Changes in the concepts of internal fixation

Alaa El-Din El-Zoheiry

Department of Orthopedic/Trauma Surgery,
Suez Canal University, Ismailia, Egypt

Correspondence to Alaa El-Din El-Zoheiry, MD,
Department of Orthopedic/Trauma Surgery,
Suez Canal University, Ismailia, Egypt
Tel: +20 100 145 7148;
fax: +00202 23930054;
e-mail: elzoheiry2002@hotmail.com

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History and introduction

Before the founding of the AO principles of internal fixation for treatment of fractures, the results of internal and external fixation were usually worse when compared with those of nonoperative treatments. Internal fixation was usually accompanied by prolonged immobilization.

(1) Ambroise Paré (1510–1590) was a French surgeon. He used external fixation in 1561 [1] (Fig. 1).
(2) Clayton Parkhill (1860–1902) was born in Vanderbilt, Pennsylvania, USA. He conducted a clinical trial in 1897 using an external fixator; eight of nine patients achieved union. The device consisted of four screws fixed with a series of plates and bolts [2] (Fig. 2).
(3) Albin Lambotte (1886–1955) was born in Brussels. He was a Belgian surgeon who pioneered documentation. He used an external fixator in 1902. He was the innovator of stable internal fixation [3].
(4) George Perkins (1892–1979) was an English orthopedic surgeon from Oxford. He explained that most disabilities occurring after fractures are related to the treatment and not to the pathology (fracture disease). Prolonged immobilization and nonweight bearing resulted in stiffness, muscle atrophy, skin atrophy, and circulatory dysfunction. He proposed that to prevent fracture disease, the affected limb must be mobilized. He also proposed that internal fixation is the solution to the problem of moving the limb yet holding the fracture in place [4].
(5) Robert Danis (1880–1962) was born in Belgium. He applied plates to fractures to obtain compression. He reported that a primary union could occur without callus formation [5] (Fig. 3).
(6) William Arbuthnot Lane (1856–1943) was born in Fort George, Scotland. He achieved interfragmentary compression with screws and plates. This procedure was known as ‘bone plating’ [6] (Fig. 4).

The pioneers of AO foundation [8,9]

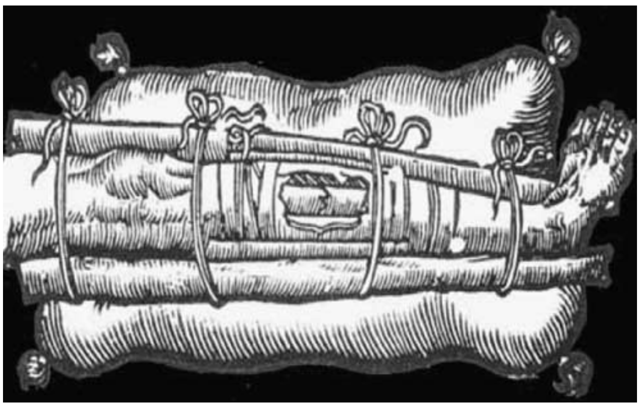
The AO foundation was founded on 6 November 1958, in Bienne, Switzerland.

(1) Maurice E Mueller was born on 28 March 1918, in Canton Bern, Switzerland.
(2) Robert Schneider was born in 1912, in Biel, Switzerland.
(3) Hans Willenegger was born on 6 January 1910, in the alpine area near Bern, Switzerland.
(4) Martin Allgoewer was born on 5 May 1917, in St Gallen, Switzerland.
(5) Walter Bandi was born in 1912, in Canton Bern, Switzerland.

Biomechanics of internal fixation

The AO principles related to fracture surgery describe the importance of soft tissues in fracture surgery and

Figure 1



An old external fixator used in 1561.

Figure 2

Another type of external fixator used in 1897.

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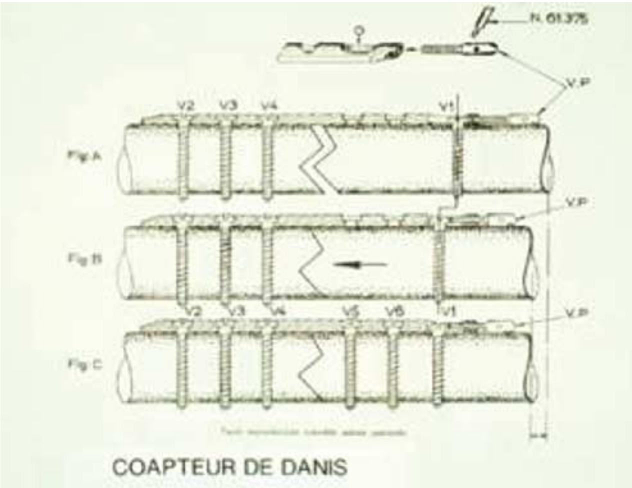
Figure 3



Old plates used by Robert Danis to treat fractures.

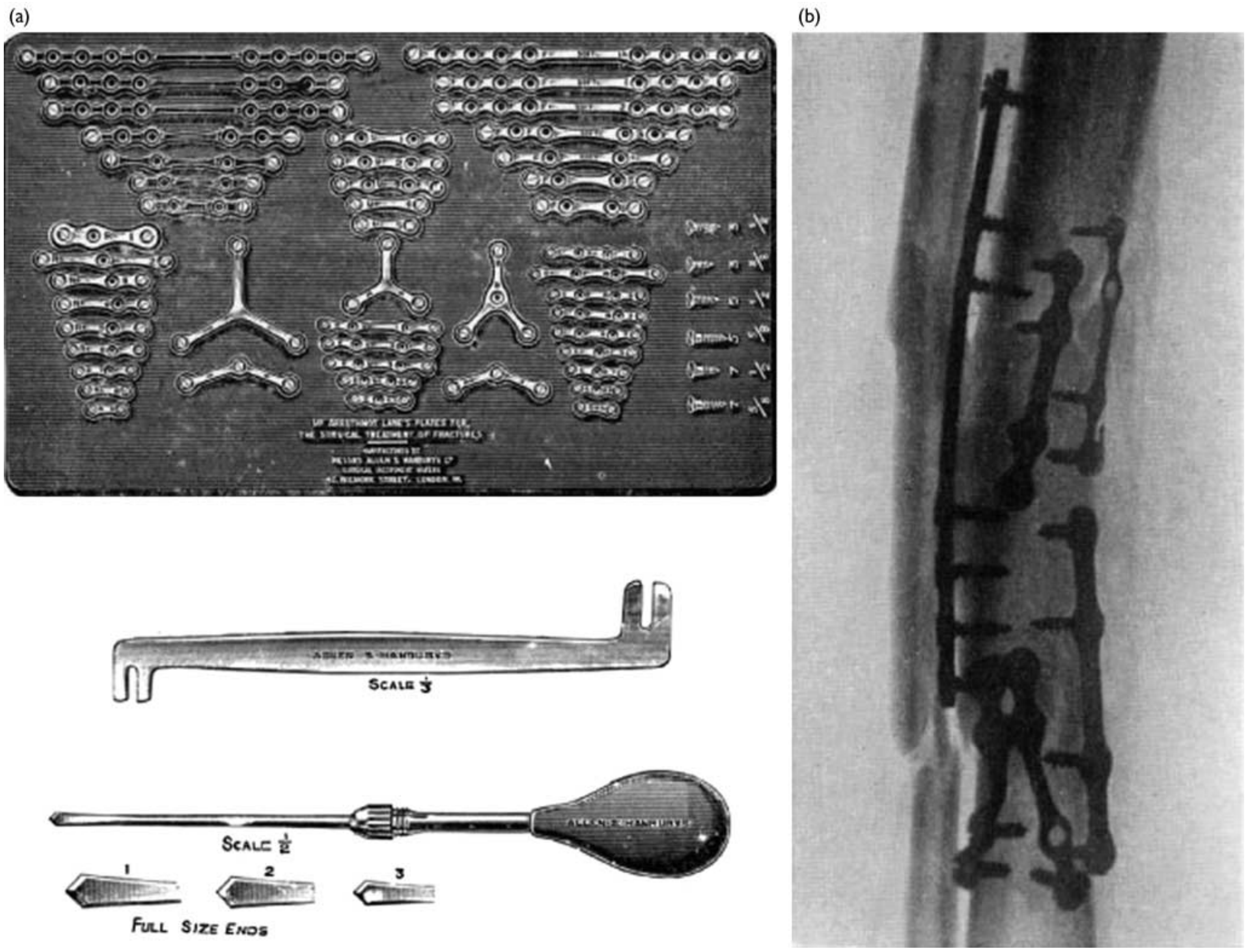
discuss the role of surgery in diaphyseal, metaphyseal, and articular fractures.

The original AO principles (1958) were anatomical reduction, rigid internal fixation, preservation of soft tissues, and early active mobilization.

Rueedi and Allgoewer documented 487 consecutive tibial shaft fractures treated by plating. They achieved a union in 98% of cases but 3% of cases developed sepsis. The AO techniques were adopted worldwide in the 1970s. In Glasgow, the results were sepsis in 30% of cases and nonunion in 20%, on treating tibial shaft fractures by plating. At St Thomas' 20% of cases developed sepsis, and nonunion was observed in 20%.

These techniques did not take into consideration the importance of soft tissues and resulted in more injury and required prolonged immobilization leading to a stiff atrophied limb (Fig. 5).

Figure 4



(a) Lane's set of plates and instruments. (b) A skiagram, taken April 2, 1911, showing repositioning of the parts, 2 months after surgery. The formation of new bone is indicated but is faint. From Lane [7]. Photograph courtesy of Library, College of Physicians of Philadelphia.

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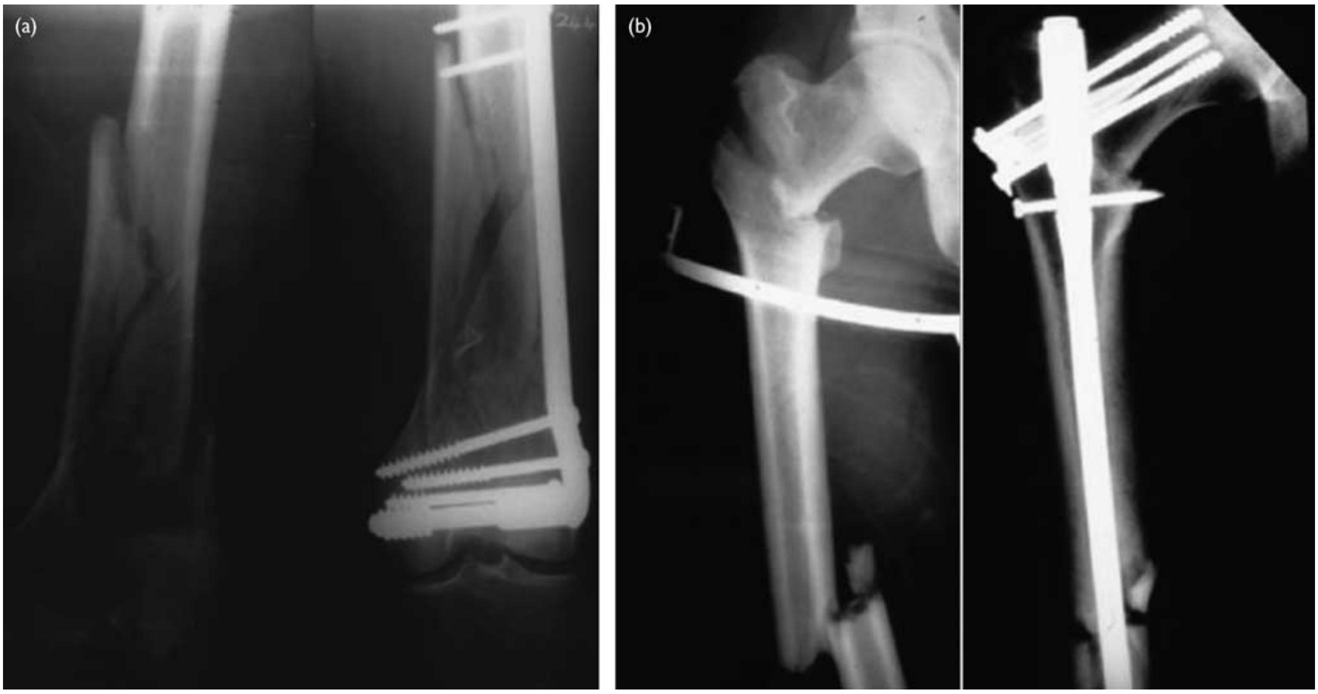
Figure 5

(a, b) Internal fixation did not take into consideration the importance of the soft tissues.

Figure 6



(a) Relative stability using fixation by plating. (b) Relative stability using fixation by intramedullary nailing.

Evolution of AO principles

Preservation of the blood supply is essential by redesigning the plates to reduce the footprint of these plates on the periosteum and bone using low-contact dynamic compression plates. It is also essential to improve the biology by changing the surgical technique, as open reduction devitalizes the bone; in contrast, indirect reduction is more soft-tissue friendly. Intra-articular fractures need anatomical reduction and absolute stability with no micromotion at the fracture site; however, shaft fractures need relative stability with restoration of the length, axis, and rotation for the normal function to be restored (functional reduction) using plates or intramedullary nailing [10–15] (Fig. 6).

The final AO principles, from conception in 2004 until now, include: preservation of the blood supply, functional reduction, stable fixation, and early active mobilization.

The use of less invasive techniques of internal fixation for treating fractures of the long bones resulted in very satisfactory results [16–18] (Fig. 7).

Summary

The aims and objectives of the AO principles are as follows:

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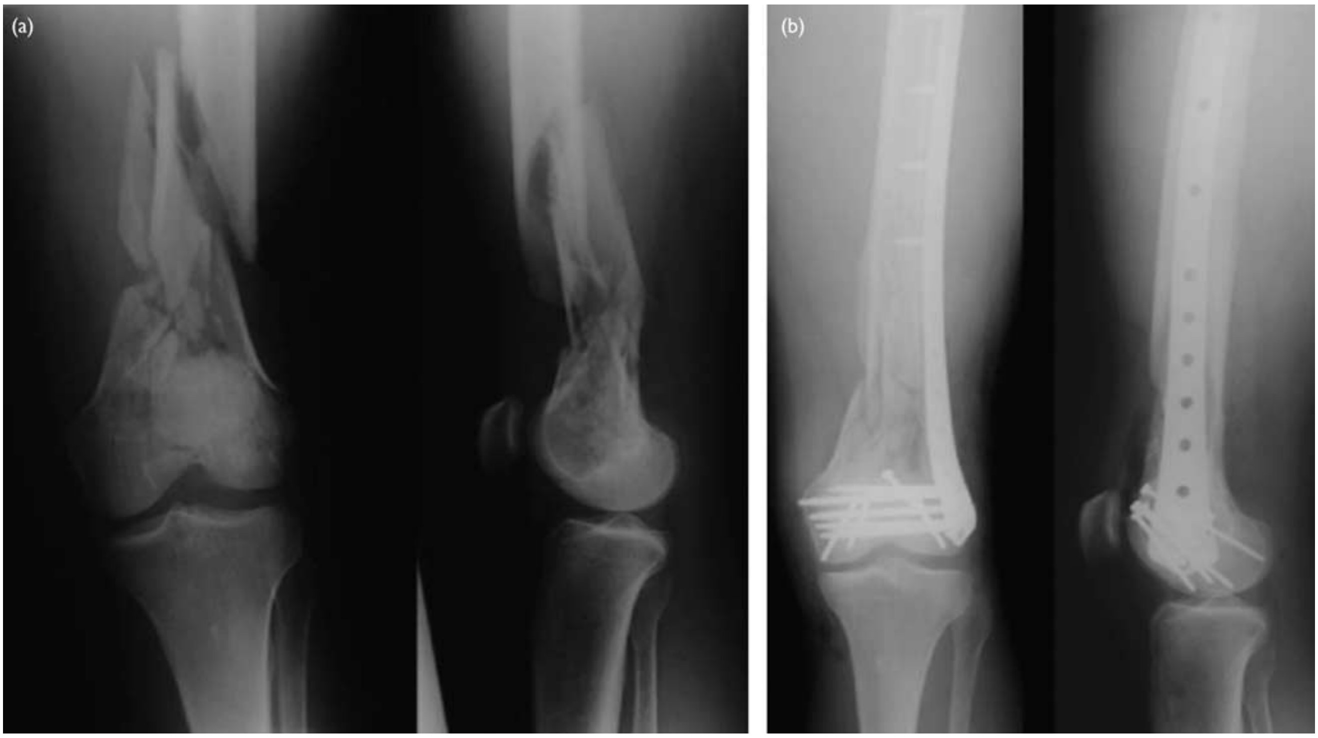
Figure 7



(a, b) Less invasive techniques of internal fixation.

(1) Taking care of the complications associated with fracture disease.
(2) Providing anatomical reduction and absolute stability for intra-articular fractures and relative stability (functional reduction) for shaft fractures.
(3) Focusing on the importance of soft-tissue care.

The objectives and treatment techniques may undergo modifications in time, but improvement of patient care will always be the foundation upon which these principles are based.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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