As with all of medicine, orthopedics is an ever-evolving science. While locking implants are a relatively recent addition to veterinary orthopedics, they have been used for humans for some time. To better understand where we are, and where we are going, with fracture repair and locking implants, we first need to look back on the history of fracture fixation – a fascinating journey through the brilliant minds of our predecessors.

In the mid-1700s, John Hunter was the first surgeon to define the four stages of callus formation during fracture repair. Around the same time, Albrecht von Haller noted that bone healing was dependent on the vascularity around the fractured region of the bone, emphasizing the role of blood supply in fracture healing. Henri Duhamel disagreed, thinking that all bone arose from the periosteum, and coined the term *cambium layer* [1].

In 1736, John Belchier was the first to identify the important role of osteoblasts in fracture healing, and in the 1840s, John Good sir confirmed that osteoblasts were the true bone-forming cells [1]. This led some, including Sir William Mac ewen, to focus strongly on the osteoblast and ignore the role of the periosteum [1]. In the late 1800s, Louis Ollier, like Duhamel, felt more than osteoblasts were in play in fracture repair. He believed that in addition to osteoblasts, the periosteum and the bone marrow all contributed to bone repair; he recommended the periosteum be protected during surgery [1].

In 1886, Carl Hansmann invented the first bone plate and screws. Ironically, it was a locking plate that protruded through the skin [1]. By contrast, Halsted in 1893 and Lane in 1894, utilized the first completely implanted plates [1].

In 1912, William Sherman, who was a surgeon for the Pittsburgh Steel Company, designed plates with better metallurgy and engineering due to this connection. Because of his improved production knowledge, his plates did not corrode or break and were the most widely used plates until the Association for Osteosynthesis (AO) plates were introduced 50 years later [1].

Up until this point, the plates in use were not designed with compression in mind; rather, they served only to stabilize and align the bone as a replacement for external splinting, similar to current locking plates. In 1946, Eggers performed experiments on animals with induced fractures to show the effects of fracture site compression on the rate of healing and, in 1949,
Robert Danis was the first to apply compression plating to human patients [1].

A decade later, George Bagby was the first to use a plate similar in design to the dynamic compression plates (DCP) used today. His plates had oval-shaped holes with beveled edges that allowed the plate to slide into compression as the screw was tightened [1].

On November 6, 1958, a critical moment in orthopedics history occurred: Arbeitsgemeinschaft fur Osteosynthesefragen (Association for Osteosynthesis) was formed by 13 surgeons in Switzerland [1, 2]. This group’s unprecedented collective focus on the study of biomechanics, osteogenesis, implants, and instruments, as well as orthopedic techniques and postoperative care, ushered in a new era. Additionally, they focused on orthopedic continuing education through instructional courses and labs and published the first AO manual in 1963 [2, 3] followed by Techniques of Internal Fixation of Fractures, published in 1965 [2]. The critical principles of primary focus in these early editions were that of anatomic reduction and rigid fixation [2]. It was thought that fracture healing with no callus formation was most desired, and that the presence of callus formation was considered a sign of instability and inappropriate repair. Willeneger and Schenk’s research on direct bone healing reinforced this theory [2, 3].

On 31 August 1969, AOVET was founded in Waldenburg, Switzerland (Figure 1.1a–d) [3]. In the decade prior to its formation, a beautiful collaboration between veterinary and human surgeons and engineers had blossomed. Transfer of knowledge between disciplines was initiated as never before in veterinary surgery, most notably by Dr. Guggenbuhl, one of the original 13 AO founders, and Dr. von Salis, a large animal veterinarian and first president of AOVET. This relationship and collaboration with von Salis’s colleagues led to the AOVET formation [3]. One of the first documented fracture cases in a dog repaired using AO principles and plates was a femur fracture in a Spitz, performed on 3 February 1969 by Dr. Geri Kasa with a four-hole 4.5 mm round hole plate (Figure 1.2) [3].

In 1970, Allgower and Perren continued research on the Bagby design and developed a sophisticated plate called the dynamic compression unit. Compression could be achieved in any equally spaced hole on either side of the fracture. Consistent fracture healing and early return to function were noted in patients treated with these plates, and the previously common “fracture disease” problem was disappearing [2]. It was also noted that complications such as sepsis, sequestrum formation, union difficulties, and re-fracture were occurring using these rigid techniques. Focus was redirected toward the effect of the plate on the bone surface and its blood supply [2].

At this same time, Dr. Hohn began the first, and soon to become annual, AOVET course held in the United States at The Ohio State University (Figure 1.3). Dr. Hohn had been the first to perform a canine fracture repair using AO principles in the United States at the Animal Medical Center in New York, as a part of a fantastic collaboration with Dr. Rosen, the first AO principled human orthopedic surgeon in the United States [3].

In 1982 and 1984, the first AO manuals on internal fixation in the horse and small animals, respectively, were published [3].

Stephen Perren built on the initial research of Ollier and in 1988 focused on the periosteum once again. He disagreed with the thought that stress protection from the plate led to osteoporosis of the bone under the plate, and, through his research, was able to prove that periosteal blood supply damage led to necrosis of the bone under the plate. This led to the development of the limited-contact dynamic compression plate (LC-DCP) in 1990 [1]. He also felt that strong compression and complete stability led to vascular damage, and instead he promoted relative stability and favored callus formation. He used longer plates with fewer screws, which favored faster healing with a mechanically strong callus [1].

Also in 1990, Reinhold Ganz developed the model of biologic fixation, promoting the “open but do not touch” approach and the use of long plates with fewer screws as well. Less emphasis was placed on complete reduction and absolute fracture site stability, but rather on alignment and relative stability with an expectation of callus formation. It was noted that fast and predictable bone healing occurred in this manner [2].

In 1997, this approach was taken even further by Chistian Krettek and Harald Tscherne, who developed the concepts of minimally invasive
plate osteosynthesis (MIPO), which produced rapid bone healing with a larger amounts of callus formation [1, 2].

One advantage that external skeletal fixator application historically had over internal fixation was lesser operative injury – that injury caused by the fracture approach, reduction and fixation. This consideration was translated into the creation of internal fixators. Perren and Tepic introduced the concept of locking implants (i.e. internal fixators) in 1993 when they created the Point Contact Fixator using monocortical locking screws and a plate with similar shape and design to the LC-DCP [1]. Next in line was the creation of the less-invasive stabilization system (LISS), which may be considered the first plate particularly designed for MIPO [2].

Seven years later, Wagner and Frigg created the combi-hole plate that allowed both...
In 2004, Boudrieau published the first case report of use of a locking plate in a dog, in which a severe malocclusion from previous hemimandibulectomy was reconstructed [4]. The following year, Keller described the use of the compact unlock system in small animal orthopedics [5] and Aguila et al. published the first biomechanical study comparing LC-DCP and locking compression plate (LCP) in cadaver canine femurs [6].

The AO research center began testing the concepts of bridging fixation in small animals using 18 different plates commonly used in small animals in 2008 [7]. This laid the groundwork for future research of MIPO. That same year, locking technology moved out of the realm of trauma and was applied to tibial plateau leveling osteotomy [8], and later reports were published on vertebral applications, double pelvic osteotomy and arthrodesis [9, 10, 11]. Since these early reports, research on and the clinical use of locking implant technology has grown exponentially in veterinary medicine.

The founders of orthopedics worked tirelessly to understand bone and biomechanics and their effects on fracture pathology and management, all to better the lives of their patients, both human and animal alike. We must continue to follow their examples and strive for perfection as we pursue the most ideal management of fractures and other orthopedic conditions.

Figure 1.2  (a, b) One of the first documented fracture cases in a dog repaired using AO principles and plates; a femur fracture in a Spitz, performed on February 3, 1969, by Dr. Geri Kasa with a four-hole 4.5 mm round hole plate. (Source: Courtesy of AO Foundation.)

Figure 1.3  The first AOVET course held in the United States at The Ohio State University, 1970. (Source: Courtesy of AO Foundation.)
References
