MATERIAL AND METHOD
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The present study was conducted at the experimental research laboratory of M.L.B. Medical College, Jhansi.

Adult Rabbits, of genus oryxotologus, were chosen for the experiments. Rabbits were selected from weight groups ranging between 1.1 Kg and 1.3 Kg. All the experimental animals were fed on a standard diet during the whole period of experiment.

Composite plan of study

Experiments were performed on ninety animals divided in two groups of 45 each, after producing a closed fracture in mid-shaft of right tibia manually.

Group I - Immobilisation with percutaneous multiple pinning and then incorporating them in a plaster cast after closed reduction.

Group II - Immobilisation done by external fixation device after reduction and final adjustment of reduction done by adjusting the external fixator.

From each group nine animals were sacrificed every week, starting from the end of second week upto
ANIMAL RESEARCH LABORATORY OF M.L.B. MEDICAL COLLEGE JHANSI WHERE THIS STUDY WAS CONDUCTED

BASIC INSTRUMENTS NEEDED FOR THE STUDY
the end of six weeks. Every animal was subjected to clinical, macroscopic and radiological examination. Finally, the animals, sacrificed every week, were subdivided in groups of three, for the purpose of testing the mechanical strength of callus, as follows:

(a) Tensile strength - 3 specimen
(b) Compression strength - 3 specimen
(c) Angulatory strength - 3 specimen

<table>
<thead>
<tr>
<th>Period</th>
<th>No. of animals</th>
<th>Methods of study</th>
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<tbody>
<tr>
<td>2 week</td>
<td>9</td>
<td>Clinical 9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Radiological 9</td>
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<tr>
<td></td>
<td></td>
<td>Mechanical test</td>
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<td></td>
<td></td>
<td>(a) Tensile strength - 3</td>
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<td></td>
<td></td>
<td>(b) Compression strength - 3</td>
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<td></td>
<td></td>
<td>(c) Angulatory strength - 3</td>
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<tr>
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<td>(a) Tensile strength - 3</td>
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<td>(b) Compression strength - 3</td>
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<td></td>
<td></td>
<td>(c) Angulatory strength - 3</td>
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</tbody>
</table>
4 week 9
Clinical 9
Radiological 9
Mechanical test
(a) Tensile strength - 3
(b) Compression strength - 3
(c) Angularity strength - 3

5 week 9
Clinical 9
Radiological 9
Mechanical test
(a) Tensile strength - 3
(b) Compression strength - 3
(c) Angularity strength - 3

6 week 9
Clinical 9
Radiological 9
Mechanical test
(a) Tensile strength - 3
(b) Compression strength - 3
(c) Angularity strength - 3

Details of external fixator

The external fixator device, used in this study, was fabricated by Sharma and Sahu, 1984 and comprised of two threaded bars, one medial and one
A SCHEMATIC REPRESENTATION OF THE EXTERNAL FIXATOR
lateral. Each bar has two overriding sleeves, with an internal diameter corresponding to the external diameter of the bars, so as to allow to and fro movement of the sleeve over the bar but without any play. Through horizontal holes in these sleeves, the transfixed kirschner wires are held firmly with the help of vertical grub screws. Each sleeve can be fixed at any desired point by two nuts on each side of the sleeve. Compression or distraction of desired amount can be applied by properly tightening or loosening these nuts and thus forcing the sleeves to move in desired direction.

Prior to surgery whole of the external fixator, kirschner wires and other instruments were sterilised by autoclaving them alongwith the linen and dressing material etc.

DETAILS OF STUDY

1- **Fracturing the bone**:

The animals were anaesthetised by intravenous nembutal (25 mg/Kg body weight) and the mid shaft of the right tibia was fractured manually by applying angulatory force. The fracture was completely displaced,
2- Immobilization by external fixation:

(a) The fractured leg was shaved. Drapping was done in sterile sheets, after painting with savlon and spirit.

(b) The fracture was reduced manually, and then with the help of a special T-handle fitted with a chuck, a K wire was inserted transversely in the proximal fragment through both the cortices. Another K wire was inserted at a distance of approximately 1 cm (measured exactly by the distance of holes in the sleeve of external fixator). Care was taken to ensure that both the transfixing pins are parallel to each other and at a horizontal level. K wires used were of two sizes - .035 and .045.

(c) Similarly two Kirschner wires were passed through the distal fragment.

(d) Both the lateral and medial bars of the external fixator were applied to these K wires, which were passed through the horizontal holes in the sleeves moving on both the bars. The bars are kept as close to the leg as possible. The K wires were tightened by the grub screws on the sleeves.
(e) Necessary adjustments were made with the help of screws and nuts to achieve the maximum possible reduction of fragments clinically. While attempting reduction, nuts No. 2 and 3 were tightened away from the fracture site while nuts No. 1 and 4 were loosened. Once the reduction had been achieved compression at the fracture site was given by tightening the No. 1 and 4 nuts on both sides of the leg towards the fracture site. Compression applied was such, so as to cause slight bending of the transfixing K wires with concavity towards fracture site.

3- Immobilization by pins and plaster:

(a) The fractured leg was shaved. Painting and draping was done.

(b) As described above, four Kirschner wires were passed, two each in the proximal and distal fragments approximately one cm apart.

(c) The fracture was then reduced with the help of Kirschner wires and then the limb was plastered incorporating the K wires keeping the fragments in alignment as far as possible
with the help of an assistant. The knee and the ankle joints were left free and the excess wires jutting out of the plaster were cut with the help of a wire cutter.

4- Post operative care:

The animals which were immobilized by pins and plaster cast, a routine checkup of toes and foot was made. In a few animals initially there was swelling for one to two days which subsided after slitting the plaster throughout its length, slitted plasters were repaired just after the slitting, so that the position of fragments was not disturbed. No antibiotics was routinely used post operatively in any of the groups. However a few animals in both the groups who showed signs of pintract infection later on, were put on intramuscular antibiotic (Oxytetracycline 100 mg/day) and the response noted.

X-rays of the fractured limb taken (both A.P. and lateral or oblique views) immediately after the reduction and immobilization in both the groups, and the state of reduction, degree of displacement, angulation and overriding at the fracture site was noted.
MANUALLY FRACTURING THE BONE BY GIVING ANGULATORY FORCE AFTER ANAESTHETISING THE EXPERIMENTAL ANIMAL.
Introduction of K wire in the proximal fragment after fracturing the leg.

Introduction of second K wire
ALL THE FOUR K WIRES PASSED

A VIEW OF EXTERNAL FIXATOR AFTER APPLICATION
APPLICATION OF PLASTER INCORPORATING THE K WIRES IN EXPERIMENTAL ANIMALS OF GROUP A.
Methods of study:

The study was done under the following heads:

1- Clinical examination.
2- Radiological examination.
3- Gross or macroscopic examination.
4- Mechanical strength of callus:
   (a) Tensile strength
   (b) Strength on applying compression force.
   (c) Strength on applying angulatory force.

1- Clinical examination:

Animals were regularly assessed throughout the period of study. Behaviour of the animal and use of the fractured limb was observed. Complications like loosening and tightening of plaster, circulatory impairment, oedema, intolerance to plaster, signs of infection were noted. External fixation devices were also checked regularly for any loosening of screws or transfixing K wires. Range of movements at knee and ankle joints of the treated side was recorded by a goniometer before sacrificing the animal.

2- Macroscopic examination:

The animal was killed by a direct blow on the neck. The plaster or the external fixation device was
carefully removed and the length of the limb was measured. The bone was freed from all the soft tissue meticulously, so as not to disturb the position of the fragments and a naked eye examination was done.

Following points were noted:

(i) Presence of external callus - size and consistency.

(ii) Presence or absence of mobility at fracture site.

(iii) Displacement and angulation of fragments.

(iv) Evidences of infection at fracture site or pintract infection if any.

(v) Length of tibia.

(vi) Any other finding which was evident was also noted.

3- Radiological examination:

Initially routine post operative radiograph of the limbs were taken to check the reduction (Anteroposterior, lateral and/or oblique views).

Oblique views were taken when lateral view was not possible due to over lapping of external fixator.

Following points were noted:

(i) Amount of overriding.
(ii) Degree of side to side displacement.
(iii) Degree of angulation.

Second radiograph was taken of every specimen just before sacrificing the animal. Anteroposterior, lateral and/or oblique views were taken and again the amount of overriding, displacement and angulation were measured. Presence of radiologically visible callus as well as the visibility of fracture line was noted in the third radiograph of every specimen, which was taken after dissecting the bone out of the soft tissues carefully, without disturbing the position of fragments. Any evidence of infection at the fracture site or the pin tract infec-
tion at the fracture site or the pin tract infection was carefully sought for.

Various exposure factors, as well as dark room factors were kept constant throughout the study.

Exposure factors used were:

<table>
<thead>
<tr>
<th>1st X-ray</th>
<th>2nd X-ray</th>
<th>3rd X-ray</th>
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<tbody>
<tr>
<td>20 m.a.</td>
<td>20 m.a.</td>
<td>10 m.a.</td>
</tr>
<tr>
<td>0.5 Sec.</td>
<td>0.5 Sec.</td>
<td>0.5 Sec.</td>
</tr>
<tr>
<td>55 KV</td>
<td>55 KV</td>
<td>40 KV</td>
</tr>
<tr>
<td>36&quot; tube distance</td>
<td>36&quot; tube distance</td>
<td>36&quot; tube distance</td>
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</tbody>
</table>
Mechanical strength of callus:

Each experimental tibia was subjected for tests to measure the mechanical strength of callus which was tested under three heads:

(i) Tensile strength
(ii) Compression strength
(iii) Angulatory strength

Machine for testing the mechanical strength of callus:

Various tests to measure the mechanical strength of the callus were carried out on a specially designed testing apparatus.

The machine comprised of various adjustments for carrying out all the three components of the callus strength.

(a) Tensile strength = was measured by holding the bone vertically upwards in a specially designed clamp of the apparatus. Through another clamp a vertical distraction load is applied through a lever system. Finer adjustments in the load were achieved by a heavy rider mounted over the horizontal bar of the lever. The load was gradually increased till failure occurred at the fracture site. The total load at which the failure occurred was noted.
(b) **Compression strength** = amount of compression force to cause failure at fracture site was measured by holding the bone vertically upwards in the same specially designed clamp of the apparatus. Through another specially designed clamp a vertical compression force was applied over the bone. The load was gradually increased till failure occurred at the fracture site. The total load at which the failure occurred was noted.

(c) **Angulatory strength** = was measured by using bending loading configuration using one support and a single loading point. The bone was held horizontally in a specially designed clamp mounted over the vertical bar of the testing apparatus. This clamp was applied at a distance of 1 cm from the fracture site. Angulatory strength at the fracture site was produced by suspending weights vertically downwards over the bone at a point 1 cm away from the fracture site. Weights were gradually increased and the total weight needed to cause failure at the fracture site was noted. All these tests were carried out within two hours of dissecting out the bone so as to avoid any loss of water content of the bone and thus affecting the mechanical strength of the bone.
TESTING APPARATUS FOR TESTING THE MECHANICAL STRENGTH OF CALLUS.