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DESIGN AND ANALYSIS OF FEMORAL NAIL EXTRACTION INSTRUMENT FOR HUMAN FEMUR BONE

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ABSTRACT

Different conventional techniques have been noticed to remove intramedullary femur distal nail, a simple method is explained to remove a broken distal closed section intramedullary nail with nail extraction instrument. The surgical technique is described. This technique reduces physical torture of patient during surgery and headache of doctors. In this article the design procedure for nail extraction instrument is explained as well as analysis results (in ANSYS) of nail extraction instrument are discussed. This technique involves removal of distal broken femur nail by on the spot creating threads in the nail, which is one of the feasible technique & the results of this analysis are helpful for orthopedic surgeons for clinical interest.

KEYWORDS: Intramedullary femur nails, tapping, extraction instrument, ANSYS).

INTRODUCTION

Removal of broken IM nails may be particularly challenging and sometimes is difficult. When a nail is broken in two parts, it is easy to extract upper part of the femur nail as at the mouth portion internal threading is provided.[3] But it becomes extremely difficult when it comes to lower distal part. We report here nail extraction instrument which will remove distal part of the femur nail by on the spot tapping in the nail. Design procedure & ANSYS results are also discussed.

DESIGN OF NAIL EXTRACTOR ROD

Selection of material: For nail extractor instrument the important aspect is to maintain corrosion resistance throughout so 410 steel is selected.

Force required extracting nail from bone: After this pull out test in ANSYS, 150N is the maximum extraction force required to remove whole nail outside the femur bone.

Calculation of diameter of nail extractor rod

The minimum diameter required for the nail extractor rod is 1.3819 is calculated but this is also important to observe the application status, that
Minimum nail Inner Diameter range is: 4.5- 5 mm
Maximum nail Outer Diameter range is: 7.5-8.5mm
So it is necessary to take bigger diameter than 8.5 mm so we select it as **10 mm.**

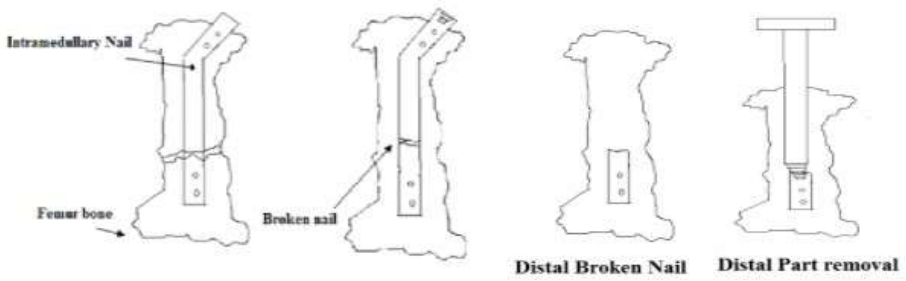

Fig. 1 Distal Part Removal Method

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Length of nail extractor rod

Total length of nail extractor = 400 mm + 20 mm for threading + 50mm handle

L = 470mm

Design of Tip Threading Of Nail Rod:

While threading at the lower end of the extractor rod Anticlockwise taping is machined on nail rod tip because after taping and locking it makes easy to pull out broken nail.Minimum nail ID is 4.5- 5 mm and maximum nail ID is 6.5- 7.5 mm so for the purpose of inside insertion minimum 3 mm diameter can be maintained at the lower end and at the upper end it should be maximum 10mm is provided reason why this mail extractor can be used for any size of nail. Even Minimum nail ID : 4.5- 5 mm we go for minimum dimension 4mm so it gives good alignment between nail extractor and broken nail.

Threading M10 = 10x 1.5

Now, Area under shearing when pulling force 150 N is applied.

Shearing stress 300 MPa

$A = \frac{150}{300}$

$A = 0.5\ mm^2$

This area 0.5 mm^2 take load 150N that means only 0.5 mm^2 minimum thread area is need to be engaged with the broken distal nail for extraction of the broken nail through the bone.

Now for safer side we will take 1mm^2

Force required to shear this area by taping =

Force = shear stress x Area

= 300 x 1

F = 300N

This force is acting on taping from this we can calculate moment acting on the head of the nail extractor.

Torque is applied at tap of 10 mm diameter thread

$T_1 = F \times R$

= 300 X 5

= 1500 N-mm

Similarly,

force applied on the head of the nail extractor

$T_2 = F \times R$

1500 = F x 15

F = 100 N

HAMMER

To avoid too much force to hammer out the nail, this was spoiling the extractor tip too quickly especially if the nail was jammed or causing disengagement of the extractor from the nail due to sudden heavy blow strong enough to dislodge this junction. The size of extractor hammer was made smaller .the force generated by this hammer is good enough to take out the nail but weaker than the force required to caused disengagement of extractor with the nail.

Design of Hammer

It is practically seen that after locking of nail extractor to broken nail it is easily pulled by human effort. But in some situation we required some impact force so we are taking maximum load 1kg. So with that for proper griping of any object the gripping length should be 55-75mm. So we can decide it as 75mm.

Length of hammer- 75 mm

Hammer is sliding on the nail extractor rod so we have to provide 1mm clearance so Inner diameter of the hammer is 11mm.And For proper griping any circular object diameter should be 25-35mm.We decide to take dimension 30mm. and second aspect for proper griping is to provide 4 groves on hammer

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Actual Photograph

Fig. 2 Femoral nail and Femoral nail extractor

FINITE ELEMENT ANALYSIS (FEA) USING ANSYS

CATIA V5 serves the basic design tasks by providing different workbenches. A workbench is defined as specified environment consisting of a set of tools which allows the user to perform specific design tasks in a particular area. Analytical methods provide quick close from solutions, but they treat only small geometries and capture only the idealized structural theory. By understanding experimental techniques, representatives or full- scale models can be tested. Experimentation is costly relative to the analytical methods both in terms of test facilities, the model, instrumentation and the actual test time. Numerical methods require very few restrictive assumptions and can treat complex geometries. They are far more cost effective than experimental techniques. The most versatile numerical methods in the hands of engineer are the finite element method (FEM).

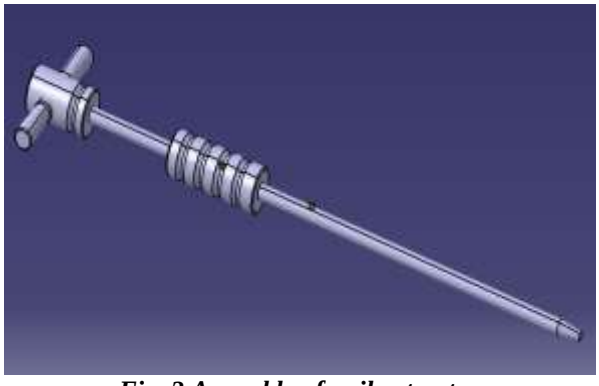

Fig. 3 Assembly of nail extractor

Fig. 3 shows an assembly of the nail extractor instrument drawn in the CATIA V5

RESULTS AND DISCUSSION

The Femur nail extractor instrument is a unique concept to extract a broken distal nail. Rather than other techniques this provides many advantages. The entire process requires a couple of hours. It may be noted that only static load applied on femur nail extractor.

Result Of Analysis Of Nail Extractor Rod
Deformation of nail extractor

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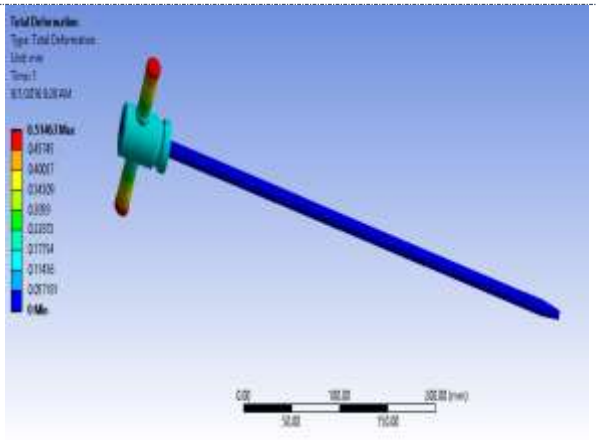

Fig. 5: Deformation of nail extractor.

The results depend on the accuracy of FE model with reference to real conditions. This study investigates stress distribution, deformation, moment and factor of safety of femur nail extractor with extraction force 150N.

Results shows that higher deformation occurs at the handle of femur nail extractor and lowest occur at the lower end. Maximum stress is 58.009 MPa. and Minimum stress is 6.44 N/mm^2. It can be observed that this model is safe enough with factor of safety 15.

Stress analysis of nail extractor

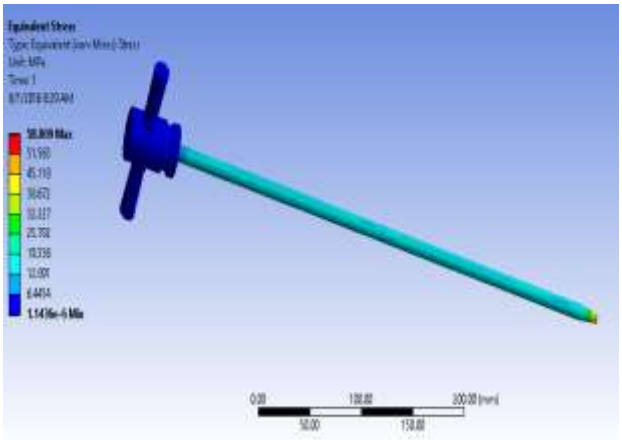

Fig. 6 Stress analysis of nail extractor

Fig.6 shows results of FEM analysis of stress of femur nail extractor with maximum stress 58.009 Mpa at the rod and it is coming on the tip portion of the threading. The minimum stress which is coming on the handle is 6.4454Mpa.

Fig. 6 shows results of the deformation occurring due to loading highest deformation occur at the handle 0.5146mm. and minimum deformation occurs at the nail extractor rod

Factor of safety of nail extractor

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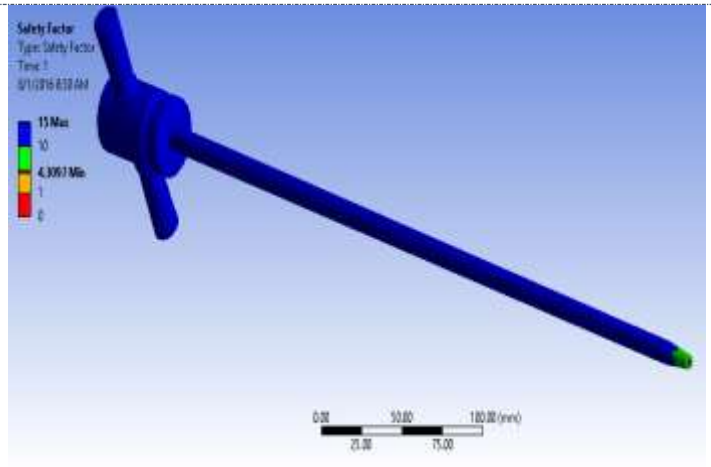

Fig. 7 Factor of safety of nail extractor

From stress distribution and deformation it is found to be safe design of the femur nail extractor instrument.

ANALYSIS OF HAMMER

Deformation of hammer

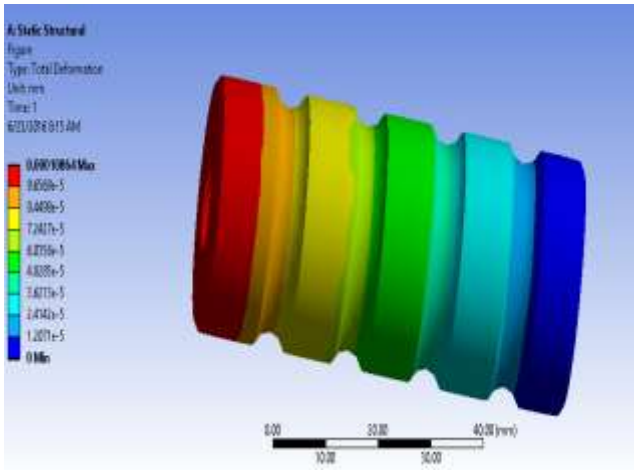

Fig. 8 Deformation of hammer

It can be observed from fig.8 that maximum deformation occurring on hammer because of the loading is 0.0001086 mm at the impacting end of the hammer and again in the fig. 9

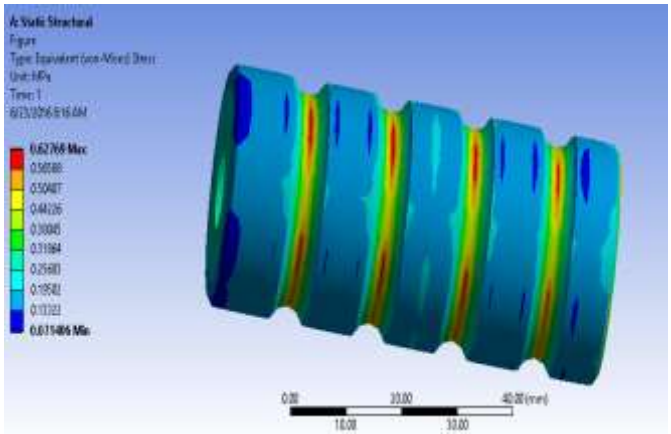

Fig. 9 Stress analysis of hammer

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It can be observed that maximum stress is coming on the neck portion of the hammer is 0.6276 N/mm^2. From stress distribution and deformation it is found to be safe.

CONCLUSIONS

The results obtained by the calculative design procedure are analyzed with the help of ANSYS results. We observed that the higher deformation occurs at the handle of femur nail extractor. It can be observed that the this model of nail extractor is safe enough with factor of safety 15. These results are useful for the orthopeadic surgeon for the surety of the working of the Instrument. It will definitely reduce the femoral nail extraction surgery time and patient's trouble at the time of surgery and it is important for patient relief.. It is observed that, extraction of broken nail with nail extraction instrument is the best technique for human femur bone. It is observed that the threading of the tip portion wears after 30-40 operation

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