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Review

The history and evolution of surgical instruments. Part XII: Complex, auxiliary and subsidiary instruments

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The arsenal of the surgeon should be as simple as its demands make possible; its contents are already very complex indeed

Doyen, 1917[1]

We are presently operating on patients, with instruments that are as crude as agricultural machinery compared with the technology of advanced avionics …

Wickham, 1994[2]

The final part of this series aims to simplify previous deductions and to classify more complicated elements of the surgical armamentarium, including items escaping analysis so far. To recapitulate earlier conclusions, noted in parts 4–11 inclusive, instruments were categorised into eight groups related to the following physical characters: (A) probe or blunt form; (B) point or needle form; (C) flat or blade form, including saws; (D) tubular or cannulated form; (E) spring forceps or tongs form; (F) pivot forceps (centric) or clamping form; (G) pivot forceps (centric) or scissors form; and (H) pivot forceps (incentric) or dilating form (Fig. 1A–H).

Exceptions to this scheme are instruments of more complex or anomalous design, including mechanised structures which are now accorded closer analysis. In addition, certain other instruments, some examined previously, require clarification in relation to the following characteristics. First, compound instruments which combine two or more of the structural forms enumerated above. Second, auxiliary or subsidiary instruments such as needle-holders which do not themselves invade the tissues, unlike the needles they hold. Third, certain diagnostic instruments which have additional therapeutic applications of a surgical character. Finally, specific instrumentation employed solely to locate implants and prostheses in the tissues, remembering these foreign bodies are not surgical instruments.

Complex or anomalous instruments

Complex instruments are not easily related to the eight basic structural forms, even if their final function can be

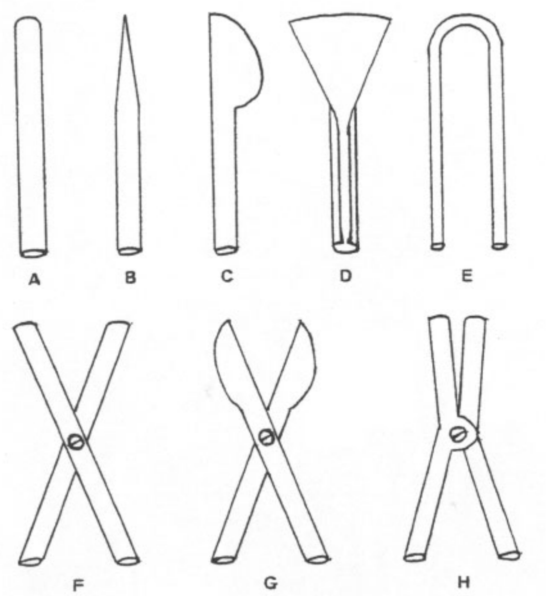

Figure 1 (A–H) Basic instrument structural forms.

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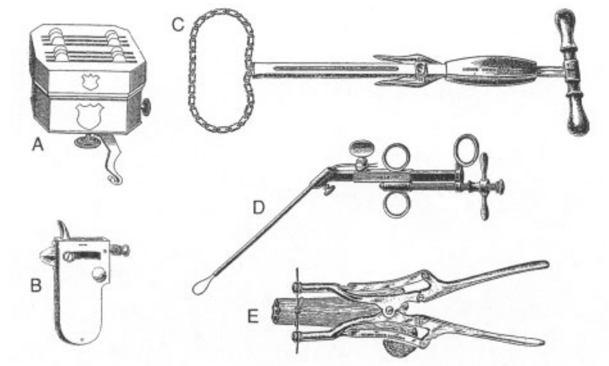

Figure 2 (A) Automatic box scarificator with 12 blades for wet cupping, by Maw, 1888. (B) Automatic spring lancet with single blade for venesection, by Maw, 1888. (C) Chassaignac's chain ecraseur for tumour strangulation, by Down, 1906. (D) Vacher's wire snare for tonsillectomy, by Collin, 1935. (E) Harris's wire tightener, for bones, Down, 1952.

identified, for example, with incision, crushing, suturing, traction and so on. The following groups of instruments are selected to illustrate complex forms.

Automatic scarificators, vaccinators and gum lancets

Box scarificators (Fig. 2A), some with up to 20 blades, are triggered automatically by powerful springs to incise skin to a predetermined depth, unseen by the operator who simply holds the box firmly against the chosen area, usually the back or chest wall. Automatic leeches, automatic vaccinators and spring lancets (Fig. 2B) act in a similar fashion. A recently devised miniature automatic lancet is also set to a predetermined depth, enabling diabetic patients to obtain their own blood samples.

Snares, ecraseurs and wire-tighteners

Snares employed suture material or wire for tonsillectomy (Fig. 2D), and ecraseurs a miniature chain (Fig. 2C) or whip-cord to excise tumours by gradual strangulation whilst achieving haemostasis. Certain wire-tighteners are also complex instruments (Fig. 2E), designed to stabilise bony tissues until united.

Lithotrites and tonsil guillotines

Superficially, lithotrites appear to be cylindrical instruments, similar to cystoscopes, whereas they are constructed from two interlocking sliding bars, the terminations of which crush bladder calculi.[3] Tonsil guillotines and uvulatomes are also composed of closely fitting sliding bars, one with a terminal fenestration into which a guillotine blade of the other engages.[4]

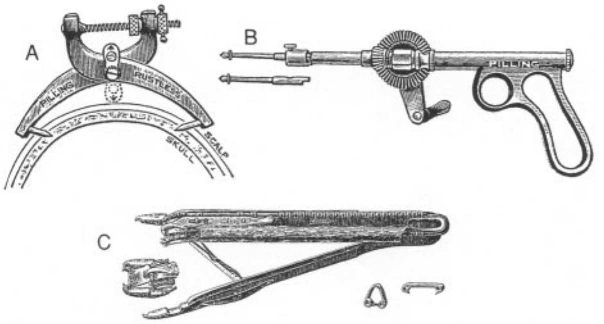

Figure 3 (A,B) Crutchfield's skull traction tongs inserted with brace and guarded drills, for neck trauma, by Pilling, 1943. (C) Michaux's semi-automatic forceps, for inserting Michel skin clips, by Collin, 1914.

Skeletal traction tongs

Traction tongs such as Crutchfield's (Fig. 3A,B) and Blackburn's for skull traction after neck trauma, and Pearson's 'ice-tongs' inserted into the femoral condyles for femoral fracture[5] incorporate both traction pins and traction stirrups in the same structure.

Staplers and stapling machines

The dispensation of Michel clips or staples, for skin suture, was partially mechanised by Michaux in 1900 (Fig. 3C). A fully automatic stapler for intestinal anastomosis was devised by Hultl in 1911; however, this weighed 5 kg and needed several hours to assemble. Later, De Petz improved this concept for gastrectomy[6] and, in 1956, Androsov made further refinements for gastric, oesophageal and colorectal anastomoses, and for bronchial closure. In the 1970s, pistol-like dispensers of fine stainless steel staples were introduced for skin closure.

Osteoclasts and joint wrenches

These large items of equipment were applied to correct bony deformities, mal-united fractures and club feet. Re-alignment was achieved without soft tissue incision, at the expense of damaging skin, ligaments, epiphyseal plates and growing bones by forcible leverage, the 'redressement brusque' of French surgeons;[7] certain 'instruments' could apply forces up to 1 ton weight (Fig. 4B). Most fell into disuse early in the 20th century, but the lesser leverage of the Thomas wrench (Fig. 4A) continued to be used, by British surgeons, until the 1960s.

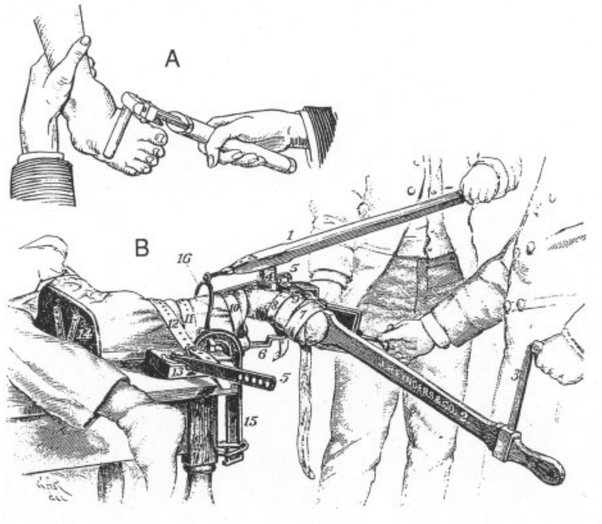

Figure 4 (A) Thomas's wrench, for club foot correction, devised 1886. (B) Phelps wrenching machine, requiring two operators, by Reynders, devised 1890.

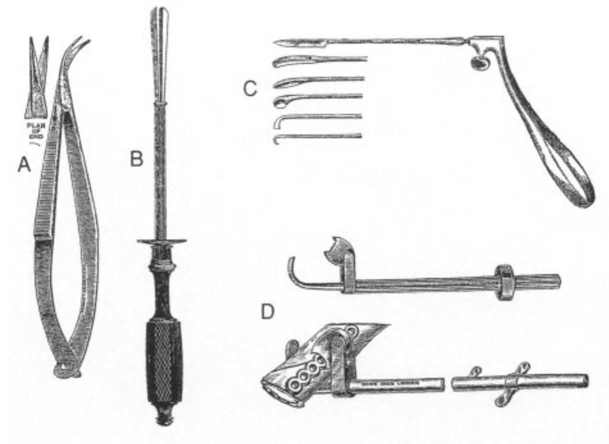

Figure 5 (A) Castroveijo's scissors, combining spring and pivot forms, for the eye, by Down, 1952. (B) Roux's type needle-holder, combining spring and tubular forms, by Maw, 1888. (C) Hajek's instruments mounting common handle, for the ethmoid sinuses, by Down, 1936. (D) Sinclair's bone and plate holding clamps, for the radius and ulna, and femur, respectively, by Down, 1952.

Compound instruments

These are composed of two or more of the eight basic structural shapes noted above and may have single, dual or multiple functions.

Single function

Examples noted earlier in the series include combinations of spring forceps and pivoting joint mechanisms to form Castroveijo ocular scissors (Fig. 5A), combinations of spring forceps and controlling tubes to form needle holders (Fig. 5B) and combinations of sharp points and tubes to form trocars and cannulae.

Dual function

Central handles with different items at each end are characteristic of many Roman instruments usually combining a probe with either a spatula, scoop or spoon.[8] Later instruments include pocket knives with two folding items and directors opposed to aneurysm needles. In addition, both trephine handles and trepan braces usually interchanged perforators and cylindrical saws.

Multiple functions

A range of instruments served by a common handle was a feature of mid-19th century pocket cases; similarly, multiple-ended aural and ethmoid sets (Fig. 5C) were devised in the early 20th century. Early endoscopes often employed interchangeable items, with differing functions, mounted on a universal handle;[9] but, at the beginning of the 21st century, it was found quicker and safer to introduce complete instruments as required.

Auxiliary and subsidiary instruments

Auxiliary instruments do not incise, penetrate or seize tissues but act as intermediate agents in holding and conducting other instruments to undertake these tasks. Auxiliary instruments include needle-holders, trephine, trepan and drill stocks, plate (Fig. 5D), screw, pin and nail holders, screw drivers, tent and stent insertors, and electric and air motor units. In the case of bone pin and nail holders, actual nail penetration requires hammer blows on the holder and, although chisels and gouges are primary instruments, their effective employment also requires hammering, undertaken by the other hand, in what becomes a double unimanual operation. Thus, hammers and mallets are designated subsidiary instruments.

Diagnostic and therapeutic instruments

Stethoscopes and thermometers are purely diagnostic in application whereas proctoscopes, cystoscopes and many endoscopes are applied both diagnostically and in a surgical therapeutic role. Hence, haemorrhoids, bladder tumours, enlarged prostates and torn menisci can be

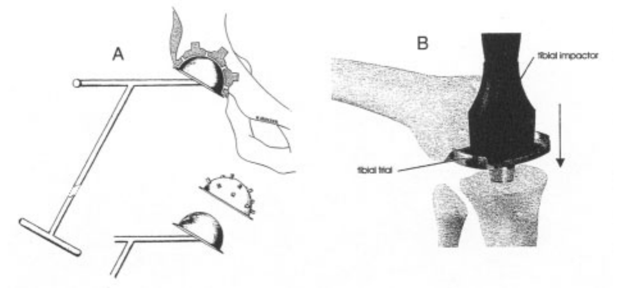

Figure 6 (A) McKee's cup holder, for hip arthroplasty, ca 1965. (B) AMC tibial trial and impactor, for Mark II knee arthroplasty, by Alphanorm, 1999.

treated on immediate visual diagnosis via these tubular instruments.

Implant and prosthetic instrumentation

Implants are foreign bodies inserted to replace mechanical defects or disordered function in the human frame on a temporary basis, for example, vessel ligatures, fracture pins, nails and screws, Murphy's intestinal anastomosis button and otological stents. Once the defects have resolved or healed, implants have no function and are either absorbed, removed surgically or passed per rectum; however, metal implants are often left in bone, unless causing symptoms. By contrast, internal prostheses (as opposed to external prostheses such as artificial limbs) are foreign bodies inserted in the tissues on a permanent basis, for example, to replace damaged joints, heart valves and main arteries.

During bone plate and screw insertion, we have already noted the auxiliary role of specific holders and, for prostheses, similar specialised instruments have been devised (Fig. 6A). Of these, prosthetic guides, saw blades and retractors invade body tissues and are, therefore, true surgical instruments, whereas introducers, holders and impactors remain auxiliary instruments, whilst templates and trial prostheses (Fig. 6B) are passive subsidiary items.

Conclusions

Until the 19th century, most instruments were simple and readily categorised into one of eight basic forms. When anaesthesia, antisepsis and especially asepsis enlarged the operative field and its instrumentation, additional complex and auxiliary items were devised. In particular, thermal sterilisation ensured safe exploration of all body cavities to stimulate an avalanche of new instruments for expanding specialities. Thus, Arnold's surgical instrument catalogue increased some six times in size between 1876 and 1904. Today, most specialities have their own specific catalogue.

This series has attempted to classify instruments to the end of the 20th century, without debating current rapid changes and a divergent future armamentarium related to computerisation, new materials, micro-engineering, new rays of energy and sophisticated biological solutions. Until the latter part of the 20th century, most surgical instruments evolved as extensions of the hand, modified by cyclical changes in material composition. Today as technology accelerates in numerous directions,[2] a spectre of surgical robots transpires with further erosion of operative instruments controlled by arduously acquired manual skill.

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