THE USE OF COMPRESSION TECHNIQUES IN THE TREATMENT OF FRACTURES

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Having perfected something—let us improve it.

The concept of the internal fixation of fractures is not new and the serious criticisms that have been levelled at it retain their basic significance. However, progress in the fields of asepsis, metallurgy, operative procedure and post-operative care have diminished some of the problems and it is a healthy exercise at any time to reappraise the integrity of surgical teaching and custom. If, with suitable management, primary healing can be obtained, there can be advantage from internal fixation on mechanical grounds. There are well known arguments for and against open operation for closed fractures. Suitable conservative care will cause most fractures to unite in time, but may cause the patient to endure certain unpleasant sequelae. In some cases there follows permanent disability such as shortening, deformity, joint stiffness and circulatory difficulties. Alternatively, it is recognised that to introduce infection into a previously closed fracture is a disaster.

The proposition is not new and is a familiar one. Indeed, if one reads Arbuthnot Lane's paper written in 1894, one realises that so much of modern thinking is an inadvertent repetition of old thinking. Lane was most concerned about the secondary effects of fractures on joints, concluding that they were "unable to carry out their physiological function with the same accuracy and perfection that they did previous to the accident".

In advocating operation he declared that certain advantages followed which are the advantages we still seek and hope, by more exact methods, to obtain.

It is not my intention to become too involved with this argument but I wish to report early impressions of a technique which is attracting increasing attention in Europe.

This began early in 1958 in Switzerland, where a group of fifteen Swiss surgeons joined together, as an Association (AO), to examine the common procedures then in use for the treatment of fractures. As a consequence, they agreed upon a system of fixation which they all now use. They have critically examined the experiences of the last half century and re-evaluated the basic principles which they insist should govern the operative treatment of fractures. They agree that modern fracture treatment must consider the functional recovery of the limb as a whole, not simply emphasize the bone lesion, and that internal fixation can only be satisfactory when the fracture is mechanically controlled so that active function may be recovered at the earliest moment after surgery. Hicks (1959), from Birmingham, drew attention to the superior results which follow rigid plating, but this was achieved largely through increasing the size of the plates, to which considerations of bulk and wound closure set obvious limits. He said that the hitherto unsuspected cause of stiffness is low amplitude movement at the fracture site and set out to show that splintage used merely to prevent visible deformity should be regarded as very low standard fixation, which may attract much of the criticism levelled at the concept of fixation in general.

THE SWISS (AO) METHOD

The Swiss (AO) have designed a set of tools and devices to facilitate operative fixation in which stability is enhanced by two compression techniques to which we will turn in more detail later. They say that the open treatment of fractures is a valuable but difficult method which involves much responsibility and cannot advise too strongly against internal fixation carried out inadequately. They first aim to achieve a precise reduction, particularly of articular surfaces, which are rebuilt first and if necessary underpinned by packing in cancellous bone. All small fragments are fitted into place as the fracture is temporarily secured with cerclage wires, clamps or Kirschner wires.

It is a well known argument that one does not require a perfect reduction to achieve a good result, but an architect, engineer or anyone who deals with mechanical stress will support the case for reduction (Fig. 1). Measurements of

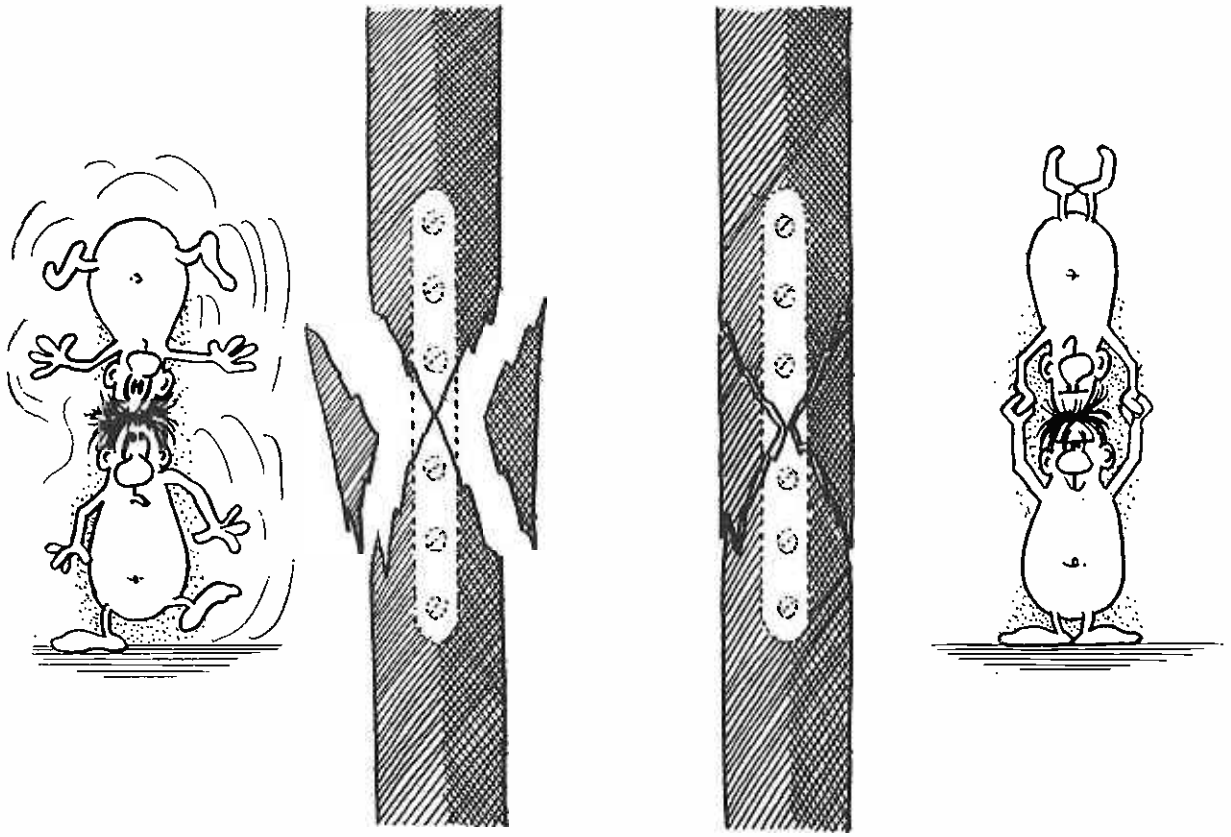

Fig. 1.

movements taking place in fractures show that ordinary plates and nails do not provide good rigidity unless they receive considerable assistance from the inherent stability of the fracture.

The operation requires time and deliberation. Gentleness is stressed at all times, using fine instruments, suckers rather than gauze and only the finest nylon or polythene sutures. All wounds are generously drained. The bone is not peeled like a banana but the plates put over the periosteum. If it is necessary to incise the periosteum to examine the fracture line, it is cut in the line of fracture and disturbed as little as possible. The reduction is secured by plates, screws or intramedullary nails, using a technique aimed at abolishing all movement at the fracture site (Figs. 2, 3 & 4). It is desirable that the stability of the fragments should be sufficient to prevent movement of even microscopic degree until consolidation has taken place. It must be so rigid that painless active movements can be continued during the period of convalescence, without endangering bony healing and without producing visible callus formation.

The plates used are of stainless steel and are robust, straight and slightly cambered. There are, in addition, blade plates for the femur. Screws are not modified wood screws but designed for bone; they are larger than usual (4·5 mm.) with a deep thread which is not self-tapping, and an octagonal slot. It has been shown that the heat from self-tapping screws is injurious to bone, and that such screws may become surrounded by connective tissue and become loose. For the Swiss (AO) screws a narrow track is drilled and a thread tapped out by hand. In cancellous areas different screws with a wider thread are used, which obtain and keep a remarkable purchase (Fig. 5).

A technique of intramedullary nailing, in which the medullary space is first reamed out, was described in 1962 by Kuntscher. The Swiss (AO) have abandoned Kuntscher's nail in favour of a slotted tubular nail with a thinner wall (Fig. 6) which increases its flexibility and if they are more reluctant than Kuntscher to recommend intramedullary nailing, it is because they believe many fractures can be fixed in simpler and less dangerous ways.

COMPRESSION

Two compression techniques are used to enhance stability. First, a compression device may be attached to the end of a plate to apply an axial force (Fig. 7a). This is of the order of up to sixty kilogrammes and effectively reduces the width of the fracture line, produces increased rigidity and often succeeds in locking in small

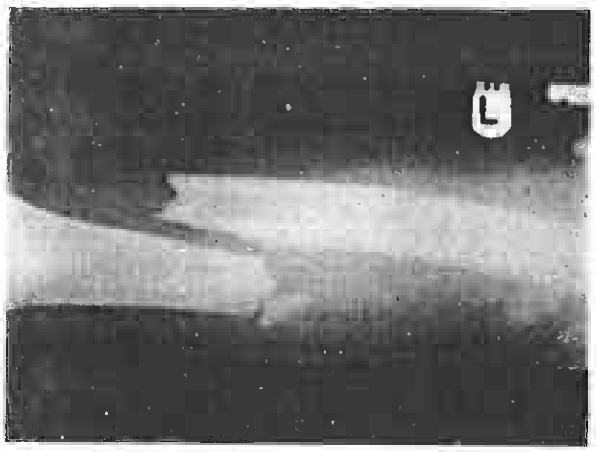

Fig. 2a.

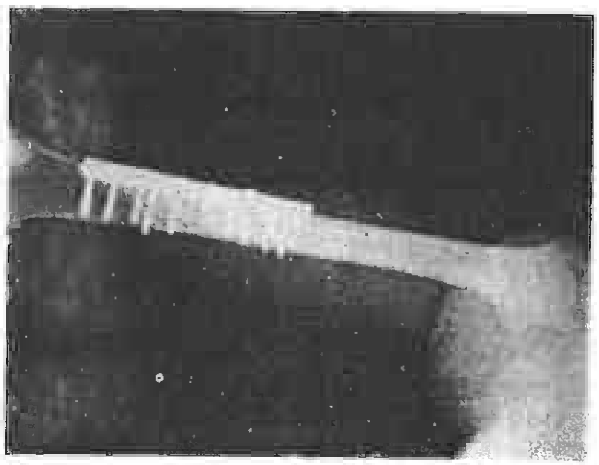

Fig. 2b.

Figs. 2a & 2b. Compression plating of fresh fracture of femur. Full knee range returned within a few days.

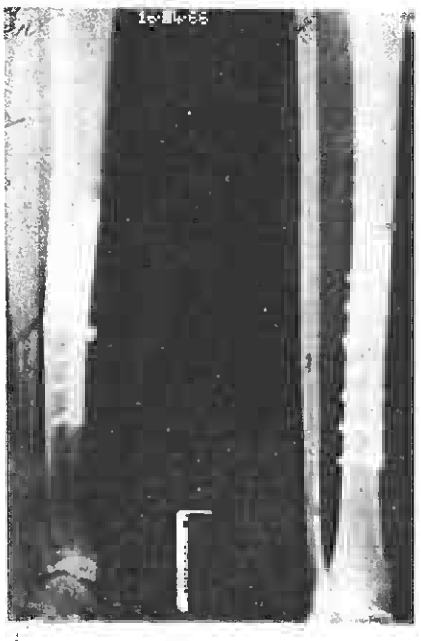

Fig. 3a.

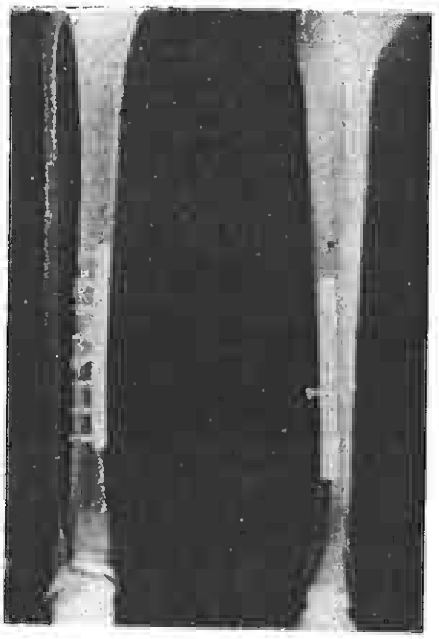

Fig. 3b.

Figs. 3a & 3b. Two examples of compression plating of tibia. The oblique screw is holding a butterfly fragment.

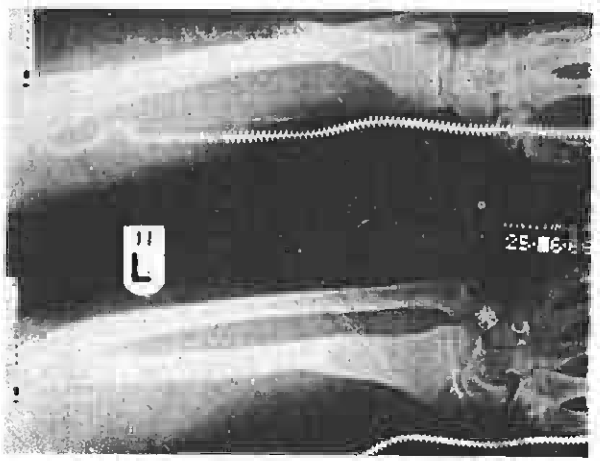

Fig. 4a.

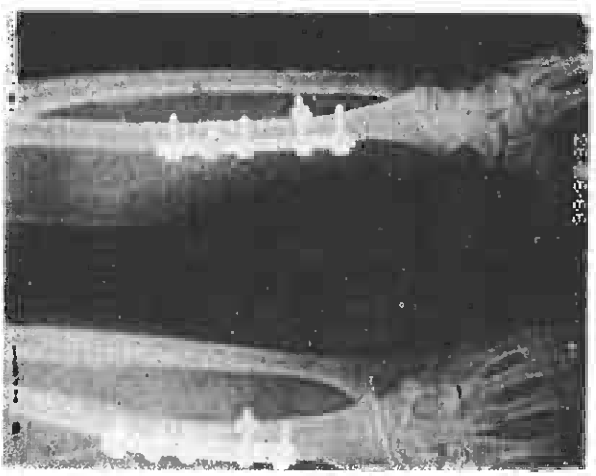

Fig. 4b.

Figs. 4a & 4b. Compression plating of Galeazzi fracture-dislocation. Note the use of the nut.

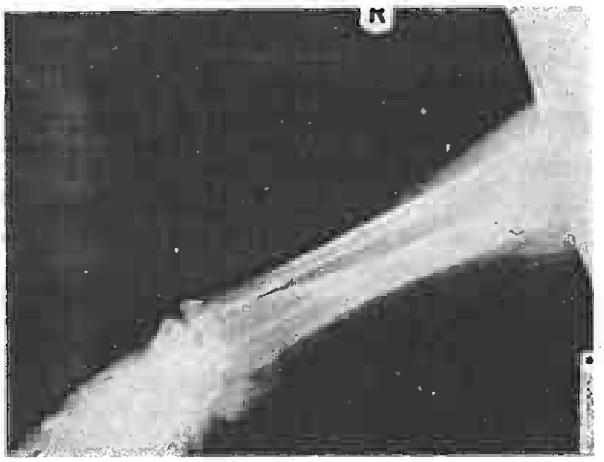

Fig. 5a.

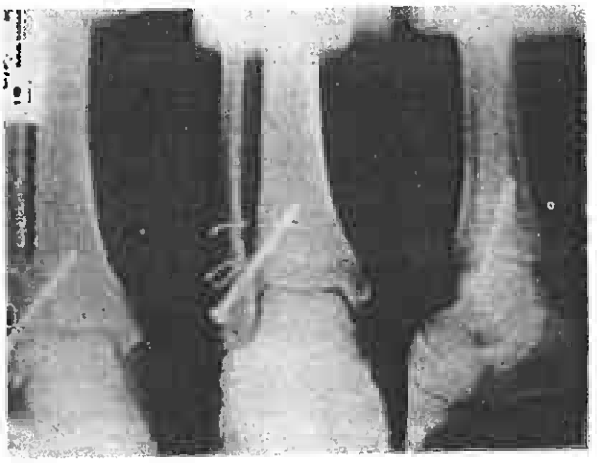

Fig. 5d.

Figs. 5c & 5d. Screw fixation combined with wire suture and open repair of the medial ligament of the ankle.

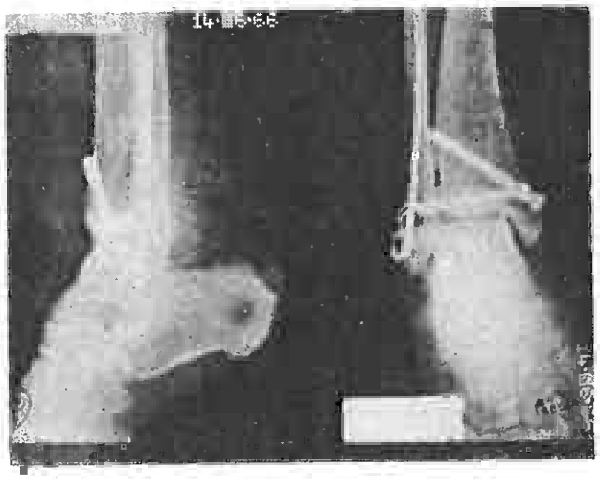

Fig. 5b.

Figs. 5a & 5b. Screw fixation combined with Rush nail and wire suture.

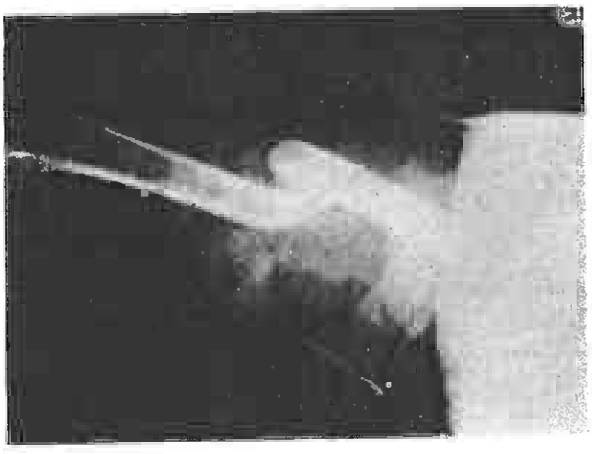

Fig. 6a.

Fig. 5c.

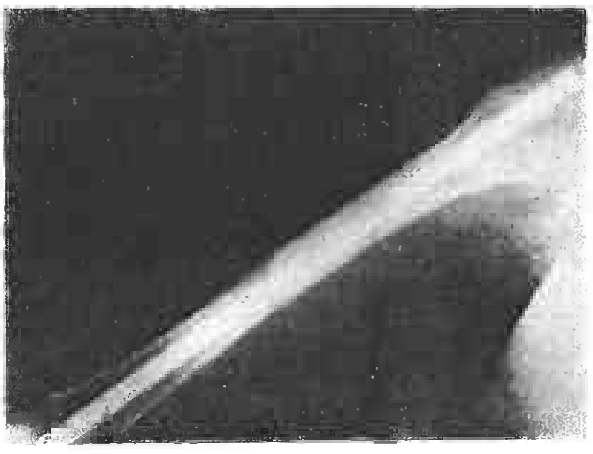

Fig. 6b.

Figs. 6a & 6b. Malunion of femur treated by the Swiss (AO) tight nail.

fragments. Second, screws are inserted on a lag-screw principle by boring out the proximal cortex so that the screw provides a powerful compression between the distal cortex and the head of the screw. Combinations of these techniques may be applied to comminuted fractures (Fig. 7b).

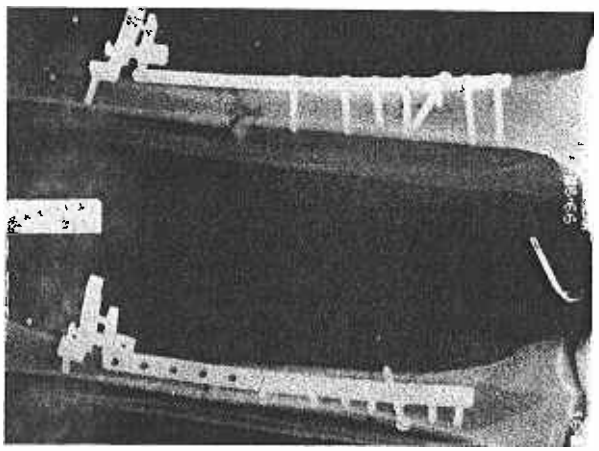

Fig. 7a.

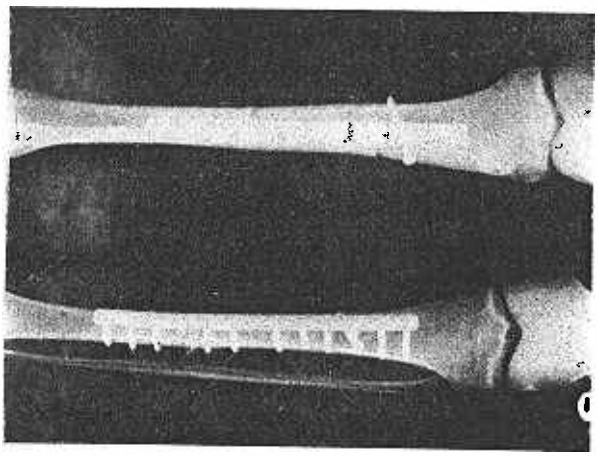

Fig. 7b.

Figs. 7a & 7b. Double fracture of the tibia treated by compression plating. Showing compression device in place and final result.

Compression probably has no particular virtue in its own right, but is simply a means of producing rigidity.

The Belgian orthopaedic surgeon Danis (1947) contributed the basis of this concept and was concerned with three main principles:—

a) to achieve stability using compression,
b) he advocated tapping threads into hard bone,
c) he advanced mechanical principles for the accurate placing of screws in butterfly fragments.

Charnley (1961) demonstrated that axial compression accelerates the union of cancellous bone, but distrusted rigid fixation of cortical bone because he could not accept the lack of visible callus that resulted.

Up to the present, no-one has been able to prove that compression of fractures of the shaft actually stimulates union primarily. The term compression plating is perhaps not a good one, for it is only a method of producing rigidity and it is this which is considered important, it being based on the assertion that the ideal rigid support for an injured limb is the intact skeleton. Watson-Jones (1962) took a fatalistic view by accepting that conventional internal fixation does not provide complete immobilisation. He prefers to call it "internal suture" and says that it must invariably be supplemented by external support. Hicks (1959) firmly believes that rigidity has a significant effect on functional recovery. Lettin (1966) has investigated this in a controlled series of rabbit experiments showing that union is enhanced by rigid fixation and has observed that there is a reduction in the amount of fibrous tissue and cartilage to be seen between the bone ends during healing. He concludes that rigid internal fixation results in the strength and stability of fractures increasing much more rapidly than in similar fractures treated in plaster.

It has been shown that axial compression forces are maintained across the fracture for up to twelve weeks, presumably disappearing as the bone itself becomes mechanically sound (Perrin and Huggler, 1966). For single screws inserted as compression screws, it has been seen that there is no destruction of bone or osteolysis; on the contrary, new bone forms very much as Charnley (1961) has shown after submitting cancellous bone to pressure. Histology shows a denser formation of bone on the pressure side than on the neutral side of the thread with the bone lamellae orientating themselves at right angles to the side of the thread exerting pressure. It is the usual practice to remove plates, screws and intramedullary nails a year after consolidation is thought to have taken place; because of the lack of external callus they are easier to remove and the well-cut threads can still be appreciated.

PRIMARY BONE HEALING

A limb in which a fracture has been rigidly plated is from the early days strikingly free from pain and stiffness. Both surgeon and patient may be tempted to take risks because it is difficult often to judge when union has occurred, and

easy to be misled into thinking it takes less time than it actually does. It was Danis (1947) who first described the phenomena which he called primary bone healing. With conservative treatment, union of the fragments depends upon callus, but under the influence of rigid internal fixation union takes place without the aid of radiologically visible callus (it is rather like comparing a plumber's joint with a high-quality weld). Standard teaching on the union of fractures is the outcome of experience by surgeons who have used only imperfect fixation, thus the idea arose that the production of plentiful callus was the essential process in the union of a fracture. Charnley (1961) even implied that rigidity is unnatural but in the one fracture that probably remains naturally rigid, in the cranial vault, we do not see callus formed. Union without callus, far from being undesirable, is the most effective form of union in terms of function (Hicks 1959). The radiological pattern of healing, seen when complete absence of movement exists, is unfamiliar and thus the interpretation of fracture healing by X-rays requires more care. Ideally after operation the fracture lines are only minimally visible, and gradually fade as union takes place (Fig. 8). Another feature is the absence of demineralisation which is most readily visible in cancellous bone areas, and which is a frequent radiological expression of functional impairment.

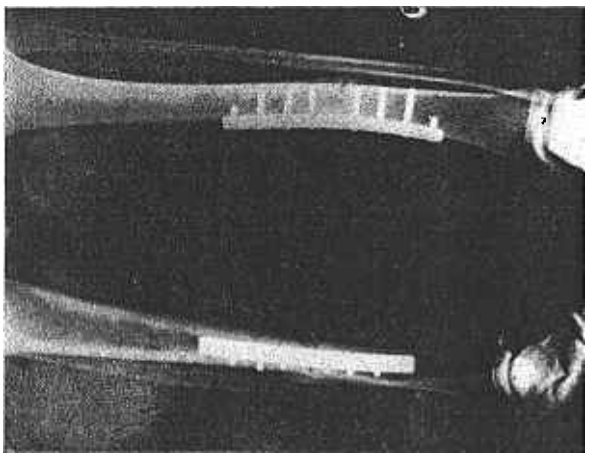

Fig. 8. Some visible callus has been formed. The fracture line was opened laterally by exerting compression on medial plate with intaer fibula.

The unit in which I work admits patients from all over the world and we are, in some ways, fortunate to witness the results of primary treatment undertaken in a world-wide cross-section of hospitals for a variety of reasons. As a result, we see a lot of remarkably inept treatment (Fig. 9), both conservative and operative, but the bad results are so often a criticism of the application of a particular method, not always of the theory behind it. Consequently we undertake a good deal of secondary or salvage treatment (Figs. 6, 10, 11 and 12). Influenced by what

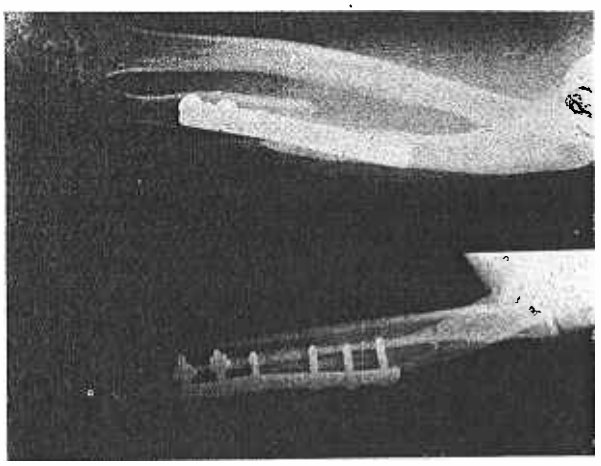

Fig. 11b.

Figs. 11a & 11b. Compression plate used for non-union of ulna after failure of Kiel bone graft.

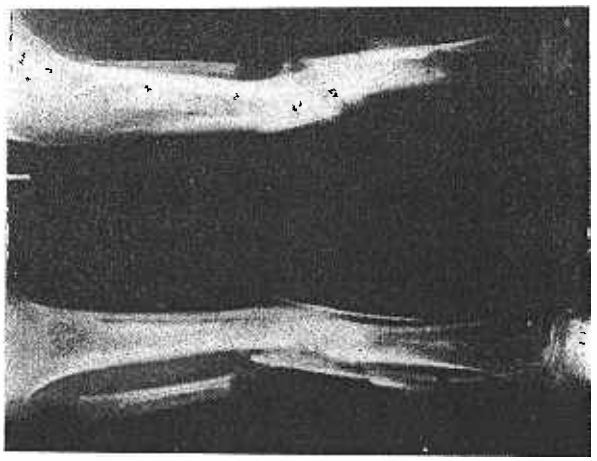

Fig. 12a.

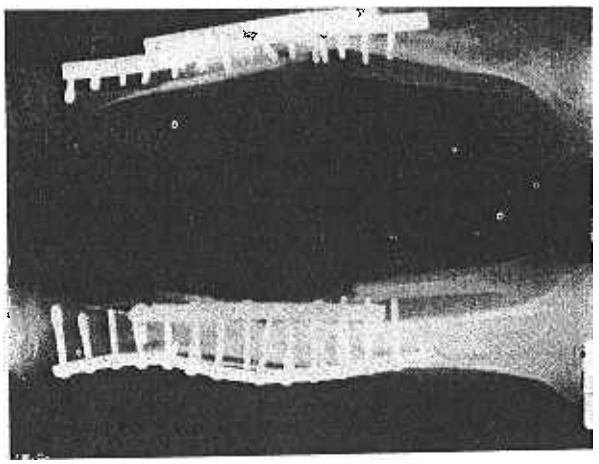

Fig. 12b.

Figs. 12a & 12b. Two compression plates used to deal with non-union of tibia. Three attempts at grafting had failed and amputation had already been reccommended.

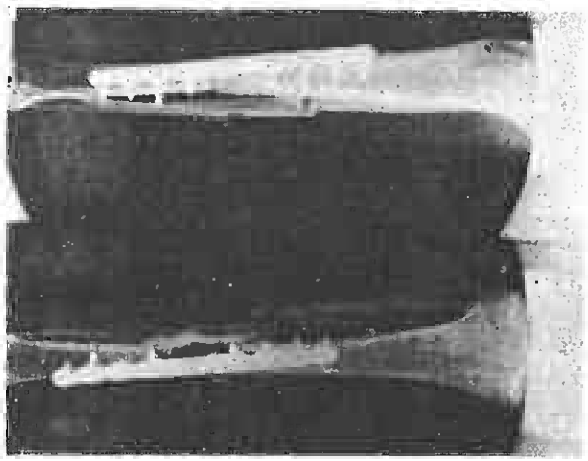

Fig. 9a.

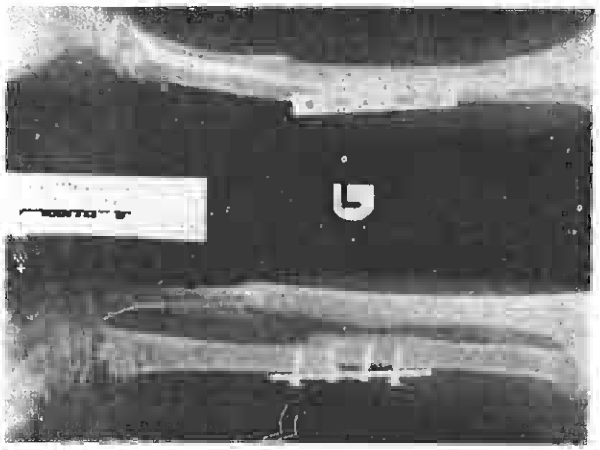

Fig. 9b.

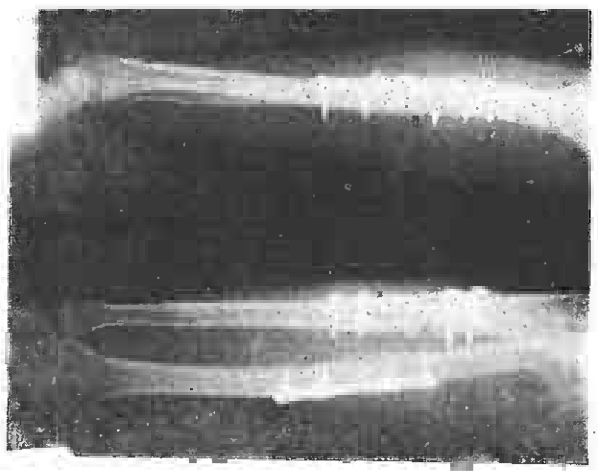

Fig. 9c.

Figs. 9a, 9b & 9c. Typical examples of poor conventional fixation.

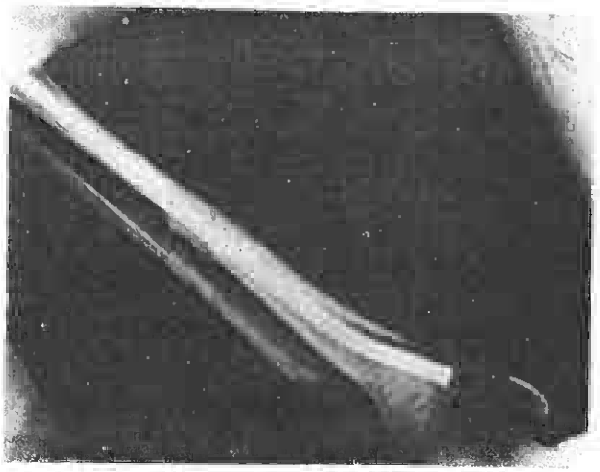

Fig. 10a.

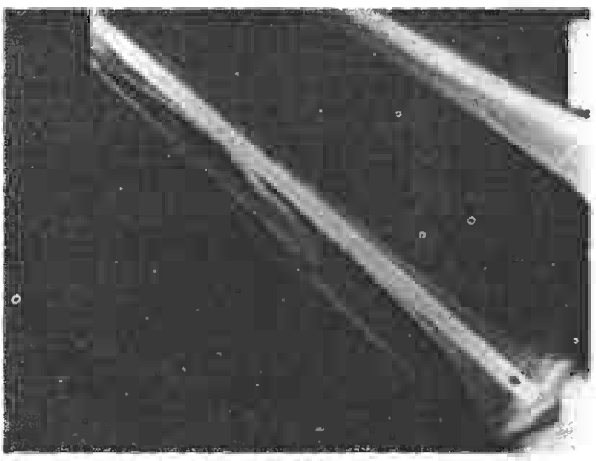

Fig. 10b.

Figs. 10a & 10b. Swiss (AO) nail for non-union of tibia.

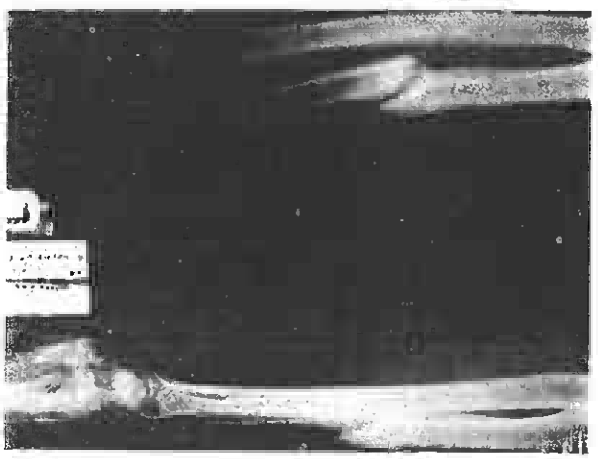

Fig. 11a.

we often see, we have never been enthusiastic about plates, particularly for the tibia, until this last year when we adopted this technique.

DELAYED UNION

It is in delayed union that we have been most impressed by compression plating, having found that union may be achieved by rigid fixation of a pseudarthrosis (Fig. 12). It is no longer necessary to violate the iliac crest and it is clearly an advantage to be able to encourage early joint movements, particularly in these patients, many of whom have already spent tedious months in plaster. One has no need to delay operation to mobilise their joints and they are able, after operation, to make full use of the remedial pool and other facilities. Above all, the patient's morale is so much better when he not only sees his limb function returning so soon, but may wear shoes and socks, bathe, sit comfortably and in every way feel more normal than he does in a cast.

FRESH FRACTURES

It is our current policy to use internal fixation in all suitable limb fractures in adults. We are doing this to avoid the obvious fallacy of treating easy fractures in plaster and difficult ones by internal fixation. We like to operate within eight hours of injury, or, where there are doubts about skin viability, after ten days. We have accepted the method without attempting to modify it in any way. So far we feel encouraged by the progress of our patients, who are most appreciative of the early return of painless function in an injured limb.

We have all been guilty of glibly dismissing the drawbacks of plaster treatment, and tend to underrate the inconveniences to the patient that can result from conservative forms of immobilisation. Apart from the immediate post-operative period, physiotherapy is not necessary and this alone saves a great deal of time and money for both the patient and the hospital, and involves less loss of working time.

It is recognised that the one big drawback is the possibility of sepsis, but again, fractures do not simply become infected, they are contaminated and more often than not this is due to faulty technique. Even in compound fractures, analysis of real sepsis has shown that the hazard of infection is no longer an over-riding objection (Hicks 1957) and we would sympathise with McLoughlin (1956) who said that internal fixation can act as a protection against infection by the prevention of small movements at the fracture site. Muller et al (1965) conclude that emergency internal fixation performed under ideal conditions does not seem to increase the danger of the complications to which all compound fractures are prone. On the contrary, their experience shows that post-operative infection occurs less frequently than after conservative treatment and that the functional results are considerably better. We have encountered infection. This followed the insertion of an intramedullary nail for delayed union in a compound fracture of the tibia that had been badly plated elsewhere. The infection was controlled by incision and drainage, followed by delayed primary suture of the wounds after five days. This was supplemented by antibiotics and hyperbaric oxygen. There has been complete resolution and I am convinced that this is due to the rigidity of the fixation. It must be emphasized that if the fixation is not rigid results like this may not be obtained. A combination of loose metal and sepsis is quite alarming.

CONCLUSION

It is vital to keep a sense of proportion. The fractures that I saw treated in Switzerland were almost exclusively skiing injuries where soft tissue injury is minimal. These, of course, occur in younger—or at least more vigorous—groups of the population, and are invariably isolated injuries. We are very aware of the distinctions when dealing with traffic accident injuries in industrial, urban surroundings. I think the Swiss (AO) techniques are a significant advance and that if one accepts internal fixation, their methods are superior.

ACKNOWLEDGEMENTS

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REFERENCES

1. Charnley, J. (1961): "The closed treatment of common fractures", Livingstone. Edinburgh and London.
2. Danis, R. (1947): "Theorie et pratique de l'osteosynthese", Masson et Cie. Paris.

3. Hicks, J.H. (1959): "In Modern Trends in Accident Surgery and Medicine", Ed. A.R. Clarke et al. London.
4. Lambotte, A. (1892): "Notice Sur L'emploi du fil de fer et de vis du mene metal dans la suture osseuse", Preose. Med. Belge 44. 125.
5. Lane, Sir A. (1894): Trans. Clin. Soc. Lond. 28, 167-175.
6. Lettin, W.H.F. (1965): "The effects of axial compression on the healing of experimental fractures of the rabbit tibia," Proc. Roy. Soc. Med. Vol. 58 (Mar) P. 882-886.
7. McLoughlin, H.L. (1956): Surgery, Vol. 39. Page 892.
8. Muller. M.E. (1963): "Internal fixation for fresh fractures and non-union," Proc. Roy. Soc. Med. Vol. 56 (June) P. 455-459.
9. Muller, M.E., Allgower, W., Willenegger, H.: "Technique of internal fixation of fractures", Springer, Varlag, Heidelberg 1965.
10. Perrin, S.M., Huggler, A. (1966): Personal communication.
11. Watson-Jones, R. (1952): "Fractures & Joint Injuries", E. & S. Livingstone. Edinburgh and London.