.74	10,000	Screw bend	12.5deg.

Interpretations:
- Five specimens out of eight had completed 50,000 cycles successfully without any gross failure.
- No failure of any implant is seen in initial 10,000 cycles.

Table 8: Correlation of BMD, Bending moment and number of cycles sustained with mode of failure in DCS specimens:

Speci. No.	TAD (mm)	BMD by DEXA	Bending Moment	Cycles Sustained	Mode of failure	
					Macroscopic	Microscopic
1	25mm	1.065	14.14	4,482	a	b & c
2	25mm	0.408	14.94	1,962	a	c
3	25mm	1.017	16.62	50,000	construct is stable	construct is stable
4	25mm	1.159	15.14	5,118	a	b
5	25mm	1.144	15.54	2,508	a & b	c
6	25mm	0.598	15.44	564	a	b & c
7	25mm	0.752	15.92	50,000		a & c
8	25mm	0.525	14.84	40,000		a, b & c

Interpretations:
- Five out of eight specimens failed within initial 5,000 cycles.
- Only two specimens out of eight completed 50,000 cycles successfully of which one had showed microscopic deformation.

SUMMARY:

Average DEXA for DCS specimen: 0.8335
Average DEXA for PFN specimen: 0.9418
Average TAD for DCS specimens: 25 mm
Average TAD for PFN specimens: 25 mm
Average bending moment force of DCS specimen 15.32
Average bending moment force of PFN specimen 10.01

Total No. of failures of DCS specimen: 7
Total No. of failures of PFN specimen: 4
In DCS group there are 4 specimen with DEXA more than 1(group c),out of which 3 failed.
-All the specimen with DEXA less than 1 (group A and B) failed.
-Only one specimen remained stable, having DEXA more than 1 (group c).
In PFN group there are 3specimen with DEXA more than 1(group c),out of which 2 remained stable and in third one only microscopic failure (2.5 bent) is noted, but has completed 50,000 cycles successfully.
-There was only one specimen from group A (Dexa <0.5), which failed at 10,000 cycles (which is the earliest failure in PFN group) and had showed maximum degree of screw bending.

Out of 3specimen from group B (DEXA >.5and <1) 2 remained stable.

Out of 8 DCS specimen 5failed within initial 5,000 cycles only and only 2 has completed 50,000 cycles.

Out of 8 PFN specimens 5 have sustained 50,000 cycles successfully.

Average bending moment in DCS group is 50% higher then PFN as the result only one DCS specimen remained stable and completed 50,000 cycles successfully.

DISCUSSION

The goal of our study was to determine whether there is a difference between a fixed-angle screw-plate device and an intramedullary nail in the treatment of a specific subset of unstable intertrochanteric fractures, namely, AO/OTA 31-A3 fractures. A3 intertrochanteric fractures differ from A1 and A2 pertrochanteric fractures in that the fracture line extends through the lateral femoral cortex distal to the vastus ridge of the greater trochanter. While a sliding hip-screw device has been favored most often for the stabilization of A1 and A2 fractures[62-69], such an implant is not generally favored for A3 fractures[70-72].

Our review of the literature revealed that A3 fractures have been classified differently by different authors, making comparison of results difficult. In some studies, the A3 fracture has been called an unstable intertrochanteric fracture; in others, a subtrochanteric fracture; and in still others, a combination of intertrochanteric and subtrochanteric fracture[75-77]. A few authors have specifically used the terms reverse oblique fracture and A3 fracture[70,72,73,75].

The ongoing debate surrounding the surgical treatment of trochanteric hip fractures, particularly unstable fractures, has led to continuous changes in the design of well-established implants and to the development of new ones.

For operative treatment of reverse oblique trochanteric fractures- two options exist: extramedullary or intramedullary stabilization.

The Dynamic Hip Screw (DHS) is the most widely used extramedullary implant for stabilization of both stable and unstable intertrochanteric fractures. A number of authors have commented on the unsatisfactory results associated with the use of a sliding hip screw for fixation of these fractures[72,73,75,77].

Despite the general success of the DHS for fixation of stable types of intertrochanteric fractures, there has been dissatisfaction with the resultant deformity associated with use of this type of device to stabilize unstable fracture patterns. Excessive sliding of the lag screw within the plate barrel results in limb shortening and medialization of the distal fragment. Jacobs et al[90] reported that the average fracture settling in stable patterns was 5.3 mm and in unstable patterns was 15.7 mm. Rha et al[91] reported that excessive sliding was the major factor causing fixation failure in unstable fracture patterns. Medialization of the femoral shaft greater than one-third of its diameter has been associated with a seven times increased rate of fixation failure[92]. Dissatisfaction with use of a sliding hip screw in unstable fracture patterns led to the development of alternate fixation devices i.e extra-medullary fixed angle implants and intramedullary hip screw devices.

Extra-medullary fixed angle devices

To eliminate the problem of medial displacement and loss of fixation a fixed-angle implant has been recommended for reverse oblique trochanteric fractures[72]. Haidukewych et al.[72] retrospectively reviewed 2472 hip fractures that were treated over a ten-year period, 1035 of which were classified as intertrochanteric or subtrochanteric. Fifty-five reverse oblique fractures were identified. The results of treatment with a sliding hip screw were then compared with the results of treatment with a 95° fixed-angle device (a blade-plate or a dynamic condylar screw). The authors concluded that the overall failure rate associated with the sliding hip screw was higher when the device was used for A3 fractures than when it was used for “standard” (A1 and A2) fractures, and they suggested that a 95° fixed-angle implant was the preferable alternative or the treatment of reverse oblique fractures.

However, Rosso et al[76] noted eight complications related to the implant (pull-out and plate breakage) among thirty elderly patients who received a dynamic condylar screw for the treatment of an unstable intertrochanteric fracture. They concluded that unstable intertrochanteric fractures in elderly patients should not be treated with this implant.

Intramedullary hip screw devices:

This type of design offers several potential advantages:

(a) an intramedullary fixation device, because of its location, theoretically provides more efficient load transfer than does a extra-medullary implant.

(b) the shorter lever arm of the intramedullary device can be expected to decrease tensile strain on the implant, thereby decreasing the risk of implant failure,

(c) because the intramedullary fixation device incorporates a sliding hip screw, the advantage of controlled fracture impaction is maintained,

(d) the intramedullary location limits the amount of sliding and therefore limb shortening and deformity that can occur; the fracture can settle until the proximal fragment abuts against the nail; and

(e) insertion of an intramedullary hip screw theoretically requires shorter operative time and less soft-tissue dissection than a DCS, potentially resulting in decreased overall morbidity.

The operative treatment of stable trochanteric fractures (AO classification type A1) is widely agreed to be the dynamic hip screw (DHS). However, because the load bearing in the proximal femur is predominantly through the calcar femorale, this type of fixation is biomechanically disadvantaged when compared with intramedullary devices. This disadvantage becomes much more significant in the unstable trochanteric fractures. For unstable fractures, the failure rate for a DHS is reported to be as high as 21%(93).

In the present study, both constructs utilize an unstable Reverse oblique trochanteric fracture model. The present model was utilized to test the stability of the constructs using DCS (8 specimens) and PFN (8 specimens) with only one proximal screw, this was done to test the bending movement in these devices. In clinical practice PFN is used with two proximal screws which render the construct more stable, but theoretically the biomechanical advantages of PFN over DCS could not have been compared in this study, since DCS has a single lag screw. Apart from the implant used, stability in pertrochanteric fracture is also a function of implant placement which is evaluated by Tip Apex Distance (TAD). Many studies have correlated the TAD and implant failure and have shown a positive correlation of failure with high values of TAD. Another factor which leads to implant failure is the quality of bone. It is axiomatic that poor quality of bone affords poor implant purchase and consequent high fixation failure rate. A large number of experimental studies have been done so far to define factors for failure of implant, but so far these factors have not been studied in combination. This study aims to combine all the factors, namely the bending movement, osteoporosis (using DEXA), loading to simulate physiological weight bearing, plate bending & plate breakage, screw bending, breakage, screw cut out and migration.

Out of eight DCS specimens in the group, one remained stable and did not show any evidence of failure till the end the study, i.e. 50000 cycles. Seven specimens showed failure including variable degree of plate bending, change in plate barrel angle and screw bending. Six constructs showed gross failure while one failed microscopically.

It is postulated that this superiority of PFN is directly attributed to its biomechanical advantage since it has less bending moment. Six specimens in DCS group failed because of bending of lag screw to the variable degree, seven specimen showed variable degree of plate bending and four showed change in plate barrel angle, showing the importance of bending moment. But in the PFN group there is screw breakage in one specimen at fracture site and in another three there is variable degree of screw bending is noted.

The DCS and PFN lag screw shafts are 8mm in diameter; however the outer diameter of DCS lag screw is 12mm but is 8mm for PFN. As a consequence the core diameter of DCS screw remains 8mm throughout its length but in PFN screw it changes from 8 to 5mm at threaded portion.

Loading both these screws and on implants, in an unstable Reverse oblique fracture constructs would exhibit different types of mechanical failures. The DCS lag screw bent at junction of barrel and screw as this was the fulcrum in the load testing machine and further, both these bending demonstrated the splintering of calcar.

These deformation in the original structure of implant occurred simultaneously and in most of constructs in combination (Plate bending=7,screw bending=6 and plate barrel angle change=5) and in five out of eight within initial 5,000 cycles and only two specimens have completed the 50,000 cycles, out of which one had undergone microscopic deformation. These complex type of failure are seen in DCS group not in PFN.

Tip Apex Distance (TAD)

Tip apex distance is accepted as an important factor in preventing and prognosticating cutout in sliding screw devices. Baumgaertner[78] in his original article conclude that it is the strongest predictor to cutout in comparison to any other variable, and that the TAD of 25mm or less would prevent cutout regardless of all other variables related to the fracture. In this study we kept this variable constant.

Type of Implant:

The implant which is complex i.e. made up of assembly of multiple component will theoretically have more chance of failure because the probability of failure of each component will add up. In DCS group there is multiple component failure to various degrees are seen in different combinations. Plate bending, plate barrel, angle deformation and screw bending in combination seen in four specimens. Plate bending and screw bending seen in two specimens and in one specimen plate barrel angle deformation and screw bending is seen. In PFN group the failure is noted in lag screw component only. In one specimen there is breakage screw and another three screw bending to variable degree is seen.

Bone Quality:

The hold and purchase of any screw in the bone is a combination of screw design and rigidity of the host bone. As such osteoporotic bone stock would theoretically have poor purchase with the same screw as compared to normal bones. Keeping this hypothesis in mind, DEXA was use to classify osteoporosis in the specimens used. The average DEXA for DCS specimens was 0.8335 and that for PFN 0.9418. But the average BMD does not give true picture because in DCS group there were more number specimens having better values of DEXA i.e. four specimens from group C (DEXA >1), while in PFN group their number was three.

In DCS group there were three specimens from group B (DEXA between 0.5and 1.0) and one from group A (DEXA<0.5).Out of these eight DCS specimens only one specimen remained stable which was from group C, having BMD more than the average DCS specimens i.e. 1.017.

In PFN group there were three specimens from group C, Out of which two remained stable and third one also remained stable grossly and successfully completed 50,000 cycles. In this group the specimen from group A (DEXA <0.5) failed macroscopically at 10,000 cycles only i.e. lowest numbers of cycles sustained by any specimen and had shown maximum screw bending, another two failures are from group B.

More specimens in DCS group are having better BMD than PFN.

In both the groups the constructs with better bone quality performed better.

In our study cut through as a mode of failure is not seen. Cut through of lag screw depend upon two factors :

1. Poor purchase of the bone (Osteoporotic bone)
2. High load concentration at the Tip of implant

As the lag screw of the DCS has the outer diameter of 12mm, so there is less load concentration at the tip and the lesser the chances of cut through.

In our study we concludes there the DEXA is not as important a factor as bending moment in the failure of the implant.

SUMMARY & CONCLUSION

1. Fixation failure in reverse oblique trochanteric fractures is a frequently encountered complication leading to increase morbidity in patients.
2. Large number of factors have been held responsible for fixation failure in reverse oblique trochanteric fractures. Biomechanical study have in recent times elucidated the role of individual factor like type of implant, tip apex distance (TAD) and osteoporosis.
3. This study is aimed to finding out the correlation among these factors in a cadaver model of unstable reverse oblique trochanteric fracture fixed with either DCS or PFN.
4. Study was conducted using standardized techniques for creating unstable reverse oblique trochanteric fracture and fixing these fractures with either DCS or PFN with single proximal screw.
5. Sixteen specimens were tested in a cyclic loading machine and the mode of failure, number of cycles to failure, bending moment and osteoporosis using DEXA evaluated.

6. Evaluation was done radiologically. Mode of failure of implant was measured after testing by comparison with pretest X-ray. Gross implant failure was defined as macroscopic failure visible to naked eye.

7. In DCS group (total eight specimens) only one specimen remained stable until the end of study. Six suffered gross implant failure while in one microscopic plate bending was noted.

8. The DEXA for DCS specimens was 0.8335 and for PFN, 0.9418. Actually the average DEXA does not give the true picture of the scenario, because the numbers of specimen having higher value of DEXA are more in DCS group than PFN.

9. The average bending moment force of DCS group was 15.32 and that for PFN group was 10.01.

10. In PFN group four remained stable till the end of study, while in one implant the breakage of proximal screw was noted and there was variable degree of proximal screw bending seen in another three specimens.

11. There was no complete correlation of implant failure with DEXA and bending moment. But this correlation is certainly more significant for PFN than DCS. However bending moment correlated most strongly with fixation failure.

12. Osteoporosis was also contributory factor towards implant failure.

13. In our study most common component failure in DCS group is plate bending (7/8) and screw bending (6/8) followed by plate barrel angle deformation (5/8). In PFN group component failure was by lag screw bending (3/8) followed by lag screw breakage (1/8).

14. This was small study of sixteen specimens. A larger study with vigorous engineering and mathematical treatment is required to validate these results.

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