

In old un-united fractures I have preferred up to the present time the long open incision and the use of Lane plates or wiring, for the reason that the ends of bones in such fractures usually need to be freshened. In selected cases of old un-united fractures I shall later experiment with dowel-pins, adding the resource of Bier (blood injection), but suitable cases for this experiment have not as yet been found in my clinic.

In cases in which we have interposed tissue, as for instance, in fractures of the patella, the dowel-pin will not be a proper resource, but it promises to have a field of usefulness in our every-day work.

The time for using the dowel-pin is ordinarily five or six days after the receipt of a fracture. At this time if we have used splints or extension apparatus, or both, exudates have undergone partial absorption, and the area is protected against infection by an established local hyperleukocytosis.

Just as this article is ready for the press, Dr. Kast suggests that accidents due to observing fracture sites from one point of view only, may be avoided by employing two x-ray tubes simultaneously, placing them at points which allow a view of fragments from two directions, without the necessity for changing the position of a fractured limb.

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EXPERIMENTAL AND CLINICAL WORK TO DETERMINE THE VALUE OF LANE'S BONE PLATING *

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A visit to Mr. Lane's clinic at Guy's Hospital inspired an inquiry into the practical utility of the traction appliance, one of the most ingenious mechanical procedures which has ever been adapted to surgical therapeutics. In pursuit thereof, thirty-four screws, about half of them infected, were driven into the long pipe bones of dogs, and withdrawn at intervals, varying from one hour to seventy-one days, to determine the force needed to dislodge them, it being presumed that our surgical interest in most fractures does or should cease in ten weeks if all goes well.

In addition fifty-two patients were operated on, at periods ranging from a few hours to eight months after the injury. A critical study of the results is undertaken after a lapse of from five weeks to one year, respectively.

REPORT OF EXPERIMENTS

EXPERIMENT 1.—Immediate withdrawal, small dog, March 18, 1911. No. 3 $\frac{3}{8}$ -inch screws.

	Pounds
Left femur.....	75
Right femur.....	74
Right humerus.....	78
Left humerus.....	90
Average	79 $\frac{1}{4}$

This animal died under the anesthetic, hence simply a preliminary test of resistance to withdrawal was made. The bones averaged about 1 cm. in diameter and the cortex about

* Read in the Section on Surgery of the American Medical Association, at the Sixty-Second Annual Session, held at Los Angeles, June, 1911.

* Because of the space that would be required, the case reports are here omitted, but the complete article appears in the Transactions of the Section, and also in the authors' reprints, a copy of which will be sent by the authors or by THE JOURNAL on receipt of a stamped and addressed envelope.

* Experimental part from Surgical Department of Washington University. Clinical part from St. Louis City Hospital.

2 mm. in thickness. I am indebted to Dr. Erlanger for suggesting a self-registering spring-balance which was used in this and all succeeding experiments.

EXPERIMENT 2.—Two days. Infected April 29, 1911. One No. 3, $\frac{3}{8}$ -inch screw in each femur and humerus. Medium-sized yellow dog. Tumor on lower jaw. No attention paid to asepsis; wounds not sewed up. Died May 1.

Dr. Garrey helped withdraw the screws with direct forceps, etc. Stinking yellow pus in each wound; peritoneum dissected by it extensively.

	Pounds
Left humerus.....	44
Right humerus.....	10
Left femur.....	40
Right femur.....	42
Average	34

Pulled with double wedge forceps may make result too low and not wholly the consequence of infection. It would seem early for screws to loosen.

EXPERIMENT 3.—Ten days. March 18, 1911. Small, white mottled bitch. One, $\frac{3}{8}$ -inch, No. 3 screw in each femur and humerus. All wounds aseptic and sutured. Brand No. "1." Right ham.

March 31, 1911: Withdrawn after death, three days ago.

	Pounds
Right femur.....	42
Left femur.....	80
Right humerus.....	75
Left humerus.....	100*
Average	74 $\frac{1}{4}$

* Wire broke.

All wounds aseptic, healed.

EXPERIMENT 4.—Twenty-seven days. April 22, 1911. Small, 4-pound grey bitch. One slit in each ear; without any asepsis; wounds left open. Six No. 3 screws, $\frac{3}{8}$ -inch long were driven in both humeri and femurs; one right radius, also one left tibia. May 19, killed by chloroform.

Original	Control
42 right humerus	44 (infected)
6 left humerus	66 (infected)
42 right femur	66 (clean)
58 left femur	76 (clean)
37 average	63 average

Radius and tibia not drawn.

Right humerus, skin healed. Granulation tissue around screw-head. Cortex absorbed (in bottle).

Left radius, open granulating wound, cortex absorbed on near side. Screw perforated bone through cortex of opposite side. No lesion on far side (bottle).

Right radius, skin healed, pus and granulation tissue around screw-head. Some absorption of cortex (bottle).

All bones on front leg showed great thickening of bone about absorption locus.

Right femur, healed, normal appearance.

Left femur, bone appearance normal.

Left humerus, granulating wound open; cortex absorbed. Screw pulled at 6 pounds, caught in cortex of one side only. Control-bone broke at lesion without pulling screw, 66 pounds.

Thickness of cortex, 1.5 mm.

Average diameter of bones, 7 mm.

EXPERIMENT 5.—Forty-two days. April 11, 1911. Largest black dog, weight 66 pounds. No. 3 screws, $\frac{3}{8}$ -inch in each femur, humerus, ulna and tibia, 8 screws in all. Killed May 23, 1911.

Original	Control
75 R. humerus	90
120 L. humerus	180 (fail)
106 R. femur	
136 L. femur	Thickening to level of head
160 R. radius	115 granulations
82 L. radius	142
150 R. tibia	
L. tibia	131 $\frac{1}{4}$ average
127 average	

All wounds healed by first intention. Left tibia preserved to show screw-head embedded under tendon in fibroma, size of small marble. Around screw in left femur thickening to level of head. In left radius, evidently an infection. Granulations, absorption of cortex around screw and thickening of adjacent bone.

EXPERIMENT 6.—Sixty days. March 25, 1911. Brand III. Yellow bitch, weight 15 pounds. A screw in each femur and humerus, No. 3, $\frac{3}{8}$ -inch. Killed May 24, 1911.

Original	Control
57 R. femur	68 bone broken at normal hole
60 L. femur	69
96 R. humerus	63
110 L. humerus	48 granulations (Path)
80 $\frac{1}{4}$ average	62 average

All wounds healed clean, screws bright. Bones (three) look as if screws had just been inserted (except left humerus). In left humerus slight osteoporosis around screw, and cortex elevated in ring surrounding it (slight). Left humerus to pathologist.

Original at sixty days pulled higher than controls.

EXPERIMENT 7.—Seventy-one days. March 21, 1911. In each femur and humerus one screw, size No. 3, $\frac{3}{8}$ -inch. Smallest Lane drill. Brand "11," right ham. Killed May 31, 1911.

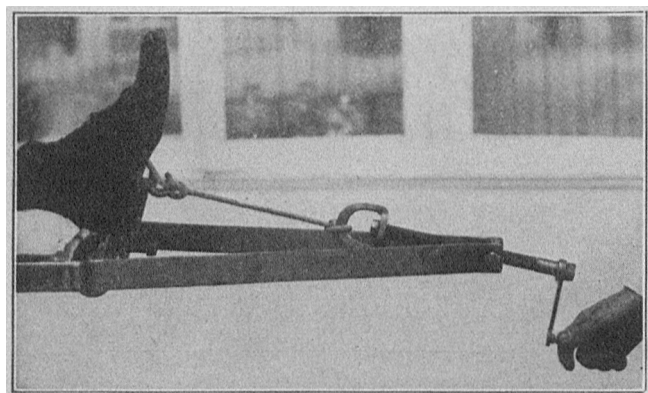


Fig. 1.—Traction appliance attached to table and in use.

Original	Control	Diameter mm.
100 R. femur	88	9
0 L. femur	112	11
130 R. humerus	128	9
125 L. humerus	110	
118 $\frac{1}{3}$ average	109 $\frac{1}{2}$ average	

All skin wounds healed.

All except left femur looked as if screws had been freshly driven. Screws bright; contour of bone unaltered. Left femur infected, granulations, osteoporosis, thickening. Average thickness of cortex, 2 mm. Average diameter of bone, 10 mm.—1 cm. Screws are 1 cm. long. Dog smaller than average used.

An average pull of 95 $\frac{4}{5}$ pounds is required to dislodge clean No. 3, $\frac{3}{8}$ -inch screws, from dog bones with average cortex of 2 mm. after they have been in place from one day to seventy-one days. On the other hand 41 $\frac{7}{9}$ pounds will accomplish the same thing with infected screws. There was but one exception to this rule; here it required 110 pounds at sixty days to withdraw an infected screw, when the average of controls on this dog was but 62 pounds. In the dog the skin heals in a few weeks over the infected screw, but this has little effect in the tractive force required to dislodge it. An interesting phenomenon is the constant absorption of bone cortex around infected screws and a thickening around this area. Often the screw-head was almost

hidden completely, so in one instance, apparently. Nature takes good care of an infected foreign body in dogs.

We are indebted to Drs. Opie and Smith for microscopic study of several bones in which screws had been driven and extracted. In Experiment 4, the left humerus presented an absorption locus around the screw and surrounding this crater there was an elevated ring. This latter proved to be young bone with osteoblasts to be seen in many fields. Osteoblasts were determined in the area where absorption was taking place and a diffuse infiltration of lymphocytes marked the tissue surrounding which was apparently the defect made by the screw. The left humerus in Experiment 6 presented practically the same microscopic picture in every particular.

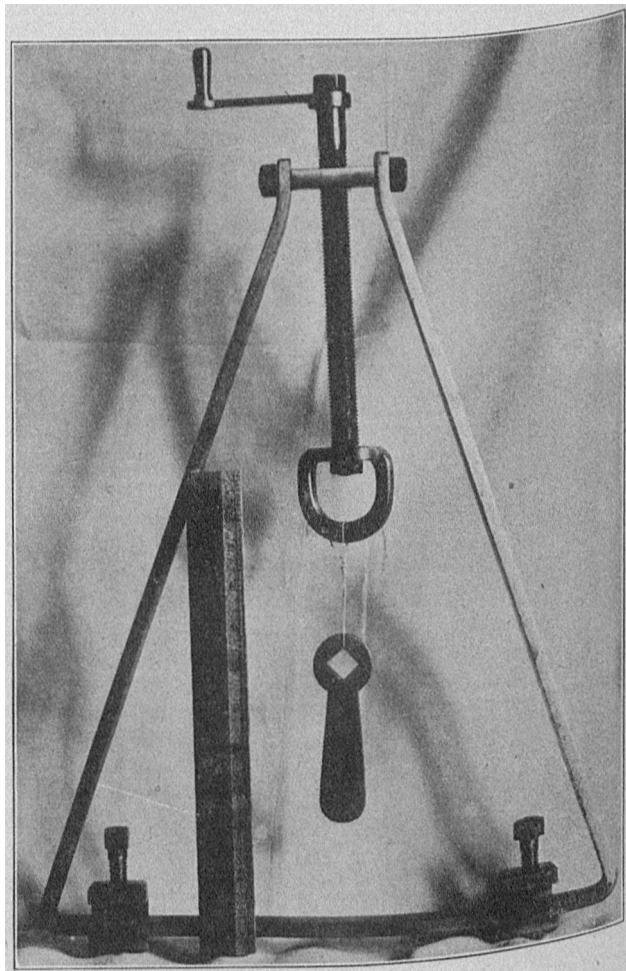


Fig. 2.—Traction appliance in detail.

A clean screw and the bone in which it is imbedded look just the same whether viewed when inserted or seventy-one days later. In other words, no macroscopic reaction occurs unless infection takes place.

It is of more than passing interest to note that clean screws, which have lain in bone for more than sixty days, required, in these experiments at least, more traction for their dislodgement than did their controls. If the same experience is had with the human subject, it is not devoid of interest so far as fractures are concerned in which union is delayed beyond the usual period. As stated above, a pull of more than ninety-five pounds was required to withdraw the average clean screw of No. 3 gauge, from bones of about 2 mm. cortex. Now, the corresponding human bones have a much

thicker cortex; moreover, we use No. 5 and No. 7 screws which are much larger in every dimension, to say nothing of the fact that as many as ten of them are imbedded at one time. It does not require much mental effort to picture the great amount of force needed to tear such a plate out of an aseptic wound at any time in its history, provided only it has been correctly applied; viz., by means of a drill the size of the screw barrel with the screw threaded to its head.

Of course, we take into consideration only a direct pull on the screws. As to leverage sufficient to break a plate or tear out a screw, that is quite another matter; it is for this that splints are used. Since not an infected screw dropped out in all my experimental work, it stands to reason that it is some external influence which

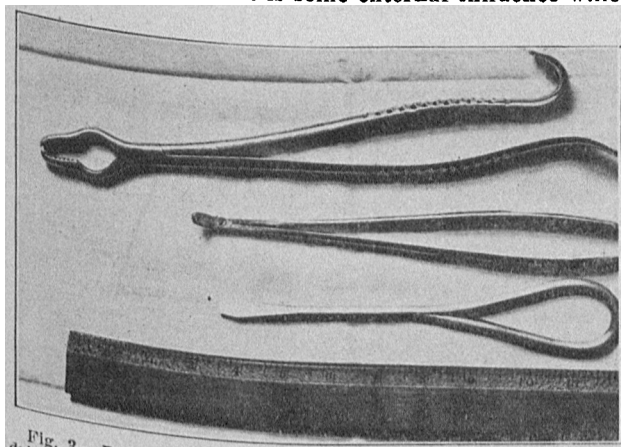


Fig. 3.—Bone forceps (Lane's), screw-holder (Lane's) and screw-driver.

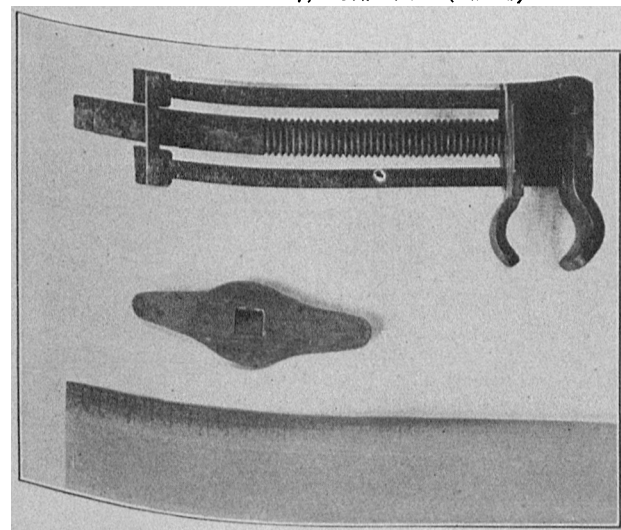


Fig. 4.—Embracing instrument.

loosens them in the human subject when infected. No doubt, this is the leverage exerted by the fragments which are not kept immobile long enough for healing to take place in the presence of a foreign body, as one experience with compound fractures has shown to be possible in certain instances.

CLINICAL DATA

At the end of this article* will be found the full histories of our fifty-two patients. We are unable to trace twenty-three from the time they left the hospital, and one is too recent to be of value; thus, we have for final study twenty-eight end-results.

* See footnote at beginning of the article.

Forty-three wounds healed by first intention, five were infected, one was left open to granulate, and in three instances, the history makes no mention of this feature. Only three of the above infections were in clean cases.

A solid union was obtained in twenty-five cases; non-union resulted once; two patients have died, and one operation was performed only five weeks ago.

Eight plates were removed; five of them being in simple fractures. One had compressed the musculo-spinal nerve; one occasioned a refracture (Case 11), one was infected at the time of operation, but as to indications for removal of the other two, we are not certain, since we did not take them out.

Five of these fractures were compound; two of them healed by first intention; two were infected; one granulated over the plate and went on to complete healing. Three of them got solid union, and in three the plate had to be removed.

There was a fatal result in two instances:

Patient 2, a chronic alcoholic, died of pneumonia, eight days after a fractured clavicle was plated. This case was badly chosen.

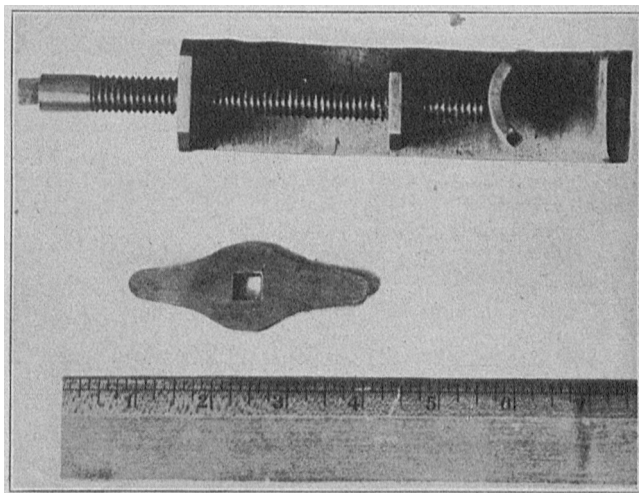


Fig. 5.—Embracing instrument.

Patient 5, another chronic alcoholic, managed to obtain whiskey from a friend a few days after the operation, became intoxicated, developed delirium tremens, saturated a thigh dressing with urine and feces, became infected and died on the fifteenth day.

This gives us a mortality of 3.84 per cent., which is not to be treated lightly where the operation is done for cosmetic or functional impairment alone.

We regret that we cannot give ultimate details in more cases. By letter, personal calls, etc., every effort to follow our patients was made, but many of them were "floaters," who had no permanent address.

If then, these statistics leave something to be desired, it must be remembered that most of these were cases picked as being too difficult for other forms of treatment, and that our city hospital patients are frequently poorly nourished and of the worst possible habits. In private practice one of us traced all his eight cases. Every patient got first intention, also solid bone union with perfect functional result. (W. B.)

Our city hospital is a training-school for doctors, hence the possibility of infection is greater. Doctors and nurses change, misunderstandings as to splints and

dressings occur and hence a method gets an unusually severe test, to say the least.

A refracture which occurred in Case 11, after plating, is of singular interest. Seventeen days after his humerus had been plated, this patient took off his dressing, swung his arm free, and something snapped. On a second operation, the three screws in the upper fragment were as they had been left, while the remaining three held firmly a triangular fragment of bone which they had torn out of the lower half of the shaft. No 11 is really not a plating case at all. We failed to make a plate hold here; the case is included merely for its allied interest.

Cases 13, 14 and 16 are interesting from the fact that all three illustrate successful surgical treatment of greatly impaired musculospiral nerves. Surely this is an argument in favor of the method at times.

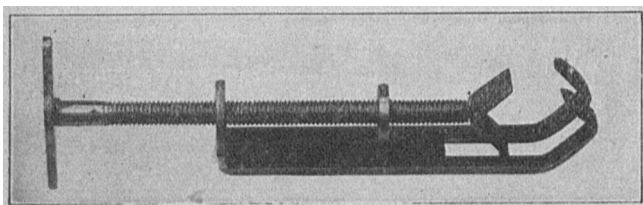


Fig. 6.—Embracing Instrument.

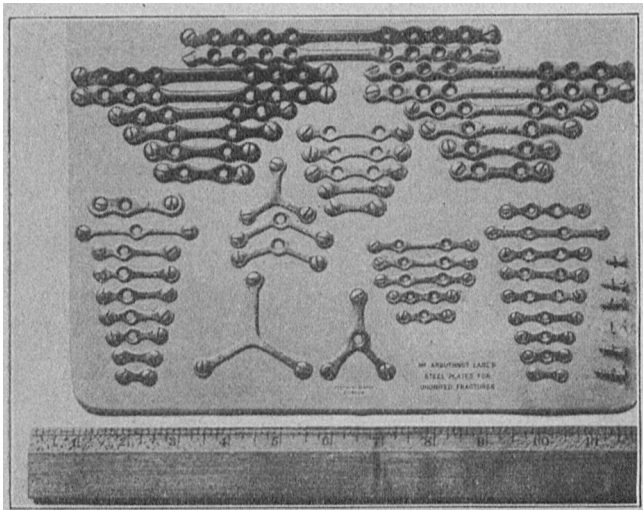


Fig. 7.—Lane's bone plates.

Case 24 will repay a perusal in its entirety. Here the ulnar nerve was sutured, the ulnar artery ligated, a number of tendons sutured, the ulna plated and other structures partially approximated in a compound injury; all these processes were accomplished with an ideal result.

A rather extensive operation was done on Patient 28. After plating an oblique fracture of the tibia, we did the same thing for a fibula which was broken in two places with a 2-inch fragment disposed at right angles to the axis. As a result, both wounds healed promptly and the man now does hard work on foot all day long.

Patient 36 was carrying trunks for a living—if his statement is to be believed—six weeks after we had plated a spiral fracture of the tibia, also a double one of the lower end of the fibula.

No amount of abstract reasoning can govern every case. Merely an effort is made here to show what our experience would indicate regarding a choice between forms of treatment.

OPEN	GENERAL ANESTHESIA	CLOSED
Always used, fairly long.		Often used, short.
INFECTION		
Can almost certainly be prevented in clean case by modern technic.		Not to be reckoned with.
DISABILITY		
Much shortened, especially in lower extremity. Of great importance to wage-earners and the aged; more so in summer.		Much longer, especially if an oblique fracture and if extension is required.
NON-UNION		
Preventable as far as interposition on tissues is concerned.		Interposition of soft tissues apparently a common cause.
ANATOMIC		
Perfect if primary healing.		Rarely perfect, often deforming.
FUNCTIONAL		
Perfect, provided primary healing is secured.		Often better than anatomic would lead one to expect.

If we heard Mr. Lane aright, he told us in London, last summer, that he plates every case. It is our opinion, however, that the surgical world will never be quite so radical.

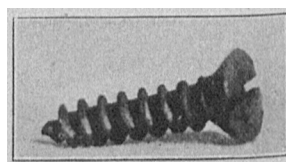


Fig. 8.—Lane's screw.

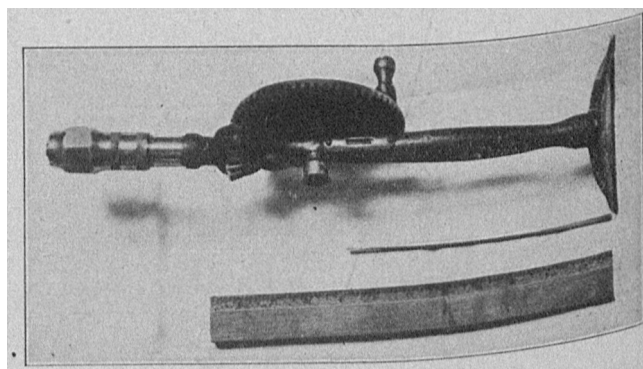


Fig. 9.—Drill-press and drill.

We try to get a result by the closed method in any fracture of any bone that can be placed and held in accurate position as shown by x-rays. Lane's treatment is never applicable to one who is a bad operative risk. No consideration of function can offset a risk to life.

Lane's plating is the best form of treatment known to us, for non-union or mal-union, and is indicated in all fractures which cannot be readily kept in place. It cannot, however, be recommended as a harmless procedure in the hands of surgeons generally. It is something of a specialty and requires its own extensive armamentarium; at the same time it will tax the mechanical resourcefulness of the best operator.

We advise waiting a few days before operating, or until the initial shock is past, bleeding has ceased, and a wall of granulation tissue partially protects from infection.

For a leg fracture not too near the ankle, traction to any degree required can be obtained and the force rather evenly distributed by applying it at the heel of the

patient's shoe. A lace-shoe large enough to permit of free dorsal padding is used after a "screw-eye" has been driven through the mid-line just in front of the heel and anchored in a thin steel plate similar to an insole (Fig. 1). Our traction appliance is shown in Figure 2.

Make an incision that reaches the bone by the most direct route, which permits important vessels and nerves to be avoided. Where there is over-riding, the incision does not have to be as long as one would suppose, since traction lengthens it markedly. None but the most rigid asepsis can avail here. The skin is covered with towels, clamped to its cut edge. No fingers go into wounds and no instruments that have been touched are allowed to come in contact with exposed tissues. All needles and threads are handled with forceps, threads being mildly antiseptic.

Long-handled instruments permit of great leverage; they also enable an operator to work without danger of a hand getting into the wound. Figure 3 depicts Lane's bone forceps and screw holder, together with our own simple screw driver which any mechanic can make.

One need not concern oneself about periosteum; in fresh cases the work will be done within this envelope, but where the operation is undertaken for deformity or non-union at remote date, the periosteum is not likely to be opened. In any event, one should hug the bone and handle the soft parts as gently as possible.

It will often be found when the fragments are exposed that the *x*-ray is not an infallible guide. We occasionally met with a double fracture when the *x*-ray showed but one, and were frequently surprised in other ways.

In a recent fracture, over-traction is exerted until the ends of the fragments are separated by $\frac{1}{4}$ to $\frac{1}{2}$ inch, after which one of the embracing instruments shown in Figures 4, 5 and 6, is applied. This lines up and guides them as the tension is relieved, with the effect that all spiculae are forced to dovetail by muscular traction so perfectly that the break can hardly be seen. The "embracer" holds a Lane plate of the desired size which can now be screwed in at leisure.

This technic reduces the difficulties of the procedure to a degree which can be greatly appreciated by the operator, who has done this work with merely the armamentarium advertized as Lane's outfit, and especially appreciated by one who has attempted it with the instruments used in general bone work.

Another value of an embracing instrument is strikingly shown in two cases in which Dr. Carson, head of the department of surgery, recently operated. After applying the Martin instrument, he simply packed the wounds and allowed them to granulate. They healed within the usual time and both patients were discharged from the hospital with solid bony union. In a personal communication, Dr. Carson assures us that no harm was done to the bone by the long-continued pressure of the metal clamp.

We use Jessup tool steel and have many plates made to fit a given injury, after the *x*-ray picture has been seen. Mr. Lane's own set of patterns is shown in Figure 7. Plates of Jessup English steel can be molded during the operation to a bony inequality by heating in the flame, bending as desired, and then cooled gradually by dipping end-wise into boiling water, after which they are ready for air or fluid of any temperature.

Mr. Lane long ago called attention to the importance of using screws threaded to the head, as in Figure 8, and drills of the same diameter as the stem of the screw,

the flanges being made thus to cut their own way into the cortex. These rather obvious mechanical principles have not been universally followed, and the results of such a neglect can be imagined.

The long drills used by us and the simple but effective mechanic's "press" used to drive them are shown in Figure 9. A screw may turn in its socket when a dull drill burns the bone; we have wrapped wire or silk-worm around bone and plate in a few such cases with satisfactory results.

Wounds must be entirely dry before they are closed; this makes the use of a drain superfluous in clean cases, if, indeed, its use be not a menace to primary healing. Every tissue plane must be accurately reunited by layer sutures until the surface is reached.

The ideal skin closure is made with subcuticular suture of catgut, after which no change of dressing is recommended until the patient is discharged at the end of several weeks. Immobilization is required for as long a time as would be the case if no open operation had been done. We like to use plaster of Paris, though in many instances board or metal splints have been applied for a few days until swelling has subsided.

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THIRTY YEARS' EXPERIENCE WITH FRACTURES AT MINNEQUA HOSPITAL: TREATMENT AND RESULTS*

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No attempt will be made to cover the field of fractures, but this paper will briefly state how we deal with fractures at the camps, plants, and hospital of the Colorado Fuel and Iron Company which employs from 15,000 to 17,000 men; including their families, about 80,000 individuals are to be cared for medically, a task made none the easier by their speaking forty-seven languages, and by the fact that not a few understand no English.

In the period above mentioned, 11,035 fractures have been treated by us. Many of our camps are located several hundred miles from the hospital.

A patient is prepared in the following manner for transportation:

SOFT PARTS

Contusion: Application of cold or wet dressings.

Slight lacerations: Dry sterile gauze dressings.

More extensive lacerations: Meddlesome cleansing avoided. Application of wet mercuric bichlorid, diluted alcohol, normal salt or 2 per cent. solution of iodine.

The covering of a wound with dry powder or closing it without free drainage is discouraged. Iodoform and other disagreeable dressings are strongly tabooed. The patient suffers enough from his injury without being made an object of disgust to fellow passengers en route. The well may tolerate or become indifferent to offensive odors, but the sick are distressed.

HARD PARTS

1. Wrap leg in plain cotton, bandaging very loosely with roller bandage, using simply enough to hold the cotton in place.

2. Elevate the leg for convenience of applying bandage. The leg should be extended and steadied by assistant making traction on foot. The leg should now be encased. Plaster-of-Paris bandage is the simplest method of applying plaster.

* Read in the Section on Surgery of the American Medical Association, at the Sixty-Second Annual Session, held at Los Angeles, June, 1911.