Introduction: Fracture neck of femur continues to be regarded as the "Unsolved fracture". There is high incidence of non union (5 to 33 %) and avascular necrosis (5 to 23 %) following internal fixation. Inadequate reduction, inadequate fixation, high fracture angle, pre-operative fracture displacement, posterior comminution and osteoporosis are cited as common reasons for failed osteosynthesis. A small size of the head of femur is considered another causative factor in failure of osteosynthesis because of inadequate fixation. Mathews and Cabanela (Clin Orthop Relat Res 2004) have used the term "unfixable head" for small proximal fragment. Attempts have been made to define the size of the proximal fragment in terms of an unfixable head or a small head. Sandhu et al (Clin Orthop Relat Res 2005) have reported poor results of fixation, when the size of the proximal fragment is less than 2.5 cm. Alho et al considered a size of ≤ 15mm to discriminate a "small head fragment" (Acta Orthop Scand 1991 & 1992). All these methods are affected by techniques of radiography such as position of patient, rotation of the limb during exposure, magnification of the image etc. A slight change in these variables can lead to discrepancies in results in view of the size of the study. Further these studies are two dimensional and therefore do not determine the true size of the head fragment. Also the methods described are liable to have interobserver and intraobserver variabilities. Thus we propose to use a method based on three dimensional computerized axial tomography scan to calculate the volume of head of femur, to know the true size of the head of femur. No study has been reported in English literature to relate failure of osteosynthesis in femoral neck fractures with volume of head of femur. We, therefore, conducted a study to measure the volume of proximal fracture fragment; to compare the rates of nonunion in intracapsular femoral neck fractures in adults, treated with closed reduction & lag screw fixation (group I) with those treated with modified Pauwels' valgus osteotomy (group II) in the light of volume of proximal femoral fragment.

Materials and Methods: 64 patients of intracapsular femoral neck fractures, who completed minimum, follow up of 2 years, constituted the clinical material for the prospective study between 2005 and 2009. All patients gave written informed consent for inclusion in the study. After plain radiographs, patients were subjected to Computerized Tomography scan to calculate the volume of proximal fracture fragment of the fractured hip, based on a study done by Kavakli et al (Saud Med J 2004).

Results: Osteosynthesis with lag screws was done in 33 patients (group I) and with 120 degrees valgus osteotomy blade plate in 31 patients (group II) Average age was 45 years in group I (26 males & 7 females) and 41.9 years in group II (16 males & 15 females). The average time between injury and surgical procedure was 4 days in group I and 55 days in group II (Group II had patients with delayed presentation). Subcapital and transcervical fractures were observed in 21 & 12 patients in group I; 13 & 18 in group II, respectively (not significant -NS). According to Garden’s classification, Type II, III, IV fractures were 8, 12, 13 in group I and 2, 11, 18 in group II, respectively (NS). Average volume of proximal fragment was 54.3 cm³ in all patients, 58.8 (range, 29.0-84.9) cm³ in group I; 49.5 (range, 28.3-84.1) cm³ in group II (statistically significant –SS). Proximal fracture fragment with volume more than average volume (54.3 cm³) was considered as large fragment. Proximal fracture fragment with volume less than average volume (54.3 cm³) was considered as small fragment. Small and large proximal fracture fragments were observed in 11 & 22 patients in group I and in 23 & 8 patients in group II, respectively (SS). More patients in group II had small proximal fracture fragments (SS). Fracture union was achieved in 25 patients in group I and 24 patients in group II (NS). Nonunion occurred in 8 patients in group I and 7 patients in group II (NS). In group I, nonunion occurred in 4 of 11 patients with small proximal fracture (36%) and in 4 of 22 (18%) patients with large proximal fragment (NS). In group II, nonunion occurred in 4 of 23 patients with small proximal fragment (17%) and in 3 of 8 patients with large proximal fragment (37%) (NS). The average volume of proximal fragment was 55.7 cm³ in patients with union (range, 28.3-84.9) and 49.8 cm³ (range, 29.1-70.6) in patients with nonunion in the whole series (NS). In group I, the average volume of proximal fragment was 62.4 cm³ (range, 36.2-84.9) in patients with fracture union and 47.9 cm³ (range, 29.1-67.8) in patients with fracture nonunion (SS). In group II, the average volume of proximal fragment was 48.7 cm³ (range, 28.3-84.1) in patients with fracture union and 52.1 cm³ (40-70.6) in patients with fracture nonunion (NS). Avascular necrosis of femoral head (AVN) occurred in one patient in group I, and 2 patients in group II (both had preoperative AVN (NS).

Discussion: Sandhu et al (Clin Orthop Relat Res 2005) have reported poor results of fixation, when the size of the proximal fragment was less than 2.5 cm. They measured the size of proximal fragment, as the distance between the upper margin of fovea centralis and the midpoint of fracture margin. Parker (Injury 1994) used the ratio of distance of the fracture line from the medial margin of head to the distance of fracture line from the lateral edge of greater trochanter, as a measure of size of proximal femoral fragment. In a study by Alho et al (Acta Orthop Scand 1991 & 1992) size of the head fragment was measured as a perpendicular distance of the center of the head to the fracture line on the AP radiograph. Here a size of ≤ 15mm was used to discriminate a "small head fragment". Barnes et al (J Bone Joint Surg Br 1976) described a different method. Three fixed point are marked on an AP radiograph i.e. the centre of the capital fragment, the midpoint of the fracture line of the distal fragment and the ridge at the base of the greater trochanter. The fracture length ratio thus calculated was used as a measure of the level of fracture. Rajan and Parker (Injury 2001) determined the femoral head size using circular overlays of different sizes. All these methods are affected by techniques of radiography such as position of patient, rotation of the limb during exposure, magnification of the image etc. Further, these studies are two dimensional and therefore do not determine the true size of the head fragment. We believe CT provides true size and volume of proximal fragment and can be used to predict failure of internal fixation in femoral neck fractures. Alho et al (Acta Orthop Scand 1992) reported fracture healing complications in 41 % of fractures with a small head fragment, against 18.9 % fractures with a large head fragment. Barnes et al (J Bone Joint Surg Br 1976) concluded that high level (thus having a small proximal fragment) displaced fractures showed a significantly lower failure rate (41.4%) than those at lower levels (28.3 %). The patients with lag screw osteosynthesis had higher rates of nonunion in fractures with small proximal fragment (36%) than in fractures with large proximal fragment (18%) in the present study. In group I, the average volume of proximal fracture fragment was more in fractures with union (62.4 cm³) in comparison to fractures with nonunion (47.9 cm³) which was statistically significant. We believe that osteosynthesis with lag screw should be avoided in patients with small proximal fracture fragment assessed on CT examination. In group II the average volume of proximal fracture fragment in fractures with union was comparable with fractures with nonunion. Osteosynthesis with 120 degrees valgus osteotomy blade plate achieved comparable union rates in both small and large proximal fragment groups. Valgus osteotomy changes the fracture inclination, makes it horizontal, and converts shearing forces into compressive forces. This result in more chances of union which explains more rates of union in fractures with small proximal fragment, despite the fact that group II had more patients with small proximal fragment and with delayed presentation.

Conclusion: Osteosynthesis with lag screws had higher rates of nonunion in fractures with small proximal fragment (36%) than fractures with large proximal fragment (18%). The average volume of proximal fracture fragment was more in fractures with union than in fractures with nonunion in patients who had osteosynthesis with lag screws (statistically significant). This mode of internal fixation should not be avoided in fractures with small proximal fragment assessed on measurements of volume of proximal fracture fragment on CT examination. Modified Pauwels' valgus intertrochanteric osteotomy was associated with lesser nonunion rates in fractures with small proximal fragment and may be advised in such fractures.