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EXPERIMENTS WITH TWO METHODS OF FORMING PINS FOR TRANSFIXING FRACTURES OF THE LONG BONES IN LARGE ANIMALS*)

By

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When the long bones of large animals are transfixed with fibre-glass re-inforced plastic it is most important that the immobilization of the fracture is as complete as possible. The method of insertion and formation of the pins is important, as are the dimension and quality of the pins and the firmness of the bandage.

It was shown in an earlier work (*Hallström* 1965) that with different methods of insertion and formation of the pins, different stresses occurred when the bone was under load and that these stresses must not exceed the proportional limit of the pins, otherwise a lasting deformation ensued, resulting in a decreased immobilization of the fracture.

When the bone was under a load of 200 kg the proportional limit of the pins was not reached with one 3 mm pin in each fragment with parallel inserted *bent* pins. The proportional limit, was, however, certainly reached with *straight* pins inserted *parallel* or *crossed*. In practice, at least two pins are always used in each fragment. The pins must be firmly anchored in the bandage, otherwise sliding of the pins occurs easily. This anchorage is achieved by stop-nuts which are put on the pins and enclosed in the plastic.

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This paper describes investigations into the two methods of transfixing with: a) parallel bent pins and b) parallel straight pins. The experiments were designed to show differences in bone fragment movements as a result of deformation of the pins under varying loads and whether changes of bone and bandage occurred as a result of these loads.

MATERIAL AND METHODS

The making of the fracture bandage

Two metacarpal bones from a 5-year old cow were used in the experiments. The epiphyses of both bones were sawn off at right angles to the axis of the bone and the end surfaces were ground flat. The medullas were filled with plaster of Paris. A 12 mm diameter hole was drilled in the centre through the bones parallel with their longitudinal axis. The bones were sawn off in the middle and an 11 mm round rod inserted into the hole in each bone. In this way, fixation of the bone fragments was secured (in relation to each other), when the bandages were later applied.

The bone fragments were pulled apart about 30 mm and transfixed according to the following method:

In each fragment two parallel pins were inserted. These were 3 mm in diameter and 300 mm long (Sandvik steel 10R52). In one bone the shanks of the pins were bent at an angle of 45° proximally in the proximal and 45° distally in the distal fragment. In the other bone the pins were inserted and left straight. Four layers of fibre-glass re-inforced plastic (Plastic Padding) were put over the pins on one side of each bone at a distance of 15 mm from the bone. When hard, the pins on the other side were treated in a similar manner. The rods joining the bone fragments were then sawn off.

When the lateral and medial splints had hardened, three layers of circular plastic were put on each bone, aluminium stop-nuts, with an outer diameter of 15 mm, were put on each pin, pressed against the bandage, tightened and covered with plastic. Steel plates, 30 mm thick, were glued on the end surfaces of the bone. The diameter of these plates was less than the distance between the lateral and medial splints.

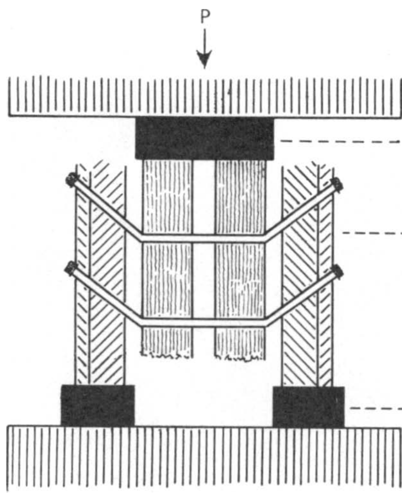


Figure 1. Method of testing bandage fragments.

*Experiment**)

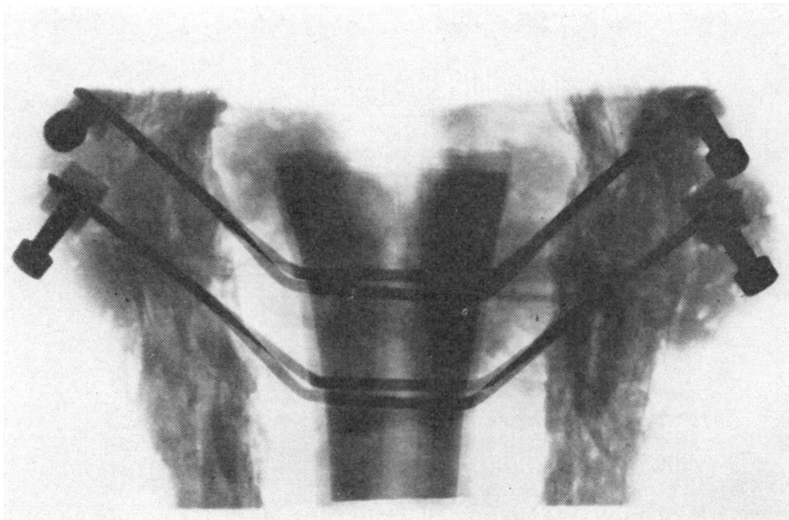
Before commencing the experiments, the two fracture bandages were cut in the middle producing four bandage fragments. These fragments were then placed between the pressure plates of the testing machine in turn (Fig. 1). The bone ends with the glued steel plates uppermost were placed under the upper pressure plate, whilst the bandages were stood on end on a steel plate laid on the lower pressure plate. This ensured that the bone did not touch the lower pressure plate when under load. The movements of the bone fragments as a function of the loads were recorded automatically on moving paper. The experiments were terminated when the bandages could no longer take an increase in load due to sliding of the pins in their stop-nuts.

The fragments were X-rayed before and after the experiments. Figs. 2, 3, 4 and 5 are double photographs showing the bone fragments before and after subjecting them to load.

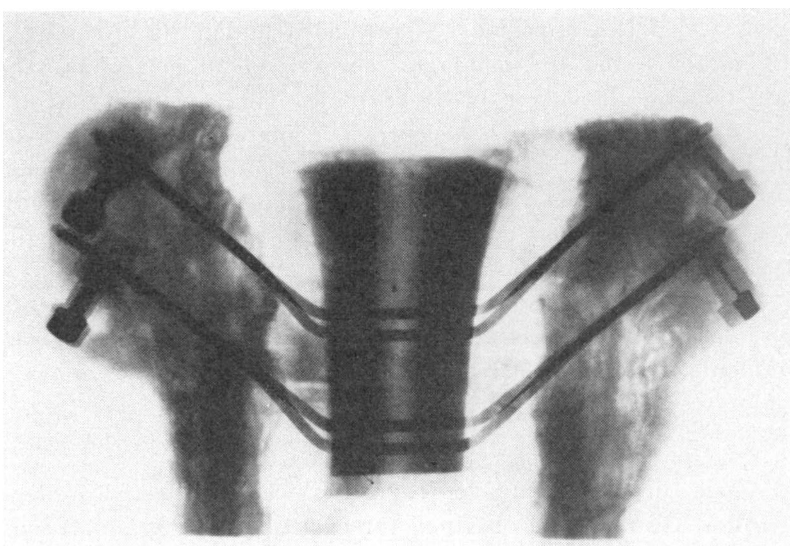
RESULTS

When the four bandage fragments were subjected to load accordant results were obtained for each method, A and B with bent pins and C and D with straight pins.

*) The experiments were performed at Institutionen för Hållfasthetslära, Tekniska Högskolan, Lund.



F i g u r e 2. Experiment A. Parallel inserted bent pins. The displacement of the bone fragment was 5 mm due to sliding of the pins. The experiment was stopped at 660 kg.



F i g u r e 3. Experiment B. Parallel inserted bent pins. The displacement of the bone fragment was 6 mm due to sliding of the pins. The experiment was stopped at 680 kg.

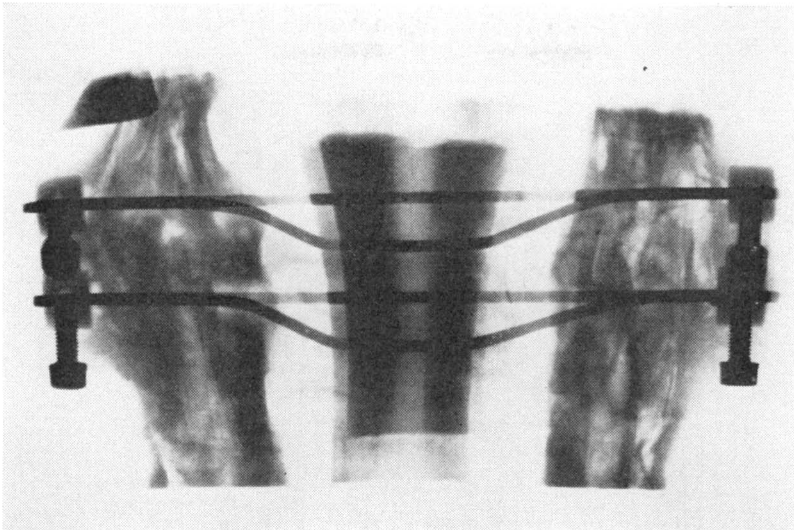


Figure 4. Experiment C. Parallel inserted straight pins. The displacement of the bone fragment was 13 mm due to deformation and sliding of the pins. The experiment was stopped at 700 kg.

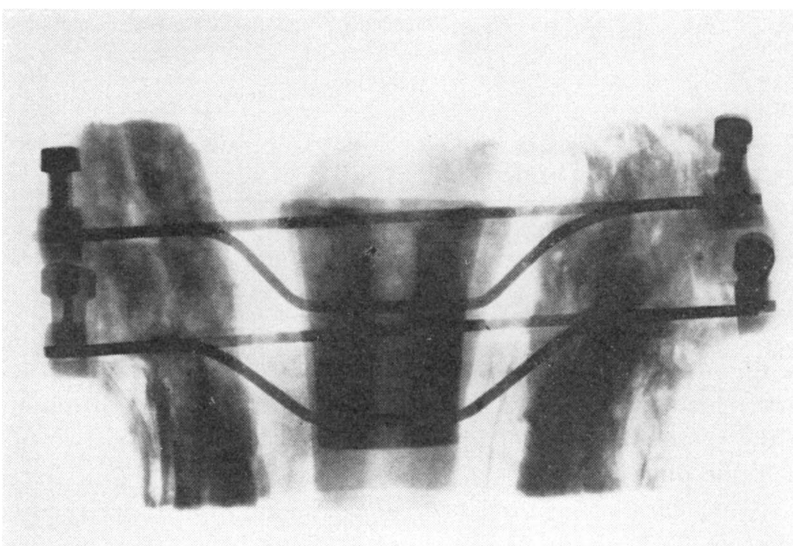


Figure 5. Experiment D. Parallel inserted straight pins. The displacement of the bone fragment was 24 mm due to deformation and sliding of the pins. The experiment was stopped at 960 kg.

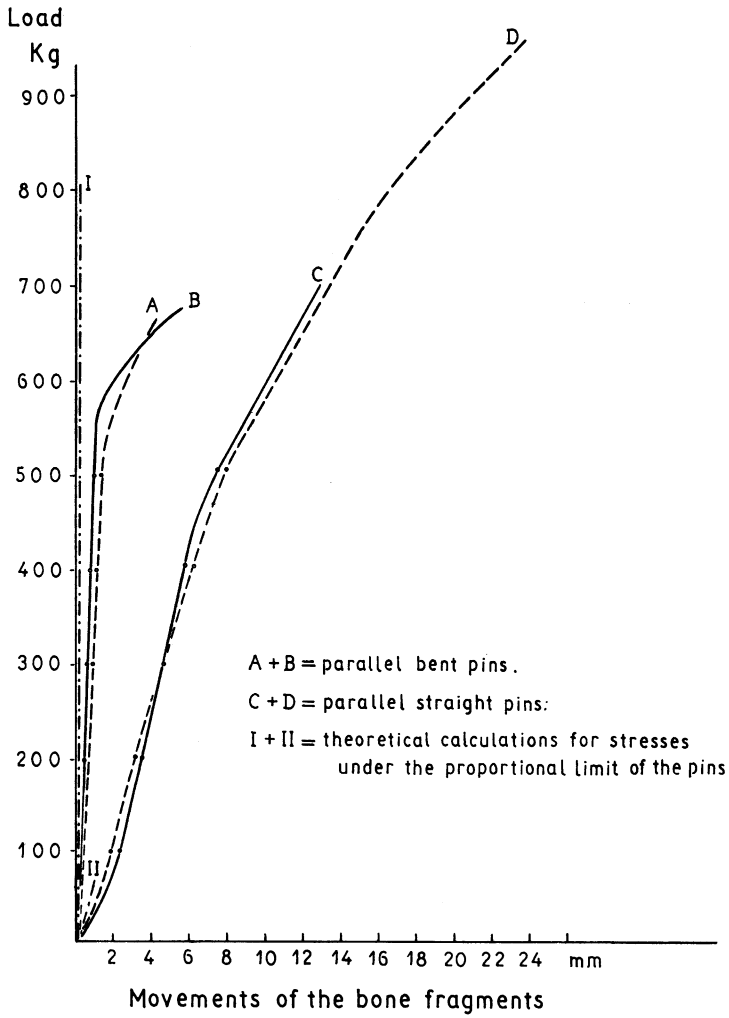


Fig. 6.

Fig. 6 shows the movement of the bone fragments in relation to the load applied and that there was a significant difference in the vertical displacement of the fragments using the two methods of pin formation.

Using parallel inserted *bent* pins, A and B, a direct relation between the load and the movement of the bone fragments was obtained up to 500 and 580 kg respectively. The displacement of the fragments was then about 1 mm. With increasing load, the deformation line began to curve due to sliding of the pins.

At about 670 kg the anchorage of the pins in the stop-nuts loosened (Figs. 2 and 3). The displacement was then about 6 mm.

With parallel inserted *straight* pins, C and D, a relatively straight relationship between load and movement was obtained up to 480 kg, the displacement was then about 7 mm. Above 480 kg, the deformation line started to curve, partly because of the pins bending due to cracking of the inner layers of the fibreglass bandage (Figs. 4 and 5), and partly because of the pins sliding. The anchorage of the pins loosened at 700 and 960 kg respectively when the displacement of the bone fragments was 13 and 24 mm. No visible damage to the bones was seen when the four samples were examined after the tests. The bandages showed no changes either (apart from the slight cracking mentioned earlier).

Table 1. Movements of the bone fragments at varying load. The values noted are approximate. For the whole fracture bandage, the movements are twice the values quoted.

Load, kg	Movements of the bone fragments, mm			
	Bent pins		Straight pins	
	A	B	C	D
100	0.2	0.2	2	2
200	0.4	0.4	4	4
300	0.5	0.5	5	5
400	0.7	0.7	6	6
500	1.0	0.8	7	8

DISCUSSION

The displacements obtained with each of the four half-fracture bandages represent half the value for a whole fractured bone. Normally, when a bone is under load, the pressure is transferred from the bone to the bandage proximal to the fracture and from the bandage to the bone distal to the fracture.

At a load of 500 kg the displacements of the bone fragments for the whole bone are about $2 \times 1 = 2$ mm with bent pins and about $2 \times 7 = 14$ mm with straight pins. At a load of 200 kg the corresponding displacements are about 0.8 and 8 mm respectively — the latter apparently 10 times greater. As a rule this load on an extremity might not be exceeded. The experiments show, however, that with bent pins a good immobilization of the fracture with a sufficient degree of safety is obtained, but that the immobilization is insufficient with straight pins.

The experiments also show that the anchorage of the pins is of considerably importance so that sliding does not occur. To prevent sliding, effective tightening of the stop-nuts is necessary. Cutting the pins 1—2 mm outside the stop-nuts, bending them towards the bandage and covering them with plastic might also help prevent sliding.

It will be seen from the above experiments that the anchorage of the pins loosened at a much smaller load when bent pins were used. This is due to the fact that nearly the whole load is carried by the stop-nuts, in contrast to the load being shared between the stop-nuts and the contact pressure between the pins and the bandage as is the case when straight pins are used.

The theoretical calculated displacements in Fig. 6 are lower than those obtained practically since the "ideal" condition is rarely obtained in practice.

ACKNOWLEDGMENT

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SUMMARY

The immobilization of fractures of the long bones in large animals after transfixation with fibre-glass re-inforced plastic bandages depends to a large extent on the method of forming the pins used to transfix the bones. The experiments described show a significant decrease in the displacement of bone fragments when parallel *bent* pins are used compared to that noted when parallel *straight* pins are used. The necessity of securely anchoring the pins in the bandage is also demonstrated. No damage to the bones was seen in any of the experiments. The bandage material showed complete firmness at all loads tested. The quality of the pins was such that no breakages occurred. Two 3 mm pins could be used in each fragment with complete safety and reliability.

ZUSAMMENFASSUNG

Versuch mit zwei verschiedenen Formen der Stifte bei Transfixierung von Röhrenknochenfrakturen grösseren Haustieren.

Bei Transfixierung von Röhrenknochenfrakturen bei grösseren Haustieren mit glasfaser-verstärktem Polyesterplast, ist die Immobilisierung der Fraktur von der Form der Stifte weitgehend abhängig. Bei den vorliegenden Versuchen mit parallel angebrachten *gebogenen* Stiften und parallel angebrachten *geraden* Stiften tritt ein deutlicher Unterschied in die Verschiebung der Bruchstücke auf. Mit gebogenen Stiften tritt eine erheblich geringere Verschiebung auf als mit geraden. Die Notwendigkeit einer sicheren Verankerung der Stifte in der Bandage wird unterstrichen. Schädigungen der Knochenteilstücke aufeinander werden nicht beobachtet. Das Bandagematerial erwies sich gegenüber Belastungen als vollständig zufriedenstellend. Bruch der Stifte trat nicht auf. Bei der verwendeten Qualität empfielt sich die Anwendung von zwei 3 mm Stiften pro Fragment.

SAMMANFATTNING

Försök med två utformningssätt av stift vid transfixering av rörbensfrakturer hos större husdjur.

Vid transfixering med glasfiberarmerad polyesterplast av rörbensfrakturer hos större husdjur är immobiliseringen av frakturen i hög grad beroende på stiftens utformningssätt. I föreliggande försök med parallellt införda *bockade* stift och parallellt införda *raka* stift synes en uttalad differens i förskjutning av benfragmenten. Med bockade stift erhålles en avsevärt mindre förskjutning av dessa än med raka stift. Nödvändigheten av en säker förankring av stiften i bandaget belyses klart. Skador på benen i form av kanttryck kunde ej iakttagas. Bandageringsmaterialet visade fullständig hållfasthet vid belastningarna. Stiftbrott uppstod ej i något fall. Med den använda stiftkvaliteten kan två 3 mm stift användas i varje fragment.

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