

Pablo Slullitel
Luciano Rossi
Gastón Camino-Willhuber
Editors

Orthopaedics and Trauma

Current Concepts and
Best Practices

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Pablo Slullitel • Luciano Rossi
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Behind this book there are countless hours of work. Hours which mean a lot considering the endeavour achieved, but which are even more meaningful because they represent time away from my wife and kids who are what I value the most in life. I dedicate this book to them.

Luciano Andrés Rossi

To Norma, Melina, and Juan Martin, for all the support and love. 'Family comes first'.

Gastón Camino-Willhuber

It has been a privilege to be Editor of this book, especially to share this position with Drs. Rossi and Camino-Willhuber, which made this journey be obstacle-less by paving the daily rocky road. I would like to recognize my parents, 'Beby' and Jorge, for providing me with all the necessary tools to help me understand what 'dedication' means in a professional career. To Victoria and Catalina, all my heart to them for their love, loyalty, patience and understanding. To my mentors and teachers, not only in Orthopaedic Surgery but also to teachers of life that have moulded my character and personality from childhood (from Saint Bartholomew's School, football coaches at Jockey Club Rosario and also teachers from the University of Medicine). My tribute to Gastón Slullitel, for always pointing me the right direction; Martín Buttaro, for believing in me in my early career time; and George Grammatopoulos, for teaching me how to do things right, no matter what it takes. Finally, I would like to acknowledge all those who actively contributed to this book, from authors to the editorial publisher, since this would have been impossible without their collaboration and effort.

Pablo Ariel Isidoro Slullitel

Foreword

There are several published textbooks aimed at orthopaedic surgery residents and fellows who are in their most malleable part of their learning curves in surgical training. However, most of these options include large textbooks which are difficult to follow on a daily basis. This textbook edited by Drs. Camino-Willhuber, Rossi and Slullitel, surgeons affiliated to 'Hospital Italiano de Buenos Aires', Argentina, includes around 200 chapters divided into two different volumes, Orthopaedics and Trauma. For each orthopaedic and trauma pathology, this text offers a comprehensive coverage of all relevant topics, including both adult and paediatric conditions. Each chapter is structured in an easy-to-read fashion with pre-established subheadings, including one named 'Senior Author's Preference for Treatment', for which the editors had invited pioneer, well-known surgeons from all around the world to share an inspirational contribution. This book is a high-quality, straight-to-the-point, updated textbook with the purpose of guiding residents and fellows in their training, and also willing to support their preparation for their board certification.

Volume I corresponds to the Trauma section, whereas Volume II includes the most relevant orthopaedic pathologies. Each chapter is structured with the following subheadings: (1) Introduction and Epidemiology, (2) Pathophysiology, (3) Applied Anatomy, (4) Classification, (5) Clinical Assessment, (6) Radiologic Evaluation, (7) Treatment, (8) Author's Preference for Treatment, (9) Prognosis and Complications, (10) Summary, (11) Key Points, and (12) References. The 'Key Points' section provides the most important take-home messages. In general, all chapters are designed to be a comprehensive review including all the 'must-know' topics and queries that will not remain unnoticed in an exam for board certification.

I have been affiliated at the same institution as the editors of this textbook for around 35 years, and I am proud and pleased to see that this very well-designed piece of orthopaedic knowledge has been grounded at 'Hospital Italiano de Buenos Aires'. I think this textbook is a landmark text that will become a resourceful tool for all orthopaedic surgeons in training around the world. So far, it only has an English version, but I hope that with time, will also be translated in multiple languages for proper distribution in different countries.

Hospital Italiano de Buenos Aires
Buenos Aires, Argentina

Miguel A. Ayerza

Preface

‘The power of dreams’

This book is certainly a ‘dream come true’. Two years ago, we got together to plan what would be—with no doubt—one of the greatest academic achievements of our careers. Initially, we sought to gather all the physicians from the Orthopedic Division of Hospital Italiano Buenos Aires, Argentina, to collaborate as authors of this book since this is the institution that enabled us to become orthopaedic surgeons. This undoubtedly had a huge emotional component because all of our teachers and mentors were about to participate in the creation of this book, many of whom are currently renowned professionals in the field not only in Argentina but internationally as well. But, since dreaming is free, we decided to go a step further. We agreed that, in order to make the project even more prestigious, we should include internationally renowned professionals from all over the world. So, with the collaboration of physicians from our Service, selected as Associated Editors, we got in contact with more than 100 top surgeons from over 60 countries around the world and invited them to participate as contributors of this project, which they did with great generosity and commitment.

Two years of intense, uninterrupted work followed, involving over 200 authors from all around the world, resulting in this book we are able to read today, which we firmly believe is a great contribution not just to young residents and fellows in training, but also for attending surgeons willing to upgrade their current knowledge. The two volumes of this book, Orthopaedics and Trauma, provide a comprehensive and updated review of the main concepts related to the clinical findings, diagnosis and management of the main orthopaedic and trauma conditions. This book not only summarizes the best up-to-date evidence available on each condition, but also addresses the main controversies surrounding each topic as well as the experts’ preferred treatments for the management of each musculoskeletal condition. We hope this book becomes a valuable tool for young doctors who must prepare for their board-certified specialty exams and a reference material for orthopaedic providers in practice. As Walt Disney said: ‘All our dreams can come true, if we have the courage to pursue them’. To all those who have contributed to this dream becoming a reality, we are eternally grateful.

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This book was conceived within the boundaries of Hospital Italiano Buenos Aires, Argentina. Hospital Italiano Buenos Aires is one of the oldest medical facilities in Argentina. Its Orthopaedic Institute was founded in 1926 by Prof. José Valls and later promoted by Prof. Vittorio Putti from Istituto Ortopedico Rizzoli in Bologna, Italy. The Orthopaedic Division was named 'Carlos E. Ottolenghi' in 1964 after Dr. Ottolenghi's death for his great academic contribution, becoming the mentor of several surgeons in training in Latin America and the father of modern orthopaedic surgery in Argentina. As Editors, we are honoured to have developed this project at this institution, involving several authors from the Orthopaedic Division. It was a means of giving something back to the orthopaedic community by revering Dr. Ottolenghi's foundation. We are truly in debt with this legacy because it was from these roots that we are able to get connected with plenty of worldwide top orthopaedic surgeons who have agreed to selflessly contribute to this book. To all contributors, we are truly grateful for their collaboration and generosity.

The Editors

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Part I

General Topics



Basic Principles in the Treatment of Fractures

1

Rodrigo Pesántez and Jaime Quintero

Introduction

In the early 1960s, the *Arbeitsgemeinschaft für Osteosynthesefragen—association of the study of osteosynthesis* (AO) established the basic principles of fracture fixation and started a revolution in musculoskeletal trauma care. The principles at that time were: restoration of anatomy, stable fracture fixation, preservation of blood supply, and early mobilization of the limb and patient. These principles have evolved over time with the understanding of bony biology and the mechanics of the healing process. The pendulum has swung several times and this is where these principles are today.

The principles of fracture care according to the AO are the following:

- Fracture reduction and fixation to restore anatomic relationships.
- Fracture fixation providing absolute or relative stability as required by the personality of the fracture, the patient, and the injury.
- Preservation of the blood supply to the soft tissues and bone by gentle reduction techniques and careful handling.
- Early and safe mobilization of the injured limb and the patient as a whole.

According to McDonald and Graves [1], the surgeon should analyze the fracture, the patient, and the injury as a whole (including the soft tissues), and then plan the surgery.

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In order to do so, they suggest the following steps: analysis of the type of fracture and soft tissue damage pattern, determination of the bony area involved, desired stability, surgical approach, reduction technique, fixation and construct stability, as well as definition of potential causes of failure.

Fracture Reduction and Fixation to Restore Anatomic Relationships

This principle has evolved from the original one which aimed to reduce anatomically every fracture fragment, in order to restore anatomic relationships. Following new guidelines, reduction of the fracture changes depending on the area of the bone involved: articular (joint), shaft, or metaphysis. The quality of fracture reduction can be anatomical or functional; the first one is the perfect restoration of every fracture fragment to its original position and it is recommended in articular fractures and some simple meta/diaphyseal fractures. On the other hand, functional fracture reduction is the restoration of the spatial relationships of the bone restoring limb length, alignment, and rotation and it is recommended in metaphyseal (extra-articular) and diaphyseal fractures.

The method of fracture reduction can be direct or indirect, and it can be achieved through an open approach, a minimally invasive approach, or a closed one. Direct reduction refers to a reduction technique where the fracture ends are exposed and fracture reduction is achieved through direct manipulation of fracture fragments, usually using an open approach, and even sometimes endoscopically-assisted, like in the tibial plateau or wrist fractures. It is indicated in articular injuries and simple metadiaphyseal fractures. Indirect reduction is usually done without direct visualization of the fracture line (i.e., without exposure). It is usually achieved through a minimally invasive approach or by closed reduction with fluoroscopy assistance and it aims to restore functional anatomy. It is most commonly used in complex metadiaphyseal fracture patterns.

Sometimes fracture reduction can be indirect through a more extensile approach but respecting muscle attachment to the bone, like in the original Kinast et al. [2] paper from 1989, where they treated subtrochanteric fractures using a condylar blade plate and compared two groups, one treated with anatomical fracture reduction of the fragments and the second using an standard approach but indirect reduction technique, but respecting medial soft tissues, and using sub-muscular plating, the results were better.

Fracture Fixation Providing Absolute or Relative Stability as Required by the Personality of the Fracture, the Injury, and the Patient

To decide the type of stability needed by the fracture, the surgeon needs to assess the fracture pattern, the area involved, and soft tissue compromise. Fracture personality is the combination of fracture pattern, soft tissue injury, mechanism and energy of the injury, and type of patient (demography, ethnicity, functional status, etc.).

Stability is achieved after a construct structure is built between the fracture and the chosen fixation method. Absolute stability refers to the absence of motion between fracture fragments under physiological load. Instability, on the other hand, is an excessive amount of motion between fracture fragments under physiological load, which impedes healing. In between these two is relative stability which is defined as a controlled motion between fracture fragments under physiological load. Stability will help to determine fracture strain: in order to heal under absolute stability, strain should be below 2%, in relative stability it should be 2–10%, and above 10% is considered instability [3, 4].

Fracture pattern can help identify the intrinsic stability of the fracture before fixation. Fracture pattern can be simple or complex; the simpler the fracture, the more intrinsic stability will be achieved. This will help the surgeon to determine the type of fixation and the construct stability. Fracture pattern also predicts the severity of soft tissue injuries, as high energy trauma produces complex fracture patterns associated with severe injury to the soft tissue. The amount of soft tissue damage will help select the best surgical approach, the need for temporary fixation modalities, and the most appropriate reduction technique.

Last, but not the least, it is important to consider patient history, age and gender, physical and clinical status, comorbidities, associated injuries, as well as expectations. Once all previous aspects have been assessed, a sound preoperative planning is needed .

Preservation of the Blood Supply to Soft Tissues and Bone by Gentle Reduction Techniques and Careful Handling

Preoperative planning should include patient positioning, surgical approach/es (considering preservation of the blood supply to the bone and soft tissues), reduction strategy with the different steps, and finally fixation with the desired stability. A variety of different surgical approaches have been described over the years [1, 2, 5]. On one hand, classic surgical approaches, fine knowledge of surgical anatomy, and direct reduction techniques have yielded good results in simple fracture patterns and low-energy soft tissue injuries. On the other hand, minimally invasive approaches allowed to treat more complex injuries with less soft tissue damage; the aim of current guidelines is to balance surgical damage to the blood supply to soft tissues and bone with adequate reduction of the fracture fragments in order to restore functional anatomy and biomechanics.

Early and Safe Mobilization of the Injured Part and the Patient as a Whole

The final goal of fracture care is to provide the patient with return to his pre-fracture status, allowing the patient to restore his/her preoperative function as soon as possible. Postoperative weight-bearing will depend on many factors including level of the fracture (articular vs. nonarticular), effectiveness in the reduction technique, and the type of fixation used.

Case Example (Articular)

A 65-year-old woman fell off the stairs, sustaining an isolated right ankle injury (Fig. 1.1). She presented at the emergency department 10 h later. She was a retired lawyer and worked part-time, being at that time an avid tennis player, without relevant past medical history issues, otherwise healthy. She was initially treated with closed reduction and a splint (Figs. 1.2 and 1.3). Since the fracture was articular, displaced, and unstable, 10 days later she underwent open reduction and internal fixation through a combined postero-medial approach and mini-lateral approach (Figs. 1.4, 1.5, and 1.6).



Fig. 1.1 Radiographic images of a right ankle fracture-dislocation, with associated posterior malleolus fracture. A clinical image of the associated soft tissue injury on the medial aspect of the foot and ankle, showing no open wound, is depicted in the right figure

Fig. 1.2 CT scan of the same patient showing a posterior malleolus fracture that extended from lateral to medial and a small fragment of the distal fibula, as well as a posterior ankle dislocation

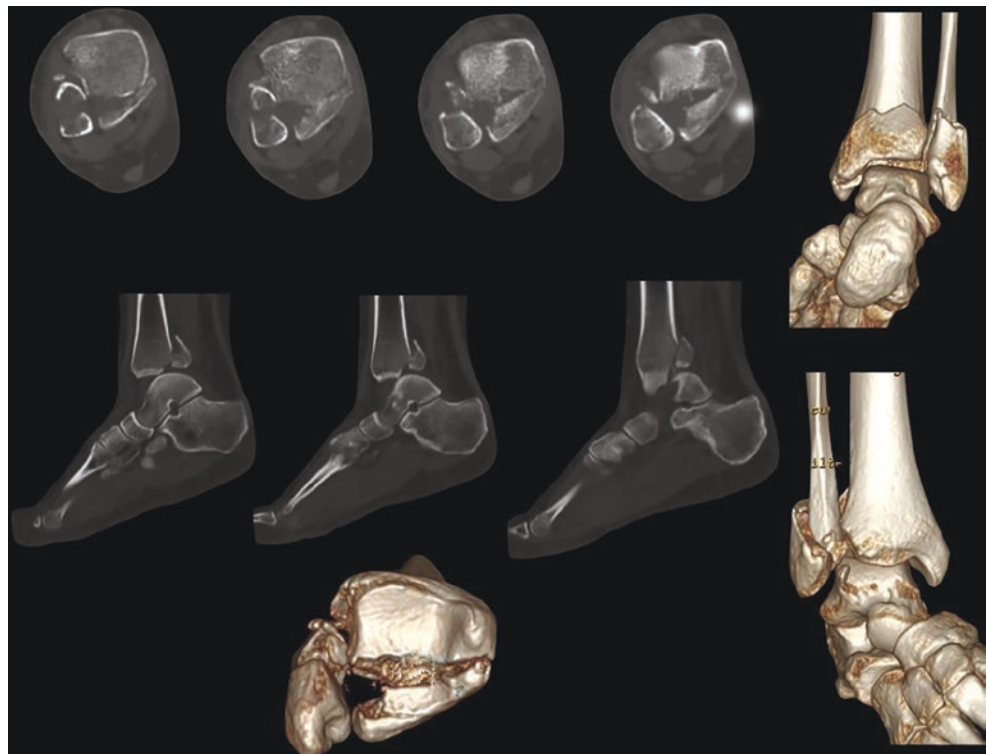


Fig. 1.3 Patient is placed in prone position with a bump to elevate the fractured ankle, using gravity to help reduce the posterior ankle dislocation

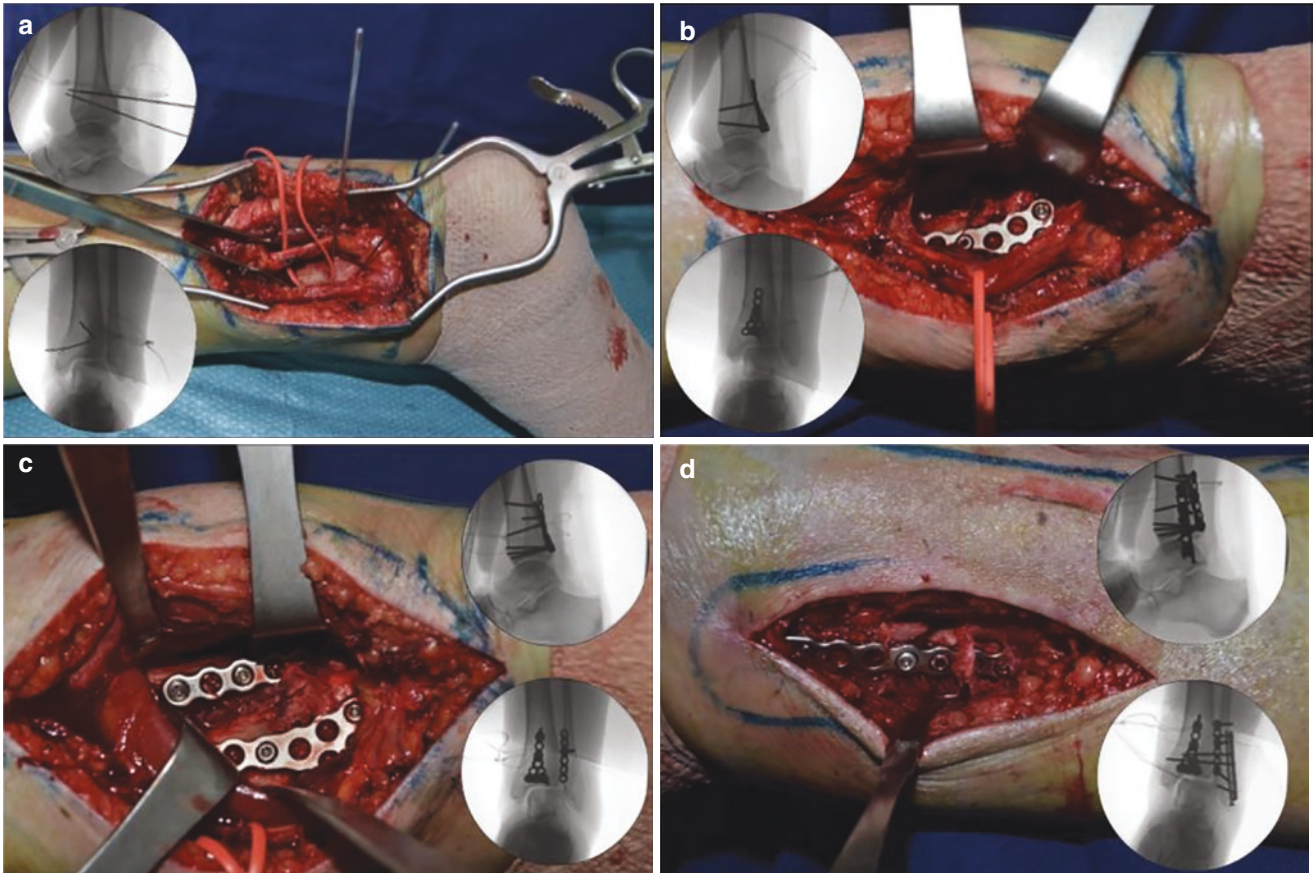
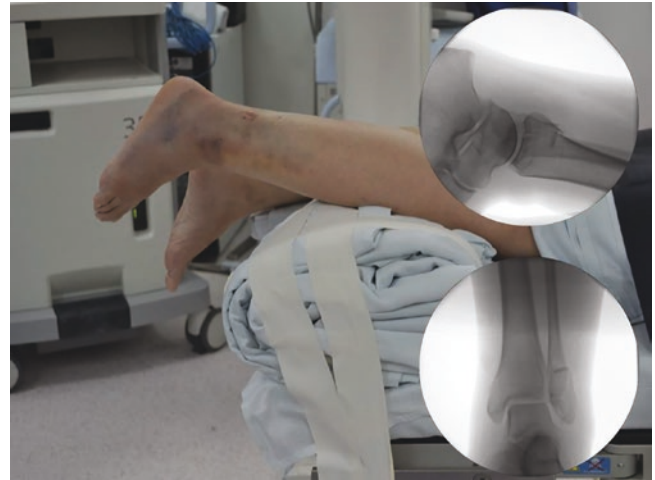


Fig. 1.4 Sequence of fracture reduction. An open reduction and internal fixation was done through an extended posteromedial approach. (a) Posteromedial approach (avoiding the soft tissue injury which was located more anteriorly) and fracture reduction using Kirschner wires under image control. (b) Posterior malleolus fixation providing absolute stability with lag screws through a plate acting as buttress. (c)

Fixation of the distal fibula through the same approach. (d) Lateral approach to fix the fibula using a second plate, an intramedullary screw, and two syndesmosis screws to reduce and stabilize the syndesmosis

Fig. 1.5 Immediate postoperative x-rays showing an anatomical reduction of the joint, restoring ankle anatomy



Fig. 1.6 Radiographic and clinical images of the same patient at 1-year follow-up, with the fracture healed and with good function and range of motion of the ankle

Case Example (Diaphyseal)

A 22 year-old male sustained an isolated trauma to his right leg. He presented to the emergency department 2 h later with

shortening and external rotation deformity and soft tissues with small blisters on the medial side of the ankle. He was immobilized in a backslab and taken 4 h later to surgery (Figs. 1.7, 1.8, 1.9, 1.10, and 1.11).

Fig. 1.7 X-rays showing a spiral midshaft tibia fracture with a proximal spiral fibula fracture. Soft tissues status with clear blisters on the medial side. Marked on the skin is the planned incision and *site for Schanz pins for the distractor device

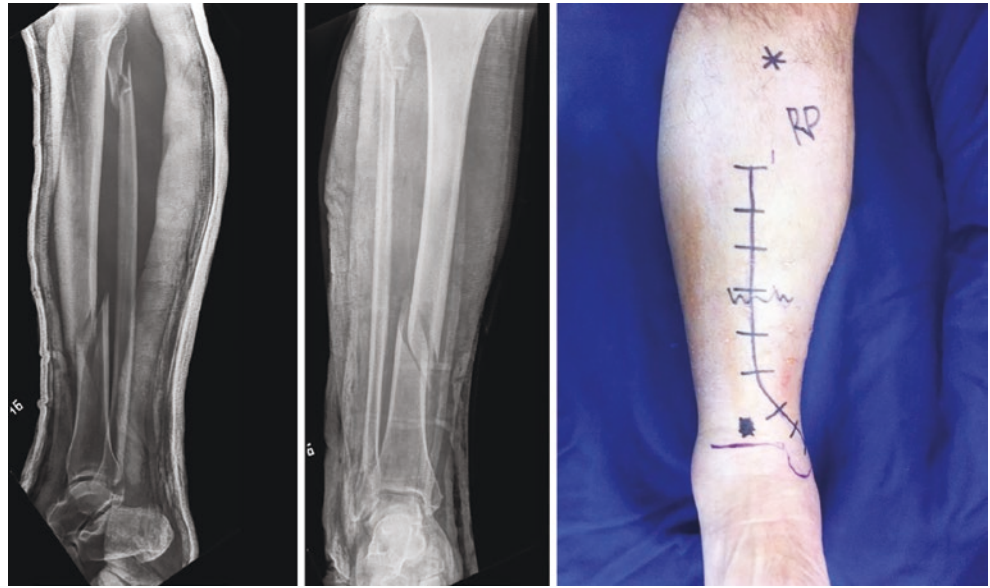


Fig. 1.8 (a) The “femoral” distractor was used anteriorly to gain length. A formal open reduction through an anteromedial approach was done, using small retractors and respecting the periosteum. (b) Reduction using pointed reduction clamps and lag screw fixation. (c) Medial contoured DCP plate used as a neutralization plate

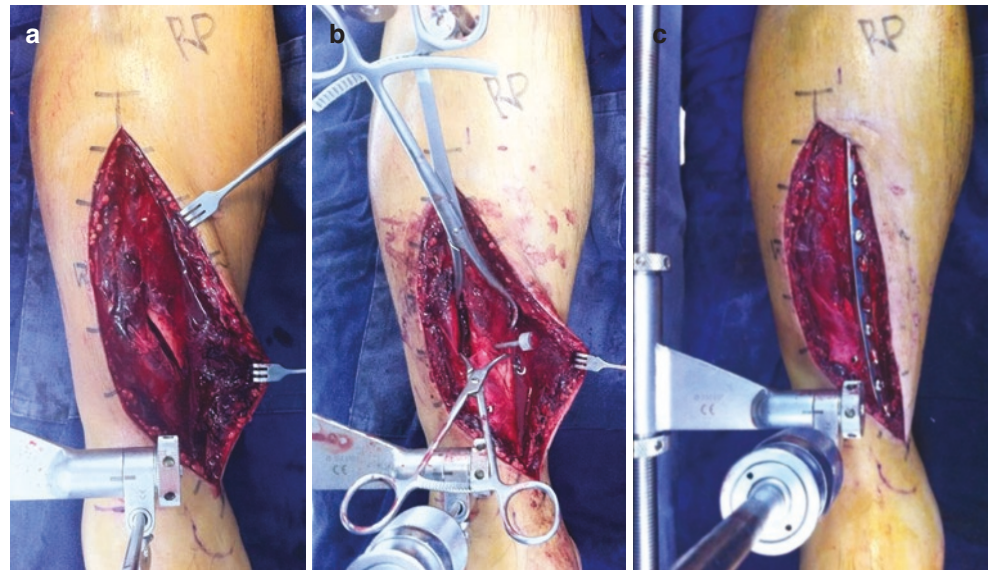


Fig. 1.9 Immediate postoperative x rays and wound after closure. Two small fragment lag screws outside the plate can be appreciated, as well as a 4.5 mm DCP plate used as a neutralization plate

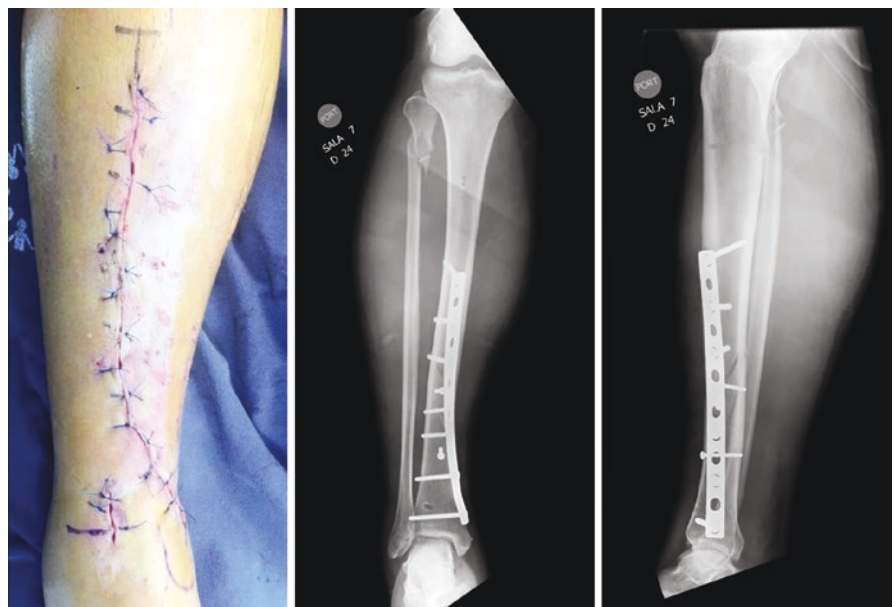




Fig. 1.10 X rays and clinical picture 2 weeks after surgery



Fig. 1.11 Radiographic and clinical images of the same patient at 1-year follow-up, with the fracture healed and with good function and range of motion of the ankle

Summary

The principles of fracture care have evolved over time, but in 2022 they have been summarized as:

- Fracture reduction and fixation in order to restore anatomic relationships.
- Fracture fixation providing absolute or relative stability as required by the personality of the fracture, the patient, and the injury.
- Preservation of the blood supply to the soft tissues and bone by gentle reduction manoeuvres and careful handling.
- Early and safe mobilization of the injured limb and the patient as a whole.

Key Points

- Reduce the fracture fragments appropriately.
- Provide the necessary stability according to fracture pattern and location on the bone.
- Respect the soft tissues.
- Restore function.

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