ORIGINAL ARTICLE

Development of new External Fixators used in high tibial Osteotomy in the treatment of Medial Compartment Osteoarthritis of the knee joint -Azhar'S Fixators (A.Z FIXATORS)

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ABSTRACT

Aim: To design, develop and manufacture a new external fixator for high tibial osteotomy in the treatment of medial compartment osteoarthritis of the knee joint which is cost effective, easy to apply, can correct post operative over correction and under correction, allows early weight bearing, early range of movement exercises, promotes early union, early return to living activities and is a patient friendly with reference to our socio economical conditions.

Methods: The fixator was designed, developed and later on manufactured in the orthopaedic workshop Mayo Hospital, Lahore. The bio mechanical strength of the material and fixator was studied in the mechanical department of Engineering University Lahore. In order to assess the bio mechanical strength of the fixator and its material, the physical and photo electrical study was conducted. The physical testing was done with respect to assessment of

a. Torsional force by using torsion testing machine, specimen and micrometer.
b. Bending material analysis by using hanger and dial gauge
c. Tensile bending force analysis by using Hounsfield TensometerApparatus.

The Photo electrical study of the material was also conducted and the results of the material were similar to physical testing study.

Conclusion: We reached to the conclusion that the bio mechanical strength of the fixator, its material and design is satisfactory to meet the requirements of good external fixator which can be used effectively in high tibial osteotomy in the treatment of medial compartment osteoarthritis of knee joint.

Key words: Osteoarthritis, High tibial osteotomy, A.Z External Fixators

INTRODUCTION

Osteoarthritis of the knee joint is the most common joint disorder in the elderly with prevelance of about 30% in adults aged more than 60 years. High tibial osteotomy has been used for many decades all over the world for the treatment of osteoarthritis of the knee joint. High Tibial Osteotomy historically started by Langenbeck in 1854 but Jackson 1958 was the first to publish his experience of High Tibial Osteotomy in the management of medial compartment osteoarthritis of the knee joint. Coventry 1965 was first to perform osteotomy proximal to tibialtubercil with the advantage of fast healing. The credit of spreading of this technique goes to Coventry's. After Jackson and Coventry, Paul, Insall, Greiphy, Mathews, Sprenger, Aglieth, Bennett's, Gillespie, Gunn, Harris, Macintosh, Maquet, Scott, Shee, Smillie, Volkmann, Wardle, etc. further popularized this technique all over the world.

It is indicated in patients with medial cartilage damage and varus deformity due to osteoarthritis, traumatic cartilage lesion, osteochondrosisdissecans, and condylar osteonecrosis. The principle of correcting malalignment is to transfer the load to relatively normal compartment of the knee joint in order to relieve symptoms and to suppress the disease progress.

Pauwels showed that previously narrowed joint space will widen post operatively and both subchondral cysts and sclerosis will regress if stress in the effected compartment is reduced sufficiently. Such a stress reduction occur in the medial compartment of the knee joint when the mechanical axis is transferred from the medial compartment to the center of the joint or just lateral to the joint. This good alignment is achieved when the correction is maintained between 7 to 10 degree of valgus post operatively.

MATERIAL AND METHODS

The fixator was designed and manufactured in Orthopaedic Workshop at Mayo Hospital Lahore and material testing was done in mechanical department of Engineering University of Punjab, Lahore. The fixator consist of six different part as shown below.

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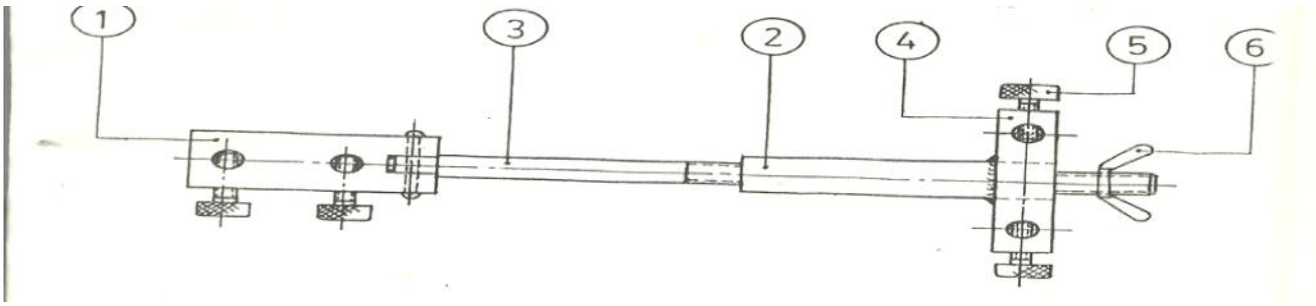
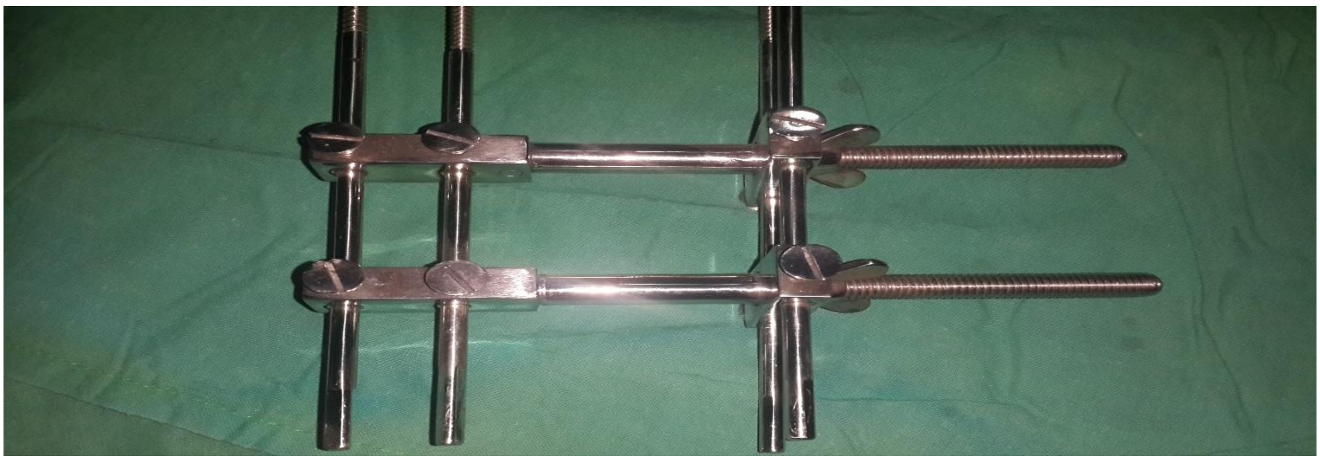
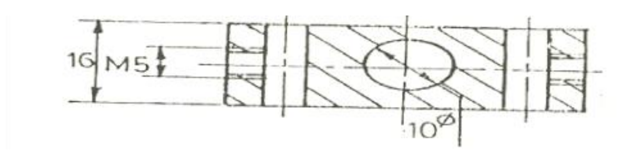




The individual description of each part is as below

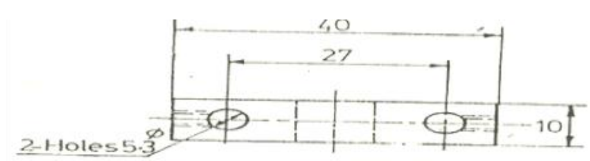
(1) Plate No. 1

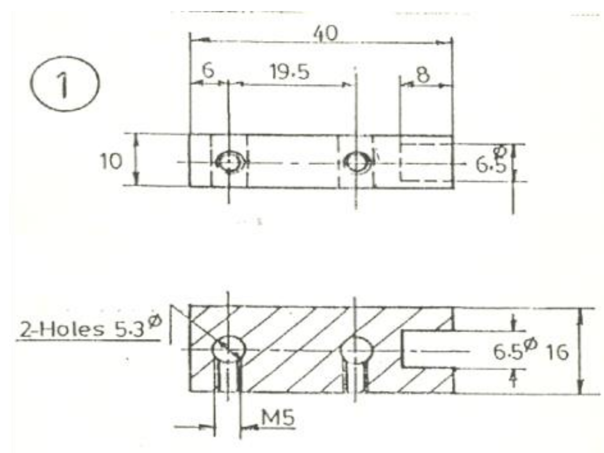
Two different views i.e., elevation and plain of the plate are shown below.



The total length of the plate attached towards proximal side is 40mm and there are two holes in it for screws. The diameter of each hole is 5.3 and the distance between the two holes is 27mm. the thickness of the plate is 10mm.

The plain view shows that there is a central hole of 10mm diameter for passing screw rod into the plate and the width of the plate is 16mm.



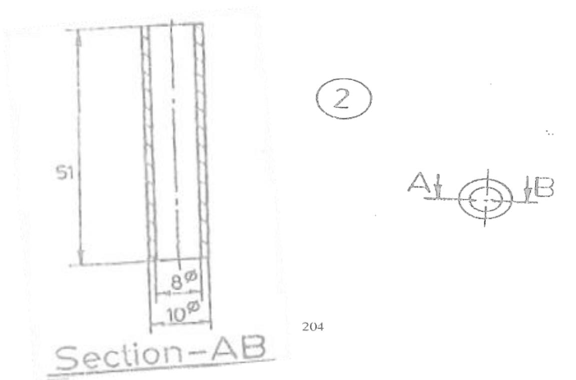


The total length of the plate is 40mm. The plate also has two holes in it. The diameter of both holes is similar to the diameter of plate No 4 i.e. 5.3mm.

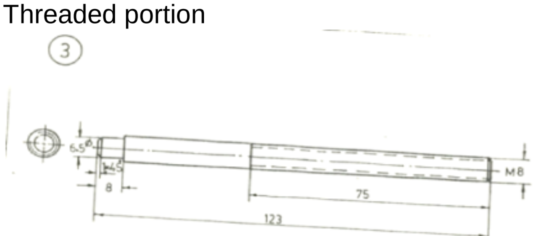
The distance between the two holes is 19.5mm. while the distance of the proximal hole to the end of plate is 14.5mm and that of the distal hole to the other end of plate is 6 mm. There is a hole of 6.5 mm diameter at proximal side of the plate for the entry of screw rod and the total distance which a screw rod enter into the plate is 8mm.

The thickness of the plate is 10mm, while the width is 16mm plain view while the dark lines drawn just below the hole shows threading inside the screw hole.

Pipe: The pipe slides in the screw rods. The total length of the pipe is 51mm. the inner diameter on which it is moving is 8mm and the outer diameter of the pipe is 10mm. the diagram shows its two different views.

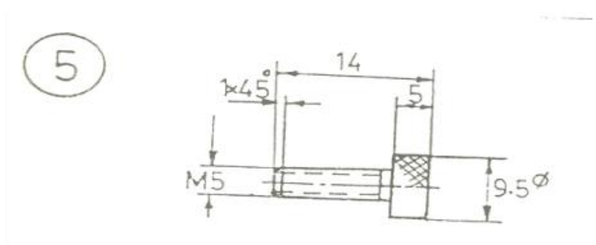


Screw rod: It has two parts A) Solid portion B) Threaded portion



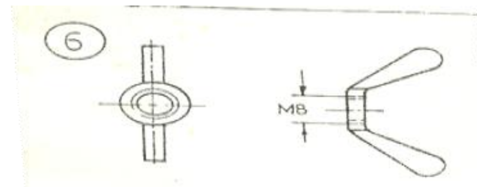
The total length of the rod is 123mm and that of the threaded portion is 75mm. the diameter of threaded portion is 8mm and of solid portion is 65mm. while the total length of screw which enter in plate is 8mm.

Screws: Total number of screws used in the fixator are four. The total length of the screws including the head portion is 14mm. while the length of the head of the screw is 5mm and the diameter of the head of the screw is 9.5mm. The threaded portion of the screw is 5mm in length while rest of the length is 9mm.



Fly nut: The diameter of the thread of fly nut is 8mm. which corresponds to the thread of the screw rod

The fig. shows both elevation and plain view..



Study of Biomechanical Strength of the Fixator and its Material: Now to see the Biomechanical strength of the fixator and its material. Physical and photoelectrical testing was done. The results are as follow:

Physical testing

a. Object; To determine the mechanical characteristics of a specimen loaded in torsion.

Apparatus.

Torsion testing machine, specimen, micrometer

METHOD;

We first measure the gauge length and diameter of the specimen. Then we mount the specimen in the torsion testing machine and after making the torque arm horizontal we started twisting the specimen by operating the straining head in one hand while on the other hand we note the reading of the torque and angle of twist at regular intervals till the specimen fracture. Following results were obtained.

Torque= T = G J Q/L

G = Sheer Modulus = 11.8 $=10^6$

J = Polar movement of Area = 11/32 = D^4 = 3.06 $=10^3$

Q = Angle of twist = 0.26 rad

T = 11.8 x 10^6 x 3.06 x 10^{-3}x 0.26 = 28,000 ft pound

(A) **Objective** = to determine the shape factor of a circular cross section cantilever beam (Bending force is –ve when material bend and loses its compressive force)

Apparatus Hanger. Dial bending gauge. When a material is subjected to pure binding force and bending movement is gradually increased a stage is reached when the extreme fibres just begin to yield. The movement corresponding to this situation is designated as the movement at first yield. When the bending movement is further increased plastic flow spreads towards the center of cross-section until at a certain value of the bending movement a plastic hings developed at the cross section. The bending movement corresponding to this situation is called the fully plastic movement.

In order to know the bending force we mounted the specimen in rig and applied load in the hanger and noted the reading on dial indicator. We increased the load gradually from initial five pounds till the specimen collapsed and calculated the force as follow.

Bending force

b = force per unit area

L- A = 3 x 10^6 -0.196sq meter=1.52x10^7 psi

B. **Tensile Strength**

Objective: To perform a tensile test in order to determine the mechanical properties of the material.

Apparatus Hounsfield Tensometer

1. 1st measure the gauge length and diameter of the specimen.
2. Set the reduction of Area – gauge at zero with the original diameter and increase in length is set at zero with original gauge length

After loading the specimen on tensometer we set the recording needle at zero on the graph. Axial loading was applied to the shaft with the movement of the handle. As the axial load is increased, increase in the original length and reduction in diameter was measured. With the movement of the handle, the needle moves on graph and autographic recording is made until the specimen fractured, we read different values graph which shows different properties of the material.

Yield Strength = 6y F/A

= 1400/II/4 $(D)^2$

= 60,000 Psi

Ultimate Tensile Strength = 6F =

$$= \frac{20,000}{II/4 \times (0.5432)^2}$$

= 86,000 Psi

Elongation = e

$$= \frac{Lf-Lo}{Lo}$$

Lo = Original length

Lf = Final length

$$= \frac{2.068 - 2.00}{2.00} = 3.4\%$$

$$\text{Reduction of Area} = \frac{Ao - Af}{Ao}$$

$$= \frac{(0.543)2 - (0.45)2}{(0.543)2}$$

= 31.3%

Photo elasticity: Photoelasticity is an experimental technique for the measurement of the stress and strain in a material object by means of the Phenomenon of mechanical bifringence. This method provides us a visual means of observing overall stress characteristic of an object by means of light pattern projected on screen.

We also tested our material by photo elasticity and noted that the result of this study were also similar to the results of physical testing study.

We reached to the conclusion that the biomechanical strength of the fixator and its material is satisfactory to meet the requirement of good external fixator which can be used effectively in high tibialosteotomy for the treatment of medial Compartment osteoarthritis of the knee joint.

DISCUSSION

The discussion about different methods of fixation after high tibial osteotomy started at the same time when Jackson 1958 and Coventry 1965 described the use of hightibial osteotomy in the treatment of medial compartment osteoarthritis of the knee joint.

The different methods of fixation described by different research workers are fixation with Plaster of Paris, Staples, stepped stables, A.O. Plates, T-Plates, L Plates, Semi-Tubular Plates, Locked Low Profile Plates, Angled Stabled Locking Bolt Fixation Plates and different types of external fixators, like Circular External Fixator, Illazarov's External Fixatror, Chanrley's External Fixators, A.O. External Fixators, Heidelberg Unilator Fixation system and Taylor Spatial Frame "Smith & Nephew" Dynamic External Fixators etc. The correct choice of Osteosynthesis is also very important. A stable osteosynthesis is the only mean by which the exact correction can be achieved and maintain long enough to allow bony union. It is the only method with the help of which we can start the range of movement exercises and functional use of extremity with early return to daily living activities immediately after reconstruction of anatomic condition. It also prevent the complications associated with prolong immobilization of extremity and also bed ridden complications common in this age group. In the aged stable osteotomy fixation might enhance the patient survival by allowing rapid return to function and avoiding strict bed rest. Another advantage of stable osteosynthsis is the fact that corrective osteotomy can be performed in the close proximity to the joint surface while retaining firm fixation of the short fragment (1 to 16).

The different methods have got different advantages and disadvantages over each other. In our society the socio economical aspect is the most importantand deciding element for surgery. So we designed a new fixator named A.Z. (Azhar's) Fixator which can fulfill majority of the requirements of stable fixation like cost effectiveness, easy to apply, promote early range of movement, early weight bearing, early return to daily living activities, promote early bone union and also correct and maintain the post operative corrections till solid union is achieved. It also prevents quadriceps wasting, joint stiffness, bed ridden complications like DVT, Pulmonary embolism, bed sores etc. and is patient friendly with respect to our socio economical conditions.

CONCLUSION/ RECOMMENDATIONS

So we reached to the conclusion that bio mechanical strength of the fixator, its material and design is satisfactory to meet the requirementsof a good external fixator and can be used safely in High Tibial Osteotomy in the treatment of medial compartment osteoarthritis of the knee joint having clear advantages and benefits to other types of external fixators.

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