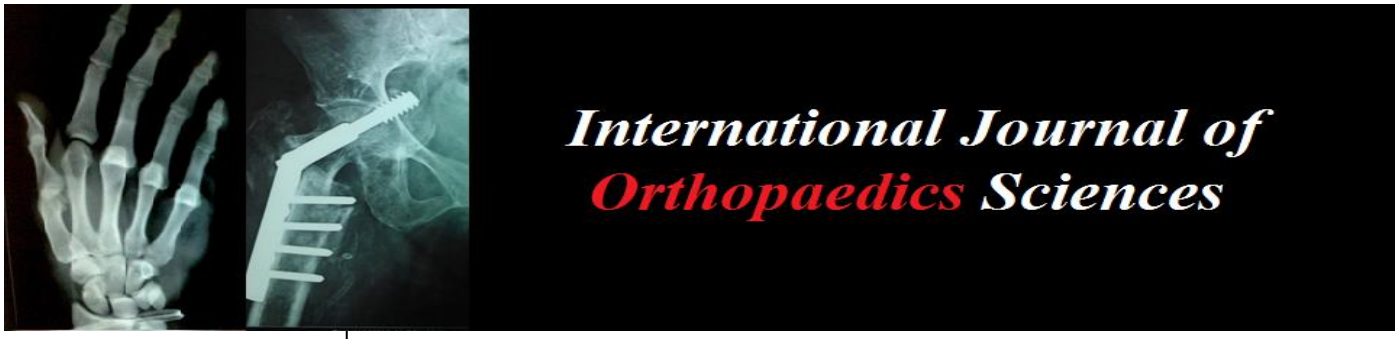

E-ISSN: 2395-1958
P-ISSN: 2706-6630
IJOS 2019; 5(4): 646-651

www.orthopaper.com
Received: 01-08-2019
Accepted: 05-09-2019

Dr. Arvind Kumar SM
Professor, Department of Orthopaedics, PSG IMS&R, Peelamedu, Coimbatore, Tamil Nadu, India

Dr. Yeluri Rama Krishna
Senior Resident, Department of Orthopaedics, PSG IMS&R, Peelamedu, Coimbatore, Tamil Nadu, India

Dr. B Arun Kumar
Junior Resident, Department of Orthopaedics, PSG IMS&R, Peelamedu, Coimbatore, Tamil Nadu, India

Corresponding Author:
Dr. Arvind Kumar SM
Professor, Department of Orthopaedics, PSG IMS&R, Peelamedu, Coimbatore, Tamil Nadu, India

Mechanical comparison of reconstruction nail and dynamic condylar screw in the treatment of unstable Subtrochanteric fracture *in vitro* study

Dr. Arvind Kumar SM, Dr. Yeluri Rama Krishna and Dr. B Arun Kumar

DOI: https://doi.org/10.22271/ortho.2019.v5.i4l.1748

Abstract
Background: Subtrochanteric femur fractures are severe injuries that are often associated with high-energy trauma in young age and a trivial fall in osteoporotic patients. These fractures constitute a major bulk of hip fractures and are difficult to treat.
Objective of this study was to determine the rigidity and strength of fixation and ultimate load of failure of certain composite femur models designed to simulate unstable subtrochanteric femur fractures fixed with DCS and Reconstruction nail.
Methods: Paired femora were osteotomized to produce like models of an unstable subtrochanteric femur fracture in vitro. The femora were fixed with the Reconstruction nail and a 95 degree dynamic condylar screw plate (DCS). Materials testing machine was used to apply compression to the femoral head through an adapter plate. Stiffness values were calculated from the load-deformation curves obtained.
Results: The Reconstruction nail-femur model was stiffer than the 95 degree DCS. The Reconstruction nail also had the highest ultimate load-to-failure than the 95 degree DCS.
Conclusion: Our findings suggest that the Reconstruction nail has greater stiffness and strength than the 95 degree dynamic condylar screw when tested in this model of an unstable subtrochanteric femur fracture.

Keywords: Subtrochanteric fractures, dynamic condylar screws, reconstruction nail

Introduction

Subtrochanteric femur fractures are severe injuries that are often associated with high-energy trauma in young age and a trivial fall in osteoporotic patients. These fractures constitute a major bulk of hip fractures [1]. These fractures are known to be difficult to treat successfully [2]. Anatomic and biomechanical variation in this region makes this area peculiar for the treating surgeons. The compressive stress in this area of the medial femur is as high as 1,200 pounds per square inch [3], which cause enormous stress on the fracture fixation devices. No single implant is ideal for all the Subtrochanteric fractures. Various implants used to address these fractures are 95 degree blade plate, 95 degree dynamic condylar screw, reconstruction nails and proximal femoral locking plate.

Through the years, numerous classification systems have been proposed for subtrochanteric fracture which have a prognostic importance and are of benefit in planning treatment.

Russell and Taylor [4] classified these fractures based on the involvement of the lesser trochanter and the piriformis fossa (Fig. 1). Intramedullary nail is the choice of implant in type I fractures as the fracture does not extend into the piriformis fossa. Extramedullary fixation with various plates is indicated in type II fractures in view of involvement of piriformis fossa. Loss of medial cortical contact and increased stress on the implant causes difficulty in treatment of Type IIB fracture.

Good results have been achieved using Dynamic condylar screw and reconstruction nail in unstable subtrochanteric fractures. The purpose of the present study is to compare the biomechanics of 95 degree dynamic condylar screw and reconstruction nail in resisting compressive loads in an unstable subtrochanteric fracture.

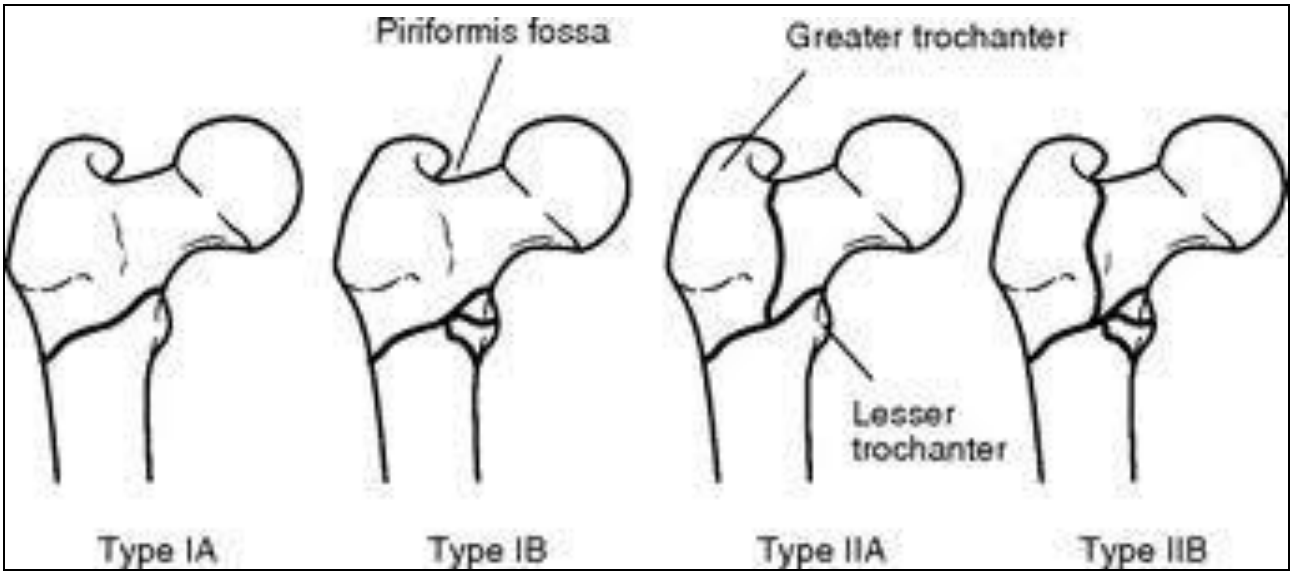

Fig 1: Russell Taylor classification of sub trochanteric fractures

Materials and Methods

Type of study: Observational study (in vitro)

Place: PSG IMS&R, Coimbatore

Selection: 3 Paired adult fresh cadaveric femora were used.

They were osteotomized to produce like models of an unstable subtrochanteric femur fracture. The femora were fixed with the Reconstruction nail and a 95 degree dynamic condylar screw plate (DCS).

The femora were placed into the materials testing machine with the femoral head placed in the metal mount over the base and the condyles superiorly held by the metal plate of the machine. The femora were placed vertically and loaded in compression to 500 newtons at a rate of one millimeter/second and a load displacement curve was obtained.

The Synthes 95 degree dynamic condylar screw plate (DCS) chosen (stock number S040-95-08) was a six-hole plate. A 75-millimeter lag screw was placed into the proximal fragment, and the plate was inserted over the lag screw and secured with the compressing screw. A 6.5-millimeter cancellous screw (70 millimeters long with a 32-millimeter thread) was placed into the most cephalad hole in the plate. The next hole was left empty, and the last four holes were filled with bicortical 4.5-millimeter screws.

The Reconstruction nail used was 09x 380mm size (stock number SMPL, S182-09L-380) and the two proximal screws were of 6.4x95mm and 6.4x80mm size and locked distally with cortical screws.

The femora were prepared for the DCS and Reconstruction nail before the osteotomy was cut. The lag screw was placed over a guide wire in the specimen receiving the DCS. The osteotomies were cut in a similar manner in both the femora. A 30 degree osteotomy was cut, leaving a two centimeter defect on the medial side of the femur. The plates were then fixed to the distal fragment with 4.5-millimeter cortical screws. Failure was determined by a sudden change in the load deformation curve. Each of the femora was then radiographed and examined to determine the cause of failure.

The stiffness of each system was determined by measuring the slope of the load deformation curve. These stiffness values and the load-to-failure values were tabulated and averaged. The measurements were analyzed by analysis of variance to determine statistical significance.

Results

From Compression Testing of Simple Bone

At the peak load the bone suddenly fractured completely as shown in the figure 2

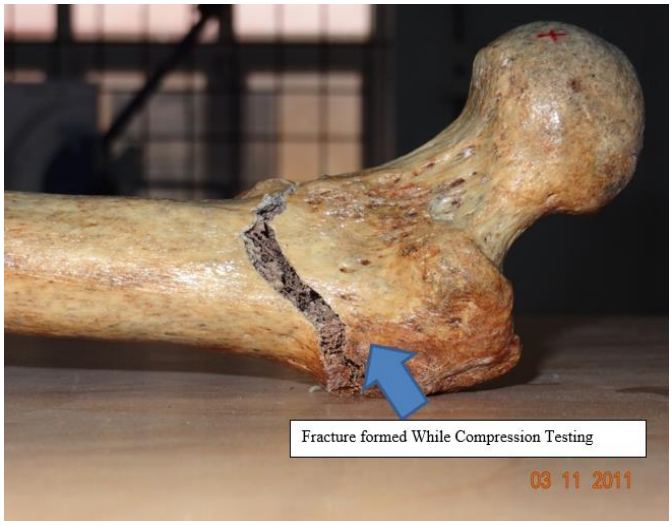

Fig 2: Fractured simple bone

The fracture is created due to the load application of load in the compression testing. When the bone is placed at a 6 degree angle as like in the human body

The fracture happened as shown in the fig 2. if the one is placed perpendicular loading arm the fracture is in the middle also breaking load also increases.

The peak load from this compression testing of the simple bone is given as he force value for Finite element analysis using ANSYS for study of the stress distribution over bone while compression loading.

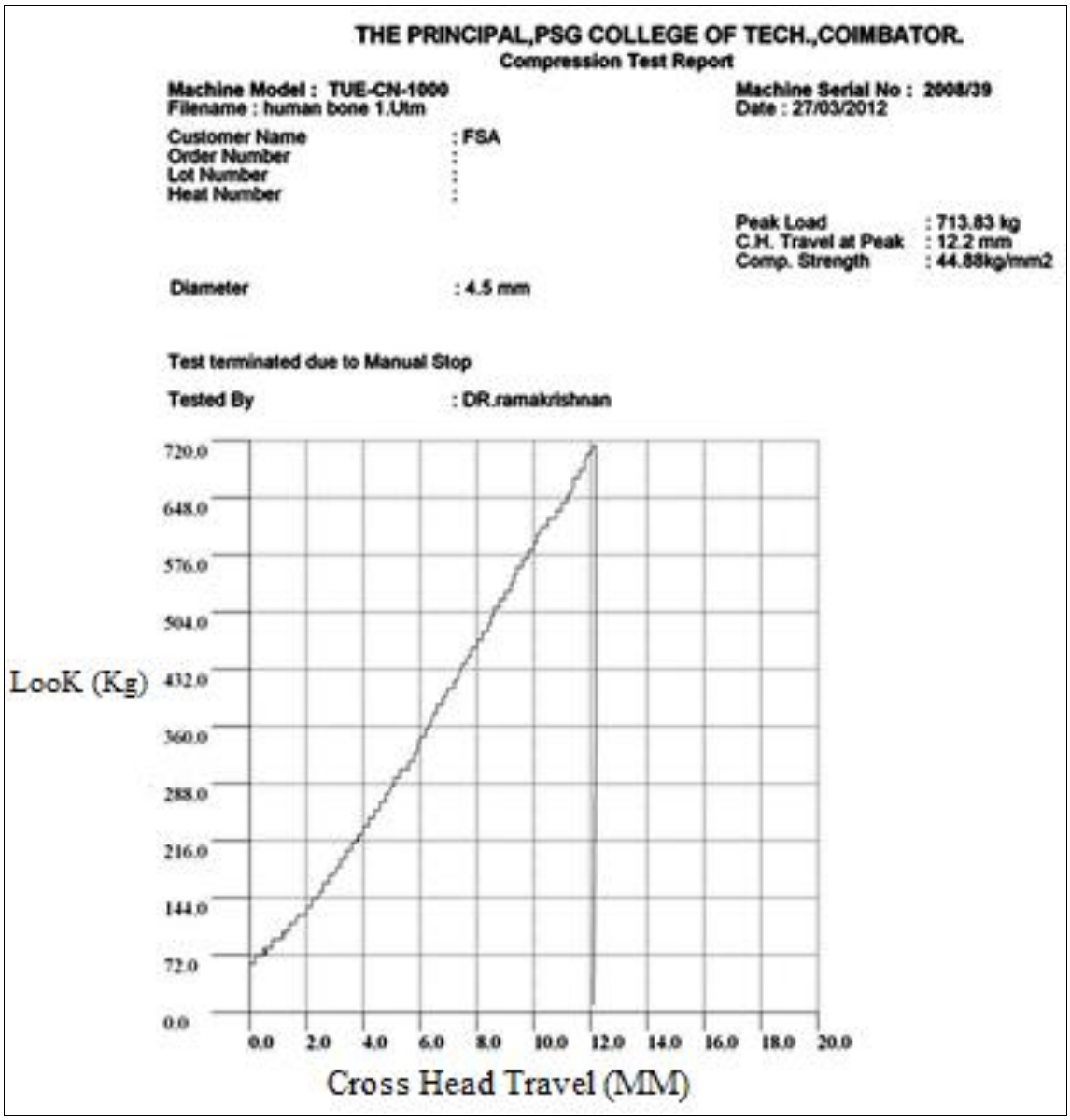

Fig 3: Load deformation curve for simple bone

The peak load at which bone Breaked is 713.83 kg and cross head travel that is deflection of the specimen is 12.2mm. The final result compressive strength is 44.88kg/mm2 was shown in the Fig 3

For testing dynamic condylar screw (DCS) Implant

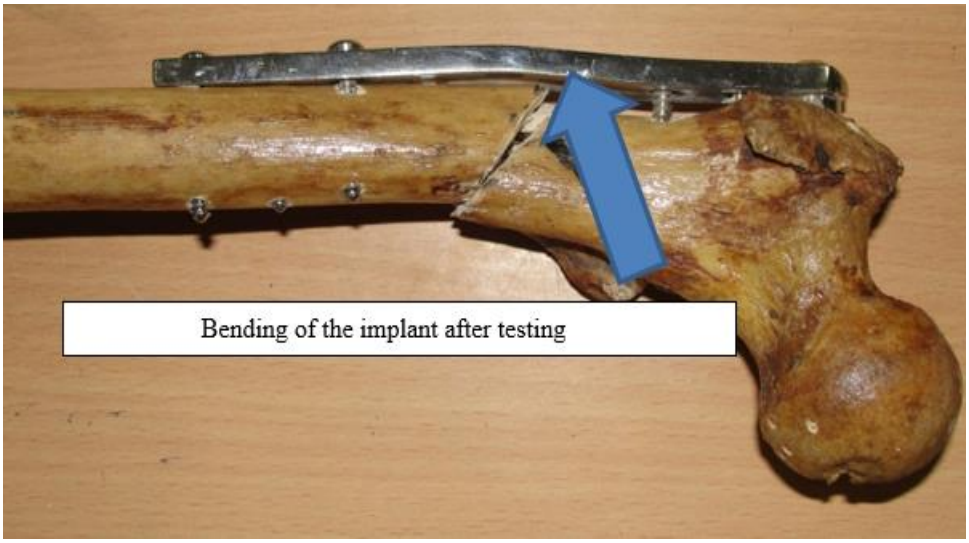

Fig 4: Failure of the DCS Fixed Bone

While testing, the bones shattered into pieces are brought together shown in fig 4 the fractured part i.e., artificial fracture created for testing the implant stability is the one first get affected and broken early while loading. At initial loading bone itself takes all the load so its obvious for fractured part to gets affected

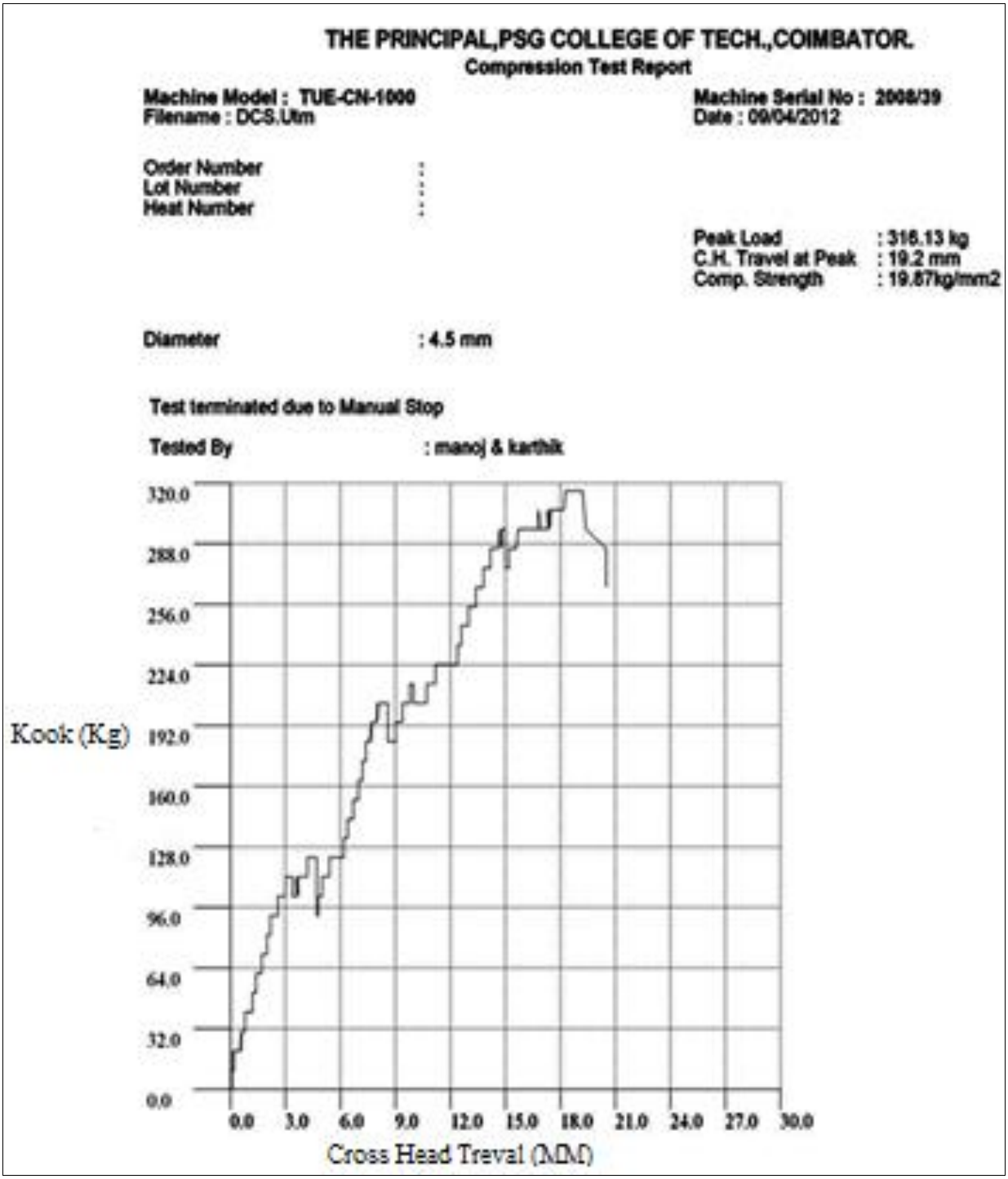

Fig 5: Load deformation curve obtained for DCS

The peak load at which implant failed is 316.13kg and cross head travel that is deflection of the specimen is 19.2mm. The final result compressive strength is 19.67kg/mm2 was shown in the fig 5.

For testing proximal femoral nail (PFN) implant

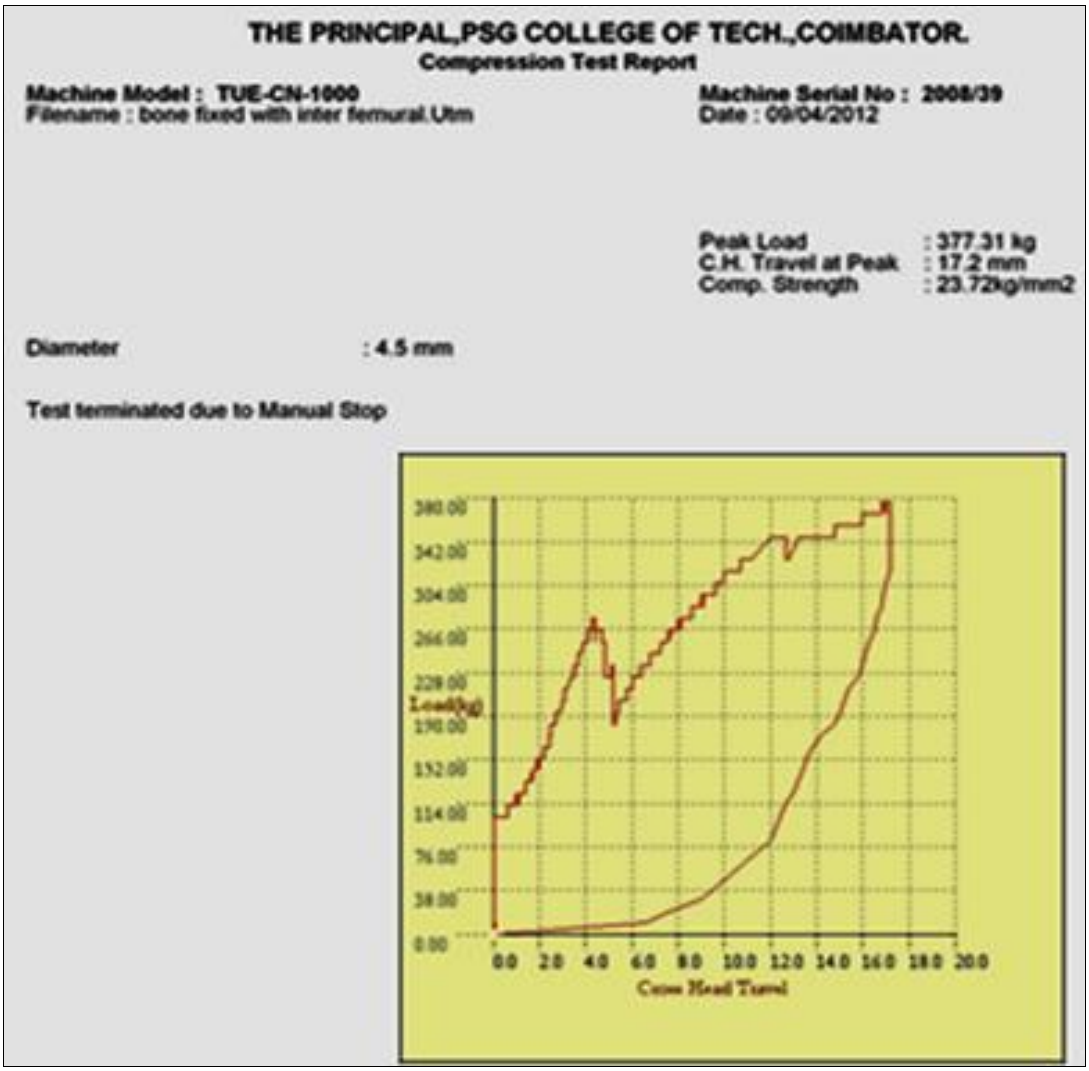

Fig 6: Load deformation curve obtained for PFN

The peak load at which implant failed is 377.31kg and cross head travel that is deflection of the specimen is 17.2mm. The final result compressive strength is 23.72kg/mm2 was shown in the fig 6

In both implant testing the loading is terminated manually at peak loads because of the significant deformation in the bone and implants is considered as failure of the implant. Compressive strength are generated based on the peak load. Simple bone's compressive strength is maximum because loading is done till the complete breaking of the bone

Fig 7: Failure of Proximal Femoral Nail fixed bone

The figure 7 & 8 shows the failure of the PFN fixed bone. PFN implant never showed any deformation while loading only the bone started to crack is considered as failure of the implant.

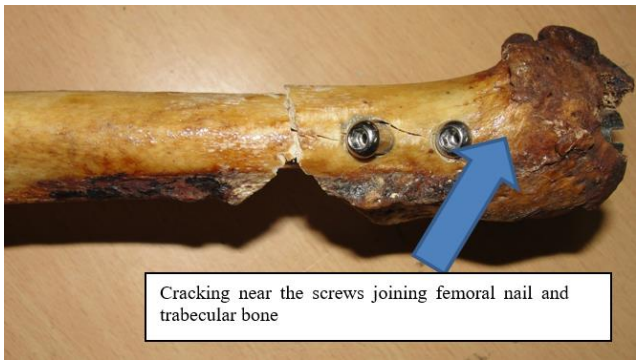

Fig 8: cracking of bone

Reconstruction nail femur composite demonstrated a stiffness of 665 newtons/millimeter and the DCS femur composite demonstrated a stiffness of 373 newtons/millimeter. Using ANOVA test the statistics were analsed. These differences were statistically significant ($p < 0.00001$).

The Reconstruction nail femur composite also had the highest load-to-failure (3773 Newton's), and for the DCS femur construct it is 3,161 newtons. These results were also statistically significant ($p < 0.00001$). The sudden change in the load-deformation curve coincided with an obvious deformation of the implant. Table 1

Discussion

Subtrochanteric fractures of the femur demands a vital place

in orthopedic traumatology, given the high rate of complications associated with their management due to the high loading forces and immense stresses in this area. An ideal implant should achieve stable fixation with no interference with the vascularity and hold the fracture till it unites. Fixation is a race between fracture healing and implant failure. Irrespective of the mode of fixation emphasis is laid on the medial cortex reconstitution as described in the study by Senter B *et al*. [5]. Intramedullary devices require less surgical exposure, enable early weight bearing and exert less biomechanical stresses (as the lever arm is moved medially) [6-8] However technical difficulties are observed in upto 63% of the cases [9, 10].

Comminuted subtrochanteric femoral fractures are often caused by high-energy trauma [12, 13] Fractures may extend into the greater and the inter-trochanteric regions [11]. Open reduction further devitalizes fragments, damages the vascular supply or soft tissues, and increases the risks of non-union, infection, and implant failure [12] whereas indirect reduction does not [19]. One case of implant failure (12.5%) is observed in fractures fixed with DCS by open reduction compared to failure rates of 20 to 23% in different studies [14, 15].

In this study the inference from the each load deformation curve is as follows.

Inference for DCS Curve

Graph indicates the increase in deformation as the load increases at the load of 122kg first failures takes place in the fractured section of the bone first drop in graph indicates this failure.

At the load of 204kg fracture gets more affected is noticed by propagation of crack all around the bone with crisping sound.

Implants start to bend at the load of 298kg that is considered as the failure of DCS fixed bone.

Inference for PFN Curve

As the load increases the deflection in the bone also increases. Drop in the deflection curve at 270 kg indicates the first failure at the fractured section of the bone after the first failure the continuous loading results in cracking of the bone at the fractured section at 350kg

Conclusion

Taking into consideration that the femoral nail implant is way tougher than the DCS implant the failure can be verified with the fracture of the bone only.

Since the inter femoral nail fails at load higher than the DCS implant it can be inferred that:

- The inter femoral (PFN) is found as more stable implant followed by dynamic condylar screw (DCS) to treat unstable sub trochanteric fracture.
- The rate of displacement of the head also is less at a higher force when compared with that of the DCS and hence it can be inferred that PFN also resists displacements.
- In the failure pattern the implant did not break in PFN but only the fracture occurred between the two screws hence again confirming that PFN is a rigid implant.

References

1. David G. Lavelle. Fractures and dislocations of the hip. In: Canale ST, Beaty JH, eds. Campbell's operative orthopaedics, 11th edn. Philadelphia, Pa: Mosby Elsevier; 2007, 52.
2. Asher MA, Tippet JW, Rockwood CA, Zilber S. Compression Fixation of subtrochanteric fractures. CORR, 117
3. Koch JC. The laws of bone architecture. Am J Anat. 1917; 21:177-298.
4. Russell TA, Taylor JC. Subtrochanteric fractures of the femur. In: *Skeletal Trauma*, ed by Browner BD, Jupiter JB, Levine AM, Trafton PG. Philadelphia, WB Saunders Company, 1992, 1485-1524.
5. Senter B, Kendig R, Savoie FH. Operative stabilization of subtrochanteric fractures of the femur. J Orthop Trauma. 1990; 4(4):399-405.
6. Ramakrishnan M, Prasad SS, Parkinson RW, Kaye JC. Management of subtrochanteric femoral fractures and metastases using long proximal femoral nail. Injury. 2004; 35:184-90.
7. Curtis MJ, Jinnah RH, Wilson V, Cunningham BW. Proximal femoral fractures: A biomechanical study to compare intramedullary and extramedullary fixation. Injury. 1994; 25:99-104.
8. Charnley GJ, Ward AJ. Reconstruction femoral nailing for nonunion of Subtrochanteric fracture: A revision technique following dynamic condylar screw failure. Int Orthop. 1996; 20:55-7.
9. Boldin C, Seibert FJ, Fankhauser F, Peicha G, Grechenig W, Szyszkowitz R. The proximal femoral nail (PFN)-a minimal invasive treatment of unstable proximal femoral fractures: A prospective study of 55 patients with a follow up of 15 months. Acta Orthop Scand. 2003; 74:53-8.
10. Garnavos C, Peterman A, Howard PW. The treatment of difficult proximal femoral fractures with the Russell-Taylor reconstruction nail. Injury. 1999; 30:407-15.
11. Siebenrock KA, Muller U, Ganz R. Indirect reduction with a condylar blade plate for osteosynthesis of subtrochanteric femoral fractures. Injury 1998; 29(3):C7-15.
12. Kinast C, Bolhofner BR, Mast JW, Ganz R. Subtrochanteric fractures of the femur. Results of treatment with the 95 degrees condylar blade-plate. Clin Orthop Relat Res. 1989; 238:122-30.
13. Celebil, Can M, Muratli HH, Yagmurlu MF, Yuksel HY, Bicimoglu A. Indirect reduction and biological internal fixation of comminuted subtrochanteric fractures of the femur. Injury. 2006; 37:740-50.
14. Nungu KS, Olerud C, Rehnberg L. Treatment of subtrochanteric fractures with the AO dynamic condylar screw. Injury. 1993; 24:90-2.
15. Kulkarni SS, Moran CG. Results of dynamic condylar screw for subtrochanteric fractures. Injury. 2003; 34:117-22.