HISTORICAL NOTE

The instruments of the bonesetter

Orthopaedic surgeons use a variety of instruments to help correct, treat, and heal bone disease. The development of these instruments mirrors the history of orthopaedic surgery. The history of bonesetting, the treatment and replacement of joints, and of those who performed these techniques, appears to originate deep in antiquity. Changing ideas within medicine and surgery over the last 200 years have shaped the discovery and evolution of orthopaedic instruments and of the bonesetters themselves. Advances have led to the use of computers as instruments in the navigational guidance of arthroplasty surgery, the use of robotics, the development of cordless drills and improvements in the design of blades to cut bone. Yet some of the old instruments remain; plaster of Paris bandages, the Thomas Splint, Liston’s bonecutter, Gigli’s saw, bone nibblers and Macewan’s osteotomes are still in use.

This paper presents a historical review of bonesetters and examines how orthopaedic instruments have evolved from antiquity to the 21st century.

In 1964 Marshall McLuhan (1911–1980) said “We shape our tools and afterwards our tools shape us”.1 This is evident in orthopaedic surgery where the development of instruments is intertwined with the history of the specialty.

The history of bonesetting, involving the treatment of fractures and reduction of joints, and the ‘bonesetters’ who performed these techniques, appears to originate deep in antiquity. The Edwin Smith papyrus of 1552 BC, the earliest known medical text, described the Ancient Egyptian treatment of fractures and dislocations.2 The early bonesetters treated fractures of the limb by applying a wooden splint wrapped in bandages, or a type of plaster made from cows milk, barley or acacia leaves held with gum and water, to surround the limb.3 Evidence of this has been found amongst the skeletal remains of workers on the pyramids of Ancient Egypt. It is unclear, however, whether they performed amputations, and little is known of the type of instruments which were used. Hippocrates (460–375 BC), writing in 400 BC, suggested that to aid the reduction of open fractures “one must have iron rods made like levers, used by stone-masons, broader at one end and narrower at the other. There should be three... while extension is going on, to make leverage, pressing the under side of the iron on the lower bone, and the upper side against the upper bone... the iron should be as strong as possible so as not to bend”.4

In the 16th century the dissolution of the monasteries in the British Isles allowed nuns and monks with some concepts of medicine to become healers and bonesetters.2,5 Local priests also used prayers, incantations and their ‘healing hands’ as their ‘instruments’ for manipulation of fractures and healing.2 However, the majority of bonesetters were not from a religious background. They were self-taught with skills which had been passed on from one generation to the next. Families such as the Matthews of the Midlands, the Thomas’s of Anglesey and the Taylors of Whitworth remained bonesetters for over 200 years.6,7 Sadly, little evidence exists about their methods of manipulation and the instruments they may have used. Some case reports survive, but little is known of their clinical results.

To the educated professional medical establishment of 18th century Great Britain, bonesetters were seen as ‘Quacks’, such as the famous Sarah Mapp (d.1737), also known as ‘Crazy Sally’. “In most cases her success was rather due to the strength of her arms, and the boldness of her undertakings, than any knowledge of anatomy or skill of surgical operations”.8 Popular culture reinforced this idea. Her portrait was characterised by George Cruickshank (1792–1878) in ‘Portrait of Sarah “Crazy Sally” Mapp Bone-Setter’ and by William Hogarth (1697–1764) in his etching ‘The Company of Undertakers
(Consultation of Quacks)” (Fig. 1), as well as in a comedy play by Charles Johnson (1679–1748), *The Husband’s Relief; or The Female Bonesetter and the Worm Doctor.* These negative perceptions were reinforced by the Apothecaries Act of 1815, which compelled surgeons to study similar courses to physicians, and led to the establishment of the medical registry in 1858. This resulted in some bonesetters being absorbed into the medical profession and interest in bone and joint surgery was encouraged, with the development of the instruments of the bonesetters into formal surgical tools.

Until the 19th century, surgery on compound fractures and gangrenous limbs was seen as the last resort for saving life or limb. The instruments used were designed to make the process of amputation as quick and as smooth as possible. In the 17th century basic knives used for amputation consisted of one small, straight double-edged catlin or ‘interosseous knife’, and a large single-edged knife with a slight curve in the blade (Fig. 2). The curved blade was used to divide the soft tissues in a rapid circular incision followed by a bone saw; the straight knife was only used to separate tissues between the tibia and the fibula, between the radius and the ulna and around the humerus (Fig. 3). The blades were made of an early type of steel which, being brittle, restricted their diameter and size, rendering them large and clumsy. It was thought that heavy blades cut through unanaesthetised tissue faster, making the amputation more tolerable to the patient.9

In the 18th century, saws used for amputation developed into two distinct types, the flat tenon saw and the large bow saw (Figs 2b and 2c). The bow saw, as used by butchers, consisted of a flexible, long, finely serrated blade held at each end by a frame with one end attached to a handle. Its frame and handle, once decorative in the 17th century, was gradually replaced by a simple plain version to avoid it catching on soft tissues. The tenon saw had a flat fine serrated blade attached to a simple grip handle based on a carpenter’s saw. The blade was reinforced along one edge to avoid buckling of the blade and prevent snagging and splitting of the bone. The refinement of steel by Benjamin Huntsman (1704–1776) in Sheffield around 1750 by beating in a crucible allowed the saw to become smaller, finer, lighter and less brittle.10 It is likely that the improved Sheffield steel prompted British bonesetters of the late 18th century to reject the bow saw, which tended to snap at crucial moments, and adopt the tenon saw, unlike the rest of Europe. Other saws began to emerge, such as the hand chain saw in 1785, which was pioneered by the Scottish surgeon John Aitken (Fig. 2e).11 It consisted of a single, finely serrated linked watch chain blade with a T-shaped or rounded handle, and was designed initially for symphysiostomy and the excision of joints. Its design led to the development of the circular saw by Machel in 1815, the hand powered chain saw by Heine in 1830, and the saw of Von Graefe in 1840, which had rotating circular blades to cut bone.9 They were all very slow machines that could not cut quickly through dense cortical bone and as a result, never became widely accepted. In 1894 it was the simple, inexpensive, twisted barbed-wire hand saw of Gigli, which
proved to be popular. It was effective, occupied minimal space and was soon adopted for use in the amputation of limbs, craniotomy and pelvic osteotomy. The bone-gouge forceps or bone nibblers, a type of scissors with a central pivot, were an alternative to cutting linearly through bone and cartilage. Being made of cast steel and with their blade contact ovoid or circular in shape enabled them to be strong enough to tear or bite through cancellous bone and cartilage. The bone cutting forceps (Fig. 2a) originally designed by Scultetus in 1653 and then reintroduced by Liston in 1820 were larger linear cutters. They were made of cast steel with one side of the blades flat which allowed them to amputate through phalanges, metacarpals and metatarsals “leaving a smooth divided surface without the least splintering”. In the early 19th century the treatment of fractures was by bed rest and restriction of activity, using wooden splints, bandages of fish paste and flour. War became the stage for the eventual emergence of a refined form of treatment for the bonesetter, the plaster of Paris bandage. Dominique Jean Larrey (1766–1842), a French army surgeon at the battle of Borodino in 1815, observed improved wound healing when a bandage stiffened with alcohol, lead acetate and egg whites was used to treat a soldier’s arm. Louis-Joseph Seutin (1793–1862), a Belgian surgeon, developed this further when treating casualties at the battle of Waterloo. He dipped his bandages in starch and applied them while wet to cardboard splints, which took between two and three days to dry. It was not until 1854 that Antonius Mathijsen (1805–1878), a Dutch army surgeon, developed a quick drying plaster. He used coarse linen rubbed with plaster of Paris which was applied by hand, moistened with water from a brush or sponge, and dried in eight minutes. The advantages of such splintage enabled the reduction to be held until the plaster dried, permitting early mobilisation.

The Crimean War of 1850 saw the plaster of Paris bandage achieve its true potential under the eye of Nikolay Ivanovich Pirogov (1810–1881). He was a surgeon in the Russian army, who believed that fractures from missile wounds should be stabilised in plaster before leaving the field hospital. His technique of plastering involved covering the limb with a soft bandage and then applying coarse linen strips soaked in plaster of Paris. Word spread of its advantages, but not all favoured or adopted these methods. Hugh Owen Thomas (1834–1891), one of the pioneers of British orthopaedic surgery and a descendent of a family of Welsh bonesetters, condemned its use, stating: “Confining a lesion to plaster of Paris or to compressive bandages is not rest, but the opposite of it, and a method of starving and injuring a diseased part, which is already below the standard of normal viability.” Both he and his nephew Robert Jones (1857–1933) believed that plaster prohibited other means of immobilisation and, by preventing air reaching the skin, caused atrophy and deterioration of the skin. Instead, in 1865, he devised a calliper splint, known as the ‘Thomas splint’, which was initially used for treating cases of tuberculosis of the knee. It consisted of two rings; one a large proximal padded oval ring and the other a small distal ring, attached to two iron rods. The inner rod was fixed to the oval ring at 45° and leather strapping was applied between the bars to support the leg. The oval ring was placed round the ischial tuberosity as a fixed point, whilst the leg was held on the splint by means of bandages. By applying a patten to the distal ring and modifying the shoe on the opposite leg, the patient was able to mobilise. It was not until the First World War when Robert Jones was appointed Consultant Orthopaedic Surgeon to the British Army that the Thomas knee splint was adopted for fractures of the middle and lower thirds of the femur, the knee and the proximal tibia. Its introduction, together with improved methods of evacuation and treatment, improved the mortality of femoral fractures at clearing stations from 80% to nearly 12%. The industrial revolutions in England and America at the start of the 19th century led many of the lower social classes to move from the country to work and live in cities. Poor sanitation, crowded living conditions and inadequate nutrition encouraged diseases and epidemics. Joint tuberculosis and rickets were common, leading many people to develop bone and joint deformities. The discovery of anaesthesia in 1846 and Joseph Lister’s (1827–1912) antiseptic technique published in The Lancet in 1867, changed the
performed in Britain”. At that time osteotomies were performed using a variety of instruments such as trephines, gimlets, bone perforators, chain saws, round saws, ordinary saws and chisels. To Macewen, the selection of the correct instrument for the purpose of osteotomy was paramount, the aim being to “effect the osseous divisions with the lease disturbance of the soft parts”. He felt that saws frequently caused soft-tissue damage and left bone debris, whilst chisels avoided “these objections”.

Chisels were originally designed from the tools of carpenters and masons and made of cast steel. The blade had a single bevelled edge allowing a wedge of bone to be cut and removed. Macewen had witnessed the disasters of surgeons using chisels to cut bone: “A case came under my own observation, where a surgeon, wanting to make a straight incision, used a thick chisel in form like a carpenter’s, which first made an oblique incision downwards, and on withdrawal and re-insertion with the sides of the chisel reversed, ended in production of a zig-zag osteotomy, accompanied by considerable comminution. The effect was disastrous, the patient dying in a few days”. In order to perform an osteotomy he needed an instrument that would cut in a controlled manner without removal of bone. In 1876 he designed the ‘osteotome’; an equal angled chisel with a symmetrical bevelled cutting edge (Fig. 4). The handle and blade were a continuous piece of equally weighted cast steel which had been polished to avoid any crevices in which organic matter could adhere and to allow thorough cleaning. The handle was octagonal rather than cylindrical, which Macewan felt had better grip and enabled “the operator to readily detect any deviation which the instrument might assume in the wound”. Delicate depth markings were engraved on one of the borders of the blade so that the depth of bone penetration could be established. He published his ideas, designs and practical application of the osteotome in his book of 1880, which became popular internationally, being translated into Italian in 1883 and German in 1885.

Accessing the deeper bones and joints of the body brought its own new challenges to the surgeon, who frequently worked alone. Pratt and Lowman designed a circular self-retaining retractor which surrounded the limb externally but whose teeth retracted the wound edges. Hey Groves developed a sickle-ended retractor which was placed behind the bone and held in place by a rod which attached to it against the tension of the surrounding soft tissues. Instruments were designed with longer handles such as the bone-holding forceps of Farabeuf and Lambotte, enabling deeper structures including open fractures to be held aseptically, without manual contamination, so reinforcing the ‘no touch’ technique described by Arbuthnot Lane. After the introduction of thermal sterilisation these were made entirely of plated cast steel to avoid rusting.

The availability of electricity and the development of power saws at the end of the 19th century by Doyen allowed rotation of the saw to increase to 2500 rpm. In about 1915 Fred Albee (1876–1955), an American surgeon, developed this technique with more powerful saws which could cut bone accurately, quickly and aseptically, especially for the purposes of bone grafting.

The 21st century bonesetter can be the educated orthopaedic surgeon, the chiropractor, the osteopath or the traditional bonesetter. In parts of the developing world the local traditional bonesetter is still very popular. Their methods and instruments are used to perform manipulation and immobilisation of joints and fractures. The results can be variable with alarming reports of gangrene, malunion and nonunion of fractures with resultant amputation. These complications can also occur with modern surgical techniques and instrumentation. All bonesetters, regardless of where they practice, are alert and conscious of the risks to the patient of their interventions.
Advances in orthopaedic surgery have led to the use of computers as robotic assistants, the use of instruments in the navigational guidance of arthroplasty surgery and to the use of cordless drills and blades to cut bone.\(^2^4\) However, some old instruments still remain. Plaster of Paris is frequently used to maintain reduction of fractures. Bandages made of fibreglass impregnated with polyurethane have the advantage of drying quicker and creating a lighter plaster, but they cannot be moulded as easily as plaster of Paris. The design of the Thomas splint remains the same today, with modern materials replacing the leather padding around the oval ring and the straps between the rods, and it still has use in the treatment of femoral fractures. Liston’s bonecutter, Gigli’s saw and bone nibblers and Macewan’s osteotome have changed little from their original designs, except they are now made of stainless steel, and have a wider variety of sizes, but they are still used in trauma and elective orthopaedic surgery.

The bonesetters and their role have changed through time, although evidence of their origins still exists through descriptions, drawings, and their instruments. Some of their instruments have stood the test of time. With future surgical advancements, our instruments may develop to meet new requirements, but some instruments documented here may well remain in use for yet another 150 years.

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