

## CLINICAL SIGNIFICANCE OF TROCHANTER SHAFT ANGLE AS DETERMINANT OF ALIGNMENT OF FEMORAL CANAL AND TROCHANTER IN MANAGEMENT OF FRACTURE SHAFT OF FEMUR

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### ABSTRACT

**Introduction:** Femoral nailing is the one of the common procedure used for the fixation of fracture shaft of femur. Since relation of the medullary canal is not constant and collinear with the any specific point over trochanter hence it is difficult to insert nail and various entry points including piriformis fossa, tip of greater trochanter has been used but anatomical determinant are not clearly defined. **Aims and Objectives:** Study aimed at analyzing the relevant anatomy of proximal femur on dry femur bone and skigram to determine the anatomical alignment of throchanter with medullary canal as angle between and its significance. **Materials and Methods:** Adult dry cadaveric femora and skigram were taken to measure angle between

the trochanter and shaft of femur for safe and anatomical femoral nail insertion confirmed by retrograde insertion of remur and radioagram. **Results:** Most favourable and least strainful path for uniplaner intramedullary nail lies in the line of medullary canal can be correlated with angle between the Trochanter and Shaft which ranges between 5-17 degrees on dry cadaveric femora and 4-14 degrees on skigram. **Discussion:** since trochanter is not collinear with the medullary canal and variation in the proximal femoral anatomy, it is difficult to define the any specific point as universal entry point for femoral nailing. Relation and angle between trochanter and central medullary cavity line can guide for selection of appropriate and safe entry point for intramedullary femoral nail insertion.

**KEYWORDS:** piriformis, skigram, throchanter, uniplaner, remur and radioagram.

## INTRODUCTION

Entry site for antegrade femoral nail insertion is one of the most crucial step in overall alignment, reduction and healing of fracture and avoiding complications in procedure. Various entry sites including Piriformis fossa.<sup>[1],[2]</sup> Tip of greater trochanter (GT)<sup>[2],[3]</sup>, lateral tip of Greater Trochanter and other have been studied but, controversy still exists as anatomical and radiological basis of selection of most appropriate and safe site is not defined.

Most appropriate entry site for uniplanar femoral nail insertion should lie in the direction of medullary canal. However, due to anatomical variations and the greater trochanter not being strictly collinear with axis of the medullary canal it becomes difficult to ascertain a ideal universal area for antegrade femoral nail insertion. Therefore, Present study was undertaken to know the alignment relationship between Trochanter and shaft of femur using dry cadaveric femur, radiogram and anatomical dissection in reference to entry sites to serve as anatomical and radiological basis for femoral ante grade nail insertion site.

## MATERIALS AND METHODS

Study involved fifty dry adult cadaveric non- fractured femora without any deformity. Selected femora and their digital radiogram were taken for anthropometric and radiological measurements in reference to nail insertion site.

Dry cadaveric femora were taken to know the most favorable anatomical entry site lying in the direction of medullary canal. Since the greater trochanter is not collinear with long axis of the femoral medullary canal hence, this relation can be expressed as Trochanter-shaft angle, which is formed between a vertical line along axis of medullary canal and a line drawn from a point on this vertical line at the level of base of lesser trochanter to the tip of Greater Trochanter (GT) (which can be easily identified on bones and digital radiogram). Level of base of lesser Trochanter signifies the transitional zone between cortical and cancellous bone at junction of Trochanter and femoral shaft. **(Figure-1)** This angle was also measured and compared on computerized digital radiograms of the dry cadaveric femora after nullifying the angle of torsion. **(Figure - 2)** Proximal femur according to Trochanter shaft angle (TSA) was divided into three zones. **(Figure – 3 and 4)** zone **A** corresponded to TSA of 0-6° **B** to TSA of 6-12° and zone **C** to TSA of more than 12 degrees.

Four formalin fixed lower limbs of adult Indian cadavers having at least 60 degrees of hip flexion and no scars in hip region, thus excluding any previous hip surgery were selected in study. Anatomical dissection of these formalin fixed adult cadaveric hip was carried out. With an awl a small hole was created at entry sites of antegrade femoral nail and reamed. Relation of entry sites with Gluteus maximus, Gluteus medius and Gluteus minimus muscles, greater trochanter capsular attachment vascular supply network of femoral head and sciatic and gluteal neurovascular structure was explored.

### OBSERVATIONS

In anthropometric study Trochanter shaft angle (TSA) was measured with maximum of 17 degree and minimum of 5 degree with average of 10.2 degrees. On Radiological measurement the range was 4 to 14 degree with average of 11.4 degrees.

In 34 cases (68%) which had Trochanter-shaft angle range between 6-12 degrees in both radiological and Anthropometric measurement, the alignment of the shaft or medullary canal (confirmed by the digital radiogram) lied just medial to the tip of Greater Trochanter (GT). In 12 cases (24%) which had Trochanter shaft angle less than 6 degree corresponded with tip of greater trochanter. In 4 (8%) cases of Trochanter-shaft angle 12-17 degrees alignment of medullary canal falls in the direction of femoral neck. **(Figure – 3 and 4).**

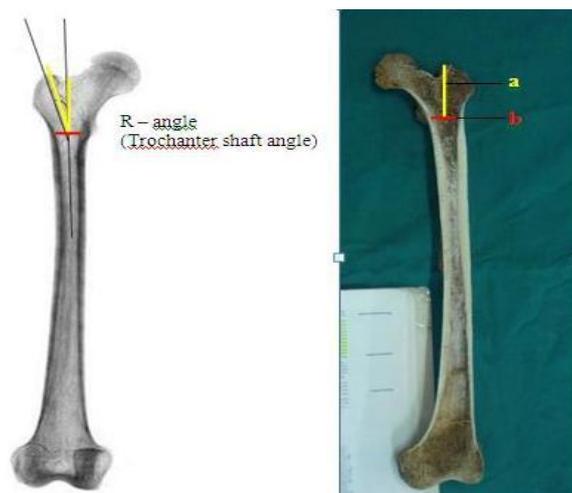
The level of base of lesser trochanter mark the transition zone between cancellous to cortical bones i.e. trochanter area and the shaft. This distance from tip of greater trochanter to the base of lesser trochanter was measured in Morphological study it was average 6.77cms and in Radiological study it was 6.73 cms.

In dissection of formalin fixed adult cadaveric hips anatomical relation was explored.

Piriformis fossa **(Figure - 5)** was identified as depression over the posterior-medial aspect of greater trochanter providing insertion of obturator externus muscle. Branches of medial circumflex femoral vessels lied in close intricacy and partly encroached at this entry site in one dissection. Attachment of capsule of the hip joint was encroached in two dissected specimen in which entry site extended medial to the central axis of the femoral canal. Tip and lateral aspect of greater trochanter provided attachment to the gluteus muscle and entry site in this region in one dissection partially violated this insertion. Inferior most branches of the superior gluteal nerve measured average 3.5 above and medial to the tip of greater trochanter

and were liable to damage if incision, awl or reamer got inserted more medially and higher. Area just medial to the tip of greater trochanter lying in the direction of the femoral shaft was found relatively safer in order to avoid the important structures.

Longitudinal section of the femur bone (**Figure - 1**) revealed bony architecture with transitional zone lying between cancellous bone (Trochanter) and cortical bone (Shaft) at the level of base of lesser trochanter. In Morphological study it was average 6.77cms and on skigram it was measured as 6.73 cms average.



**Figure - 1** Measurement of Trochanter shaft angle (TSA) on skigram, B distance at the level of base of lesser trochanter, C distance from tip of Trochanter to base of lesser trochanter mark junction of cancellous bone (Trochanter) and cortical bone (shaft femur).



**Figure - 2** Variable alignments of trochanter and femoral shaft on skiagram and dry bones.

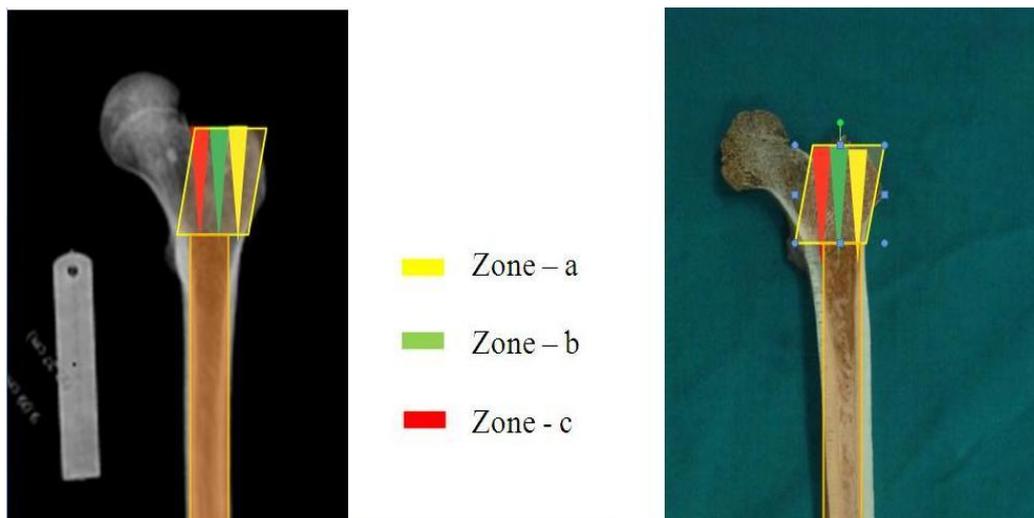


Figure - 3 and 4 illustrating anatomical zones with Zone “A” corresponding to trochanter shaft angle 0-6 degree, Zone “B” corresponding to trochanter shaft angle 6-12 degrees, Zone “C” corresponding to trochanter shaft angle 12-17 degrees.

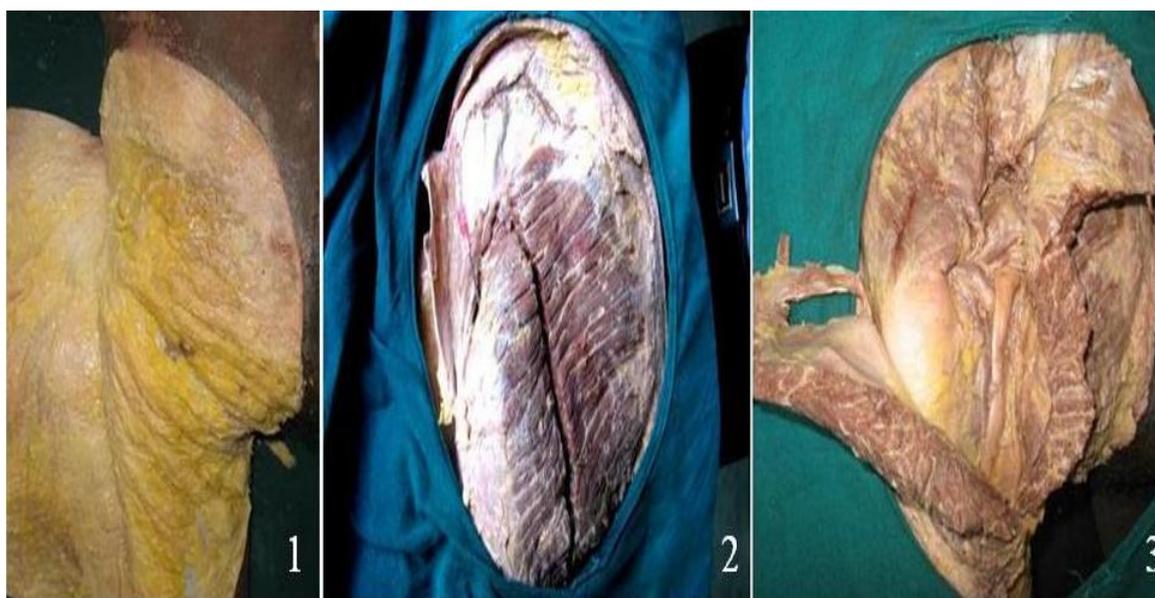
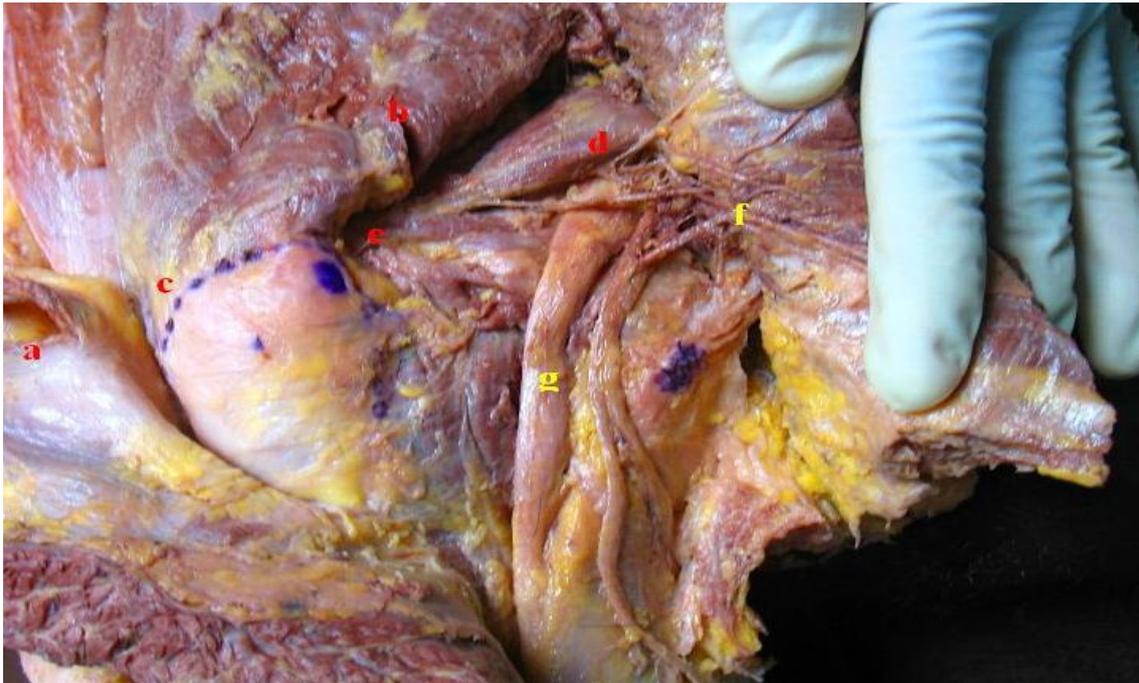


Figure – 5 Picture (1) anatomic dissection of hip after reflecting the skin flap, (2) Picture of dissection dividing Gluteus maximus and identifying entry site on greater trochanter, (3) showing dissection picture after reflecting gluteus maximus and medius exposing deeper structures.



**Figure - 6** Illustration (a) and (b) incision in Gluteus maximus and medius approaching entry site. (c) Attachment of main abductor Gluteus medius over greater trochanter, (d) Piriformis muscle (e) Attachment of short external rotators obturators, Gemelli and Piriformis over piriformis fossa and posterior medial aspect of Greater Trochanter, deep to this lies capsule of hip joint, (f) Branching of the Gluteal neurovascular bundle (g) Sciatic nerve.

#### DISCUSSION AND CONCLUSIONS

Conventional intramedullary nails being flexible enough provide the variation in entry point selection hence Piriformis fossa, Greater trochanter or any nearby point can be used without much inconvenience and complications. Rigid interlocking nails are less forgiving in selection of entry point hence various complications.<sup>[4]-[7]</sup> like iatrogenic fracture of neck, comminution of the proximal part of femur, osteonecrosis of the femoral head have been reported. Anatomical site for the safe insertion of uniplanar rigid interlocking nail should lie in the direction of medullary canal of femur but medullary canal of femur is not collinear with trochanter hence, to decide the safe anatomical entry point consideration needs to be given to this alignment which can be better objectified by determining Trochanter – shaft angle (TSA).

It was measured on dry femora and Computerized digital radiograms of the dry cadaveric femora after nullifying the angle of torsion. Zoning of proximal femur on the basis Trochanter shaft angle (TSA) (**Figure – 3 and 4**) might help in selecting most suitable entry

point in a particular patient. In patients having zone “A” (TSA 0-6°) tip of greater trochanter practically lies in line with long axis of femoral medullary canal and thus can be taken as suitable entry site. **For patients with zone B (TSA 6-12°), which was found most common in 68 percent cases, most appropriate site lie just medial to greater trochanter. zone C (TSA more than 12) warrants the use of biplanar bent nails to avoid complication and difficulty in nail insertion.**

The level of base of lesser trochanter in longitudinal section of femur revealed a transitional zone between cancellous to cortical bones i.e. trochanter area and the shaft. (**Figure -1**) It the distance between tip of GT and base of lesser trochanter may serve as a guide for bending site in biplanar nails. Wolfgang Grechenig *et al.*<sup>[8]</sup> studied the Anatomy of the greater trochanter and its clinical importance for intramedullary femoral nailing in cadaver specimens. They reported that trochanter may cover the actual entry site resulting in a much more medial entry site and recommended resection of parts of the Trochanter and preoperative CT scan, but this facility may not be available in all cases hence application of Trochanter shaft angle (TSA) is useful during surgery under image intensifier guidance. In a clinical study by Robert F. Ostrum<sup>[3]</sup> and cadaveric study by Wolfgang Grechenig<sup>[8]</sup> and Gausepohl T *et al.*<sup>[9]</sup> it has been found that anatomy of the Greater Trochanter (GT) is variable and sought its clinical importance but how it can be made to the clinical application was not clear. In our study we tried to develop useful actual clinical application by measuring the Trochanter-Shaft angle (TSA) and its significance in deciding selection of entry point.

Edward A. Perez.<sup>[10]</sup> (2007) Studied the Gluteus medius tendon injury in medial Trochanter entry point. Study by Adam J. Starr in a prospective, randomized comparison of Trochanteric Versus Piriformis Fossa Entry Portal found the ideal starting point for nail placement in proximal femur fractures is controversial.

Georgiadis GM.<sup>[11]</sup> (1996) and T Gausepohl<sup>[9]</sup> (2002) had studied and found anatomical determination of the correct entry point in 88% of the specimen. The ideal entry point for a straight nail was found constantly at the medial border of the greater Trochanter, this correlated with zone B in our study with Trochanter shaft angle 6-12 degrees. C. Dora *et al.*<sup>[12]</sup> in a cadaveric study reported soft tissue damage in antegrade femoral nailing at entry point and concluded that, entry point selection with ease of nail insertion must be weighed against the resulting soft tissue damage.

Exploring the entry sites by anatomical dissection showed entry point at piriformis fossa (**Figure -7**) lie in close vicinity of external rotator muscles obturator externus, gemelli, piriformis muscles and medial femoral circumflex vessels and likely to damage these structures. entry site at tip of greater trochanter lie at the tendinous insertion of gluteal medius and may cause disruption of tendon. Entry site just medial to greater trochanter in region “B” is relatively safer site for nail insertion.

Anatomical entry point lying in region “C” with trochanter shaft angle 12-17 degree lie at junction of neck and trochanter and risks fracture and vascular damage, hence requires to choose the bent biplane nail.

Anatomical and radiological evaluation revealed, the entry point for antegrade femoral nail insertion is highly variable and it cannot be defined in terms of piriformis fossa or greater trochanter. The anatomical entry site need to be correlated with the proximal femoral anatomy, anatomy of the trochanter itself and trochanter-shaft angle (TSA).

However, this study dealt with relatively small number of femora and it will be worthwhile to perform similar studies with a larger number of bones from different age groups and from diverse population.

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