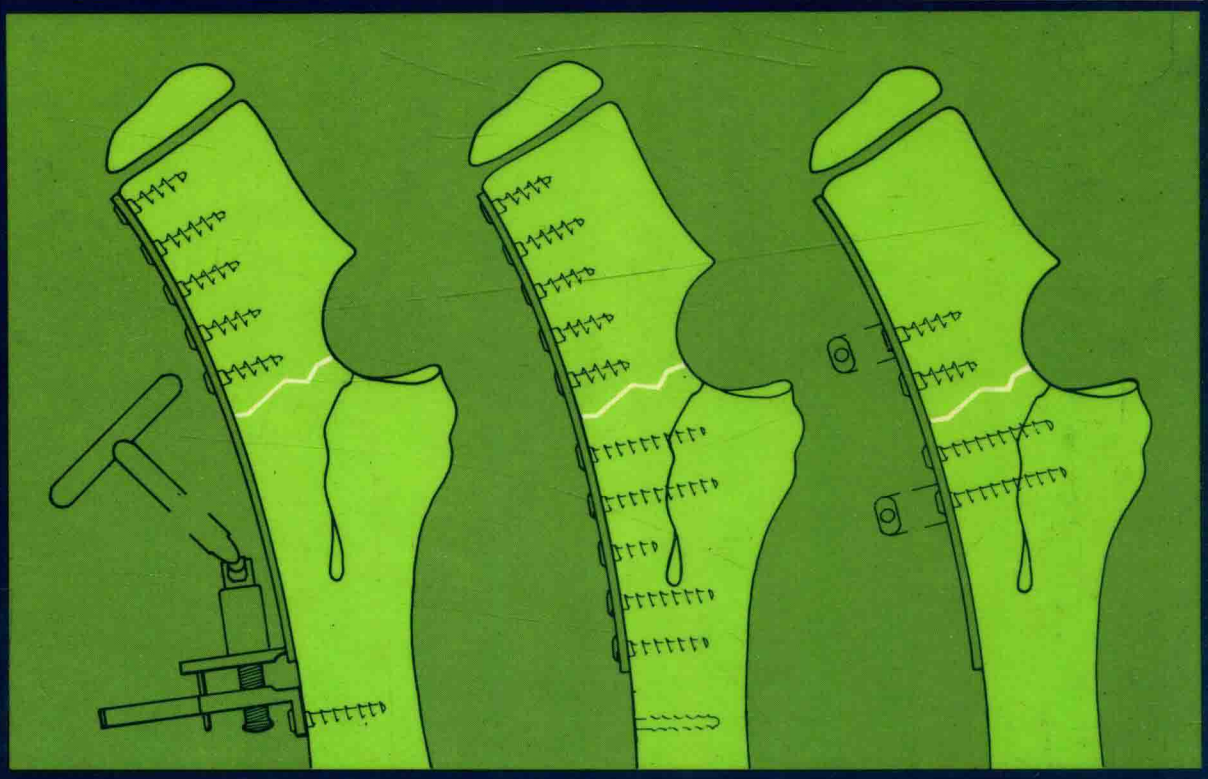
G.E.Fackelman D.M.Nunamaker

Manual of Internal Fixation in the Horse



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Manual of Internal Fixation in the Horse

In Collaboration with B. von Salis and O. Pohler

Foreword by M. E. Müller, M. Allgöwer, R. Schneider, H. Willenegger

With 187 Figures in 282 Separate Illustrations

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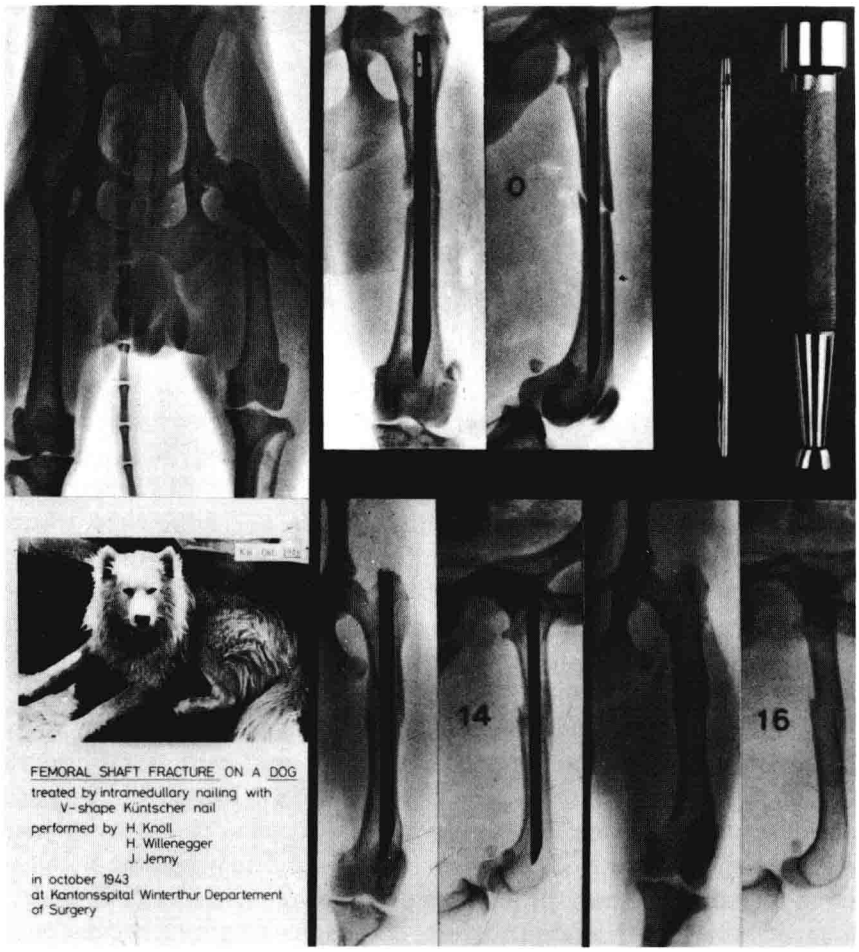
In Memory of
Prof. Jacques Jenny

Foreword

It is with pleasure that we offer these introductory remarks for the Manual of Internal Fixation in the Horse, a book describing a further application of AO or ASIF techniques. The letters A-O stand for the Arbeitsgemeinschaft für Osteosynthesefragen and have been translated into the Association for the Study of Internal Fixation. The organization is truly a "study group", created in Switzerland, that met for the first time in 1958. The major goal was to establish a task force committed to the improvement of fracture treatment by osteosynthesis.

The group's motivation arose out of the then prevailing unsound or inconsistently successful attempts at fracture treatment. According to statistics obtained from the Swiss National Health Insurance Program at the time, the so-called conservative treatment of fractures had resulted in a high rate of persistent morbidity. The problems encountered included: irreparable damage due to long-term immobilization; delayed union or pseudoarthrosis; malalignment; and, inadequate reduction of intraarticular fractures with resultant osteoarthritis. Accurate, stable osteosynthesis seemed the only practical way to address those various shortcomings. However, many of the osteosyntheses performed at that time had led to new problems, since most were not stable and, in some cases, actually worked to prevent healing. In those cases, external immobilization, with all its inherent drawbacks, again became necessary. This set of circumstances seemed particularly common when cerclage was used in the repair of long bone fractures. When inadequate technique was complicated by postoperative infection, the outcome was disastrous; and it is no surprise that there were many opponents to any plan designed to further the development of internal fixation.

Against this background the AO group set out to find, based on solid scientific evidence, a way to perform osteosynthesis with an absolute minimum of complications. Through close cooperation between surgeons, basic researchers, metallurgists, and statisticians, our goal was achieved and osteosynthesis has been standardized as a surgical method. The techniques developed were applicable not only to fracture treatment, but also to many other areas in the surgery of the locomotor system. Along with the basic principle of absolute stability in internal fixation, early postoperative mobilization and even weight-



bearing played an important role in bringing about a positive outcome. This latter point seemed particularly important in stimulating the expansion of operative treatment of fractures into clinical veterinary surgery.

In Switzerland, intramedullary nailing found immediate acceptance, the first dog having been treated by the technique in October 1943. The case in question had historical implications, in that it was carried out with the help of Dr. Jacques Jenny, then a resident at the University of Zurich and a man that would later play a key role in the refinement of internal fixation, especially in large animals. The first plate fixation in animals in Switzerland was performed by Dr. R. Fischer, an AO member, in collaboration with a veterinarian, Dr. Eppenburger. The implants were applied to successfully repair fractures of the mandible in two oxen.

Eighteen years after the above-mentioned canine intramedullary nailing, further decisive contacts were established. Dr. Howard Rosen and Dr. Bruce Hohn first met at the Annual Congress of the American Academy of Orthopedic Surgeons in January 1965. Hohn was at that time the Head of the Surgical Section at the Animal Medical Center in

New York, where Rosen was soon thereafter appointed as consultant. Later that year Dr. Jacques Jenny became acquainted with the former two individuals and a nucleus was formed around which other colleagues soon gathered.

The founders of the AO owe a vote of thanks of their veterinary colleagues, who have helped immeasurably through clinical work and basic research to advance the high standards we now enjoy. The authors of the Manual der Osteosynthese wish the authors of this present volume every success and trust that the book will find enthusiastic acceptance and broad application.

M. E. Müller
M. Allgöwer
R. Schneider
H. Willenegger

Preface

In the 1960s, veterinarians became aware of a system of fracture treatment developed by the AO (Arbeitsgemeinschaft für Osteosynthesefragen), a Swiss group of surgeons dedicated to the improvement of internal fixation devices and techniques for the treatment of fractures in humans. The basic goals of the group, which rapidly developed an American counterpart, the ASIF (Association for the Study of Internal Fixation), seemed very similar to our own: early post-operative weight bearing; accurate reconstruction; healing with minimal callus; and the elimination of joint stiffness and "fracture disease."

It was therefore not surprising to see reports appearing in veterinary journals and conference proceedings of the use of ASIF techniques in animals by such pioneers as Jacques Jenny, Wade Brinker and R. Bruce Hohn. In 1967, these veterinarians and several others attended a short course designed to introduce the AO technique to physicians. The following year special courses for a small number of veterinarians were set up in Davos, Switzerland, and in Columbus, Ohio, and "AO Vet." groups began to form on both sides of the Atlantic.

Acknowledging the youth of the field and the present shortcomings of fracture treatment in the horse, it is our purpose to set out in print the principles of internal fixation, using case illustrations to describe the techniques which have been most successful. It is not the purpose of this book to exclude the techniques of others, nor to imply that techniques which have not been included are unsatisfactory, it is just that the ones presented here have been used by either one or both of us, and, since they are based on a certain degree of satisfactory results, are considered important enough to be included. Not all fractures are identical as they present themselves clinically, and subtle variations in form may require modifications or combinations of techniques to produce the desired end-result. *Stability* of the fracture fragments relative to one another is the keynote to healing. This is more important in horses than in other species, since the stresses to be withstood by the implants are much greater and the rate of healing of bone may be, according to some preliminary work, slower than in other animals studied.

When assessing the case material presented, it is noted that most of the techniques described are limited to screw fixation. This method,

together with plate fixation, is frequently used in long-bone fractures in the horse. Shaft fractures are covered in the general discussion of Part I and are not covered bone by bone in the more specilized Part II. This has been done so that the principles of internal fixation can be followed even though there are such great variations between individual bones and degrees of injury. No detailed instructions are given for shaft fractures since success will depend on the skill and experience of each surgeon. Not all shaft fractures are presently amenable to treatment.

This manual serves to describe the implements and techniques of internal fixation in large animals to the best of our knowledge at the time of publication. Though the illustrations and text deal only with horses, most of the techniques and all of the principles apply equally to other large domestic and exotic animal species. The book will be especially useful to anyone who has participated in practical courses teaching the ASIF method. Readers are encouraged to continue to update their knowledge and maintain contact with those engaged in research on internal fixation through periodic participation in such courses.

Boston and Philadelphia
October 1981

Gustave E. Fackelman
David M. Nunamaker

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Part I

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Part I

Chapter 1. Basic Principles of Fracture Treatment

The basic philosophy of the ASIF technique is functional fracture treatment provided by stable internal fixation and early mobilization of the joints with partial and then full weight bearing. Stable internal fixation is achieved through accurate anatomic reduction and interfragmentary compression of the bone fragments so that the injured bone itself transmits and supports weight-bearing loads. Exact anatomic reduction can be accomplished with screws alone or with screws and one or more plates. The intimate contact between the reduced fragments, necessary for stability of the reduced fractures, can be achieved with interfragmentary compression. Complete reconstruction of the bone is absolutely necessary in order to transfer weight-bearing loads through the bone, thus sparing the relatively weak implant (Fig. 1.1a). This basic premise allows successful fracture treatment in a large animal, such as the horse, without the use of implants that might overpower the bone. Any inability to transmit loads across the fracture site will result in implant deformation (Fig. 1.1b) and/or failure of the implant (Fig. 1.1c).

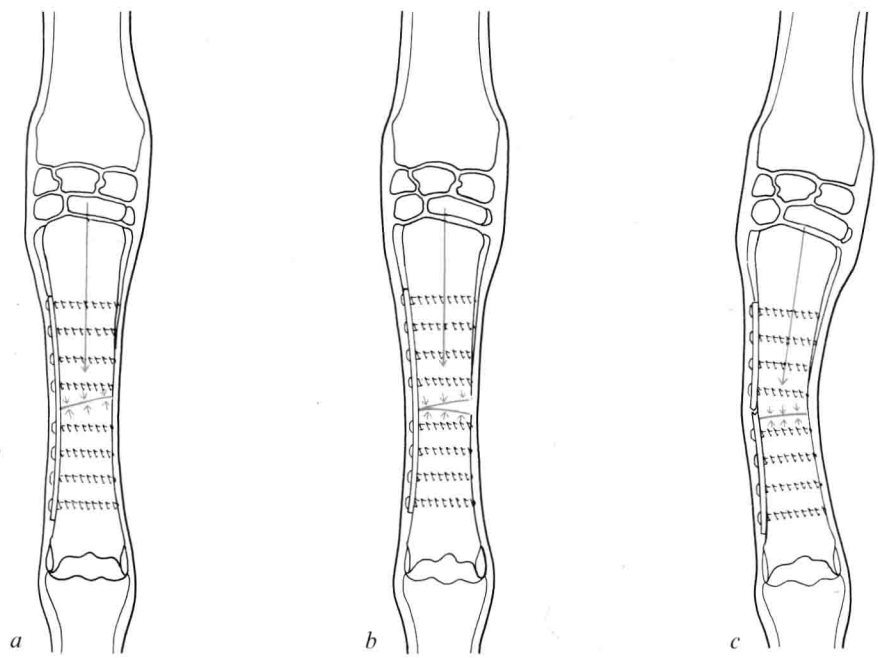

Fig. 1.1 a–c. *a* Load transmission across the fracture line after anatomic reduction with resultant stability. *b* Any inability to transmit loads across the fracture site will result in implant deformation. *c* Persistent cyclic deformation will result in implant failure.

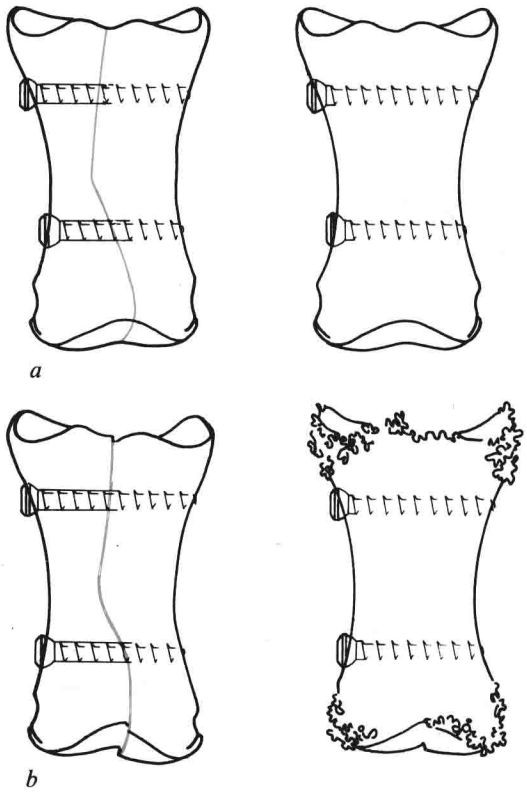

Fig. 1.2 a, b. *a* The potential good result obtained with perfect anatomic reduction. *b* The bad result after inadequate reduction.

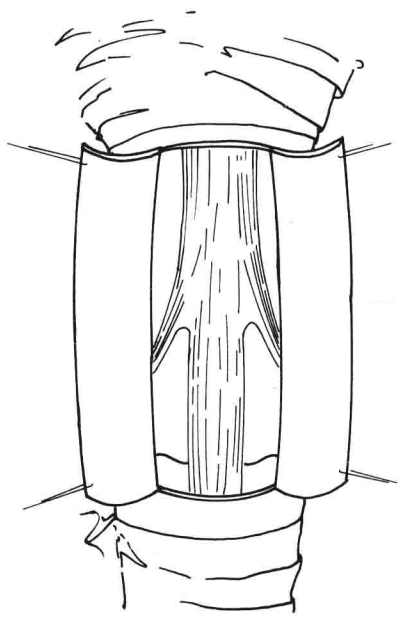

Fig. 1.3. Wide exposure of a first phalangeal fracture allows the adequate visualization of the fracture necessary for its repair.

1.1 Accurate Reduction of the Fracture Fragments

Normal joint function can be maintained only if fractures through articular surfaces are accurately and anatomically reduced and stabilized so that congruence of the joint surfaces is maintained (Fig. 1.2a). Even a small step in the joint surface will lead to a degenerative joint with proliferative, periarticular changes that may preclude a functional recovery (Fig. 1.2b). Such demanding surgery usually requires visualization of the fracture and the joint surface and new or more radical surgical exposures than have

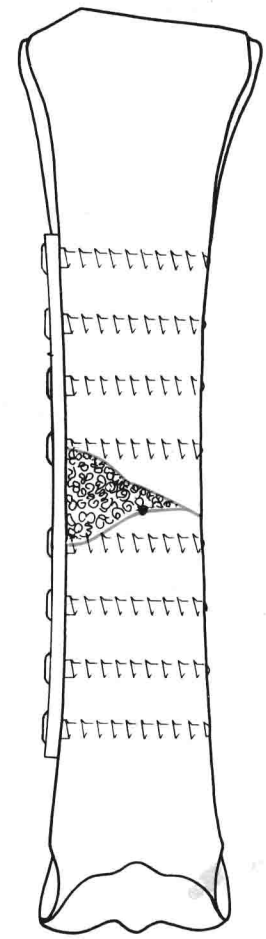

Fig. 1.4. A cancellous bone graft is used to form a bridge across any gap caused by comminution of the fracture. Note the placement of the plate over the area of comminution to maintain stability.

been advocated in the past (Fig. 1.3). Comminution, which plays such a great role in the equine shaft fractures, emphasizes the need for anatomic reduction of the fragments with the use of cancellous bone grafts. Direct continuity must be maintained across the fracture site, either by using the animal's own cortical bone or with a mass of cancellous bone that can eventually form a solid bridge (Fig. 1.4). The plate is placed over the area of comminution to maintain stability. Whenever cancellous bone is used to cause the development of a buttress across a bony defect, weight bearing must be delayed. Full, immediate weight bearing in such cases will lead to catastrophic failure of the reduction and therefore of the internal fixation. In the horse, external fixation is necessary to prevent weight bearing, and full functional treatment is delayed until the bone-plate composite is capable of full weight support. Only when this stage is reached can mobilization of the associated joints begin. This present drawback of fracture treatment in the horse awaits further developments in operative techniques as well as in postoperative management.

1.2 Stable Internal Fixation

The heart of the ASIF system consists of achieving fixation by means of interfragmentary compression. Interfragmentary compression causes high frictional forces at the fracture surfaces, and these forces confer stability. Compression can be extended across the fracture site by the use of screws alone (Fig. 1.5a) or, as in the case of a transverse fracture, axial interfragmentary compression may be achieved by a combination of screws and a plate (Fig. 1.5b). Many times, reconstruction of a fracture in the horse requires both axial compression, applied through the use of a plate in combination with screws, and interfragmentary compression achieved by using screws alone (Fig. 1.5c).

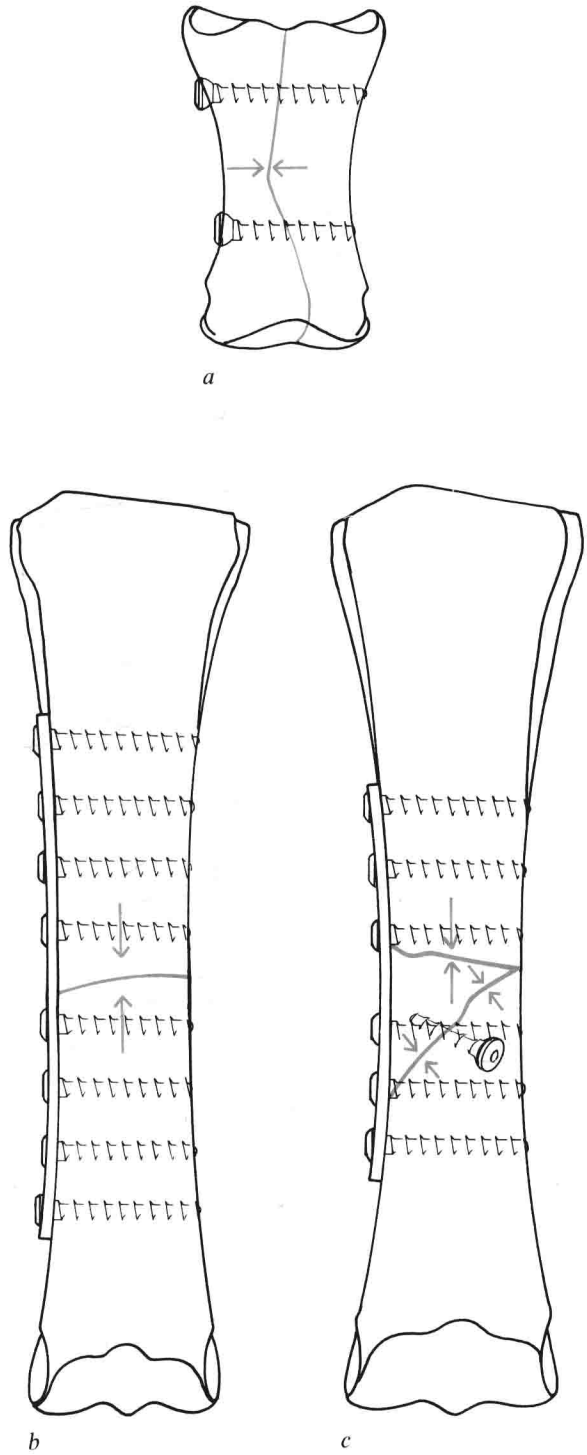

Fig. 1.5 a–c. *a* Sagittal first phalangeal fracture with screws providing interfragmentary compression. *b* A plate applied to the reduced fracture provides axial compression. *c* A combination of plate axial compression and interfragmentary screw compression in a comminuted fracture.

In stable internal fixation, the emphasis should be placed on the word "stable," since it has been shown that when bone fragments are approximated anatomically, subsequent motion interferes with fracture union. Therefore, it is very important for the surgeon to prevent relative motion at the fracture site when using this technique. This is not to say that fracture healing never occurs when there is motion at the fracture site, because it surely does, as demonstrated time and again with the use of casts and splints in many species. The key to this apparent discrepancy may lie in the distance between the ends of the fracture fragments in relationship to the amount of motion present.

1.3 Soft-Tissue Problems

Fracture healing depends on adequate vascularization of the bone. The vascular supply to the bone is always destroyed to some extent at the time of the fracture, since the main blood supply to the diaphysis of a long bone originates from the medullary canal. This source is interrupted at the time of the fracture and must be reconstituted before complete healing can occur. Revascularization through the medullary canal is greatly hastened by stable internal fixation, using compression techniques. The periosteal blood supply, however, becomes relatively more important before reconstitution of the medullary supply occurs. The periosteal blood comes from the surrounding soft tissues. In most equine fractures a great amount of energy is expended into the soft tissues at the time of the fracture. This explosion of the bone into the soft tissues may cause immediate disruption of the periosteal blood supply of the bone. Therefore, even before any surgical intervention, there is usually a great deal of damage already present around the fracture site, which may be the cause of significant postoperative complications, such as wound dehiscence, superficial and deep wound infections, and osteomyelitis. The risk of complications because of soft tissue injury must be weighed heavily before making a decision about open reduction and internal fixation. If surgery is indicated, it is of the utmost importance to maintain all remaining vascularity to the fractured bone. Some internal fixations may be achieved through stab incisions using fluoroscopic control. This procedure is usually accomplished in non-displaced fractures or in easily reduced simple fractures (Fig. 1.6). The soft tissues are protected during the internal fixation by using different drill

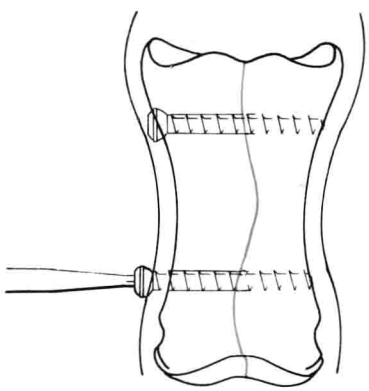

Fig. 1.6. Stab incisions can be used in non-displaced fractures for insertion of screws to minimize surgical soft-tissue injury.

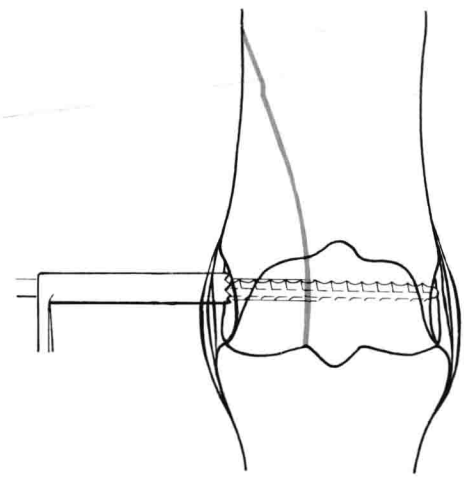

Fig. 1.7. Drill and tap guides are necessary to protect the soft tissues.