THE HISTORY OF CRANIOTOMY:

AN ACCOUNT OF THE METHODS WHICH HAVE BEEN PRACTICED AND THE INSTRUMENTS USED FOR OPENING THE HUMAN SKULL DURING LIFE

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'Tis Man's worst deed
To let the things that have been, run to waste
And in the unmeaning Present sink the Past.—Lowell

Ideas are born; they develop; they are transformed; they never die. The history of ideas is the history of the race. They are the real events. Let them be never so new or strange, they have their roots in the far past with a continuity of growth.

Sir Andrew Macphail

Introduction

FAMILIAR though most of us are with the modern methods of performing craniotomy, not all of us are equally well acquainted with the way in which the operations practiced today have evolved from the more primitive efforts of our surgical forefathers. Nor do all of us realise how ancient an operation craniotomy really is, how many and varied have been the methods practiced for its performance and how curious and highly ingenious have been certain of the implements used by its practitioners.

Prof. Archibald Young[130] in his presidential address for the year 1924 to the Royal Medico-Chirurgical Society of Glasgow, used these words:

Many addresses and lectures have been written in recent years, and many papers contributed to medical journals, whose chief purpose has been to dilate upon the great advances of modern surgery. The lay Press has contributed its quota to the same process of what one may almost call self deception. We are too apt, in consequence, to get into the habit of thinking that most of the achievements of present day surgery are peculiar to this century, or perhaps even to this last decade; that there was no such thing as surgery, in the real sense, until almost within the memory of, say, our grandfathers.

It is a very salutary corrective to this impression or assumption to glance back for a little upon the history of surgery in the past.

If any of us have acquired this impression or assumption, this paper may prove a salutary corrective such as that to which Prof. Young refers, but it was not with this high object that its preparation was undertaken but because of a much more lowly one. At one stage in his ascent of the Mountain of Purgatory, Dante reached a high terrace from which, while resting for a moment, he turned to the East and remarked to his conductor: "all men are delighted to look back," and from the terrace reached by the practice of cerebral surgery today I am delighted to look back and report the retrospect.

While the knowledge gained by the toil of one generation soon becomes the commonplace of the next, it is equally true that the discoveries of our forefathers have a habit of attaining a new importance many decades later. This is well exemplified in the history of surgical craniotomy. It will be seen that certain instruments used for performing the operation in quite recent years and even some of the most modern had their proto-

types which were used by our surgical forefathers many decades before and were subsequently lost or forgotten.

In an introduction to an account of surgical instruments in Greek and Roman times, published in 1907, the author, Mr. J. S. Milne, remarked that prior to the publication of his essay, no systematic attempt to reconstruct the surgical armamentarium of the ancients had been made, that comparatively little attention had been given to this department of archaeology, and that literature bearing on it was scarce. If this applies to surgical instruments generally, it does so with greater force as regards those instruments appertaining to a particular operation such as opening the skull. A research into the literature has failed to reveal any systematic and comprehensive account of this aspect of the history of surgery so that the time seems opportune to present this brief history of the methods which have been practiced and the instruments used for opening the human skull during life.

Part I. Neolithic

L'origine de la chirurgie cranienne se perd dans la nuit des temps.—Velpeau.

Sir William Osler[78] described the modern operation of cerebral decompression as the oldest known surgical procedure, and it is certain that the operation of opening the skull during life dates back to the very dawn of civilisation. In all probability the operation was performed as far back as the Carnac Epoch of the Neolithic Period which is supposed to have ended in northwestern Europe about the year 2000 B.C.[123] That distinguished French neurologist and anthropologist, Paul Broca,[9,14] gave sound reasons for thinking that it was performed even before this, namely in the Campigny or Early Neolithic Period.

Many prehistoric human skulls have been discovered and continue to be unearthed with pieces of bone missing from them. The defects in the bone are due to various causes. They may have been produced by a deliberate operation performed during the life of the subject, and it is with holes so produced that this paper is concerned; but on the other hand they may have been caused by comminution, the result of violence such as that from spears or clubs; they may have been produced by disease during life, by defective development in early life, by post-mortem decay or injury by the picks or shovels with which the skulls were unearthed, or they may have been the work of necrophilous beetles, portions of the elytra of which were identified in connection with certain cranial openings around which a notable controversy[141] raged some years ago. From the types of opening known to result from each of these various processes, however, the nature of the bone destruction, and the fact that signs of reparation around the bony edges of holes produced some time before death are apparent after death, it is possible to recognise attempts made to remove bone discs from the skulls of the living. There are numerous examples of successful attempts so made upon neolithic skulls.

In the British Isles there are but few examples but France is rich in them,* many having been unearthed

* Some ideas of their frequency will be gathered from the fact that at Vendrest, 60 miles east of Paris, remains of over 120 individuals were found buried in a neolithic tomb and no less than 8 of the skulls had been opened during life and discs of bone removed therefrom. Badouin, M. Société Préhistorique Française. 1911.

since 1865 when M. Prunières,[87,91] a medical practitioner of Marvejols in the department of La Lozère, first aroused interest in them by a discovery which he then made near Aiguières. In a dolmen there he found a human skull from which a large portion of bone had been removed. Part of the edge of the hole in this skull was polished and Prunières surmised that the skull had been used by a neolithic savage as a drinking cup, a custom not infrequent among savages, and that the bone edge had been worn smooth by the lips of drinkers from it. Broca[12] however pointed out that the polishing was really due to a healing process which during life had taken place in a wound made in the skull for removing a *rondelle* of bone. Prior to this it had not been realised that in prehistoric times our primitive ancestors used to remove discs of bone from the living skulls of their fellow tribesmen with implements made of stone. The effect of this startling discovery on contemporary thought can well be imagined, for it was not long before ample confirmation of Broca's hypothesis was forthcoming.

Speculation next centered around the methods of making these openings in the skull and many and varied were the suggestions put forward to account for them. Lucas-Championnière[61] gave it as his opinion that they were made either by scraping or else by first drilling a series of small holes and then connecting these perforations by sawing or scraping. Sir Victor Horsley[49] from an inspection of the collection of skulls in the Broca Museum of Anthropology in the University of Paris, thought the openings had in most cases been made by sawing, possibly supplemented in some by scraping also, while more recently Dr. Wilson Parry, [119,123,124] after investigating the question very minutely and performing much experimental work relating to it, concluded that the openings were made with sharp flakes of either flint or obsidian used to scrape out a hole or to plough a groove in the bone until the gradually deepened groove ultimately perforated the skull and released a bony *rondelle*. Dr. Parry claims that boring a series of small holes and connecting these by sawing, the method suggested by Lucas-Championnière as that used for making the larger openings, is a very arduous procedure taking considerably longer to perform than what he calls "push ploughing" out a bone disc and that for this reason and also because of the absence, in his opinion, of any evidence of the bored holes in the great majority of the French neolithic specimens, he believes the usual method of performing the operation to have been the simpler furrowing out of a circular or oval groove with a sharp stone.

What were the possible reasons for producing these openings in the skull? In his treatise on Prehistoric Problems, Dr. Robert Munro[74] asks, "Were the motives that guided the hand of the neolithic operator inspired by therapeutic exigencies or by religious sentiments? Was the result of the operation to benefit the individual in this or in a future world?" Dr. Munro then proceeds to discuss these questions at length. It appears difficult to divorce therapy from religion especially in the days of primitive man. Probably the operation was most often performed as a religious or thaumaturgic rite applied to cases of epilepsy with a view to releasing supposed imprisoned spirits. Prunières believed that it was also performed for fracture, and from one

specimen found by M. Gaillard[38] at Saint-Pierre de Quiberon, it appears that the neolithic surgeon also operated for the evacuation of abscesses following compound fractures of the skull. From his examination of the Broca Museum specimens, Sir Victor Horsley[49] even went as far as to suggest that the prehistoric surgeons had some idea of localisation of function in the brain since a number of the openings had been made over those areas of the brain which comprise the motor cortex, irritation of which gives rise to movements of the opposite side of the body and to other syndromes well known today.* Horsley's opinion however was not at the time nor has it since been generally accepted.

Support to the view that the cranial openings were in most cases made for religious reasons, is furnished by the discovery of numerous amulets made from bone discs or taken from perforated skulls in relation to openings in them, but although amulets occur in association with the neolithic skulls of France they have never been found in Peru where openings in neolithic skulls also are quite frequently encountered.[119] Since in the Peruvian skulls fractures are quite common it appears as if in that part of the world the operation had a basis more definitely surgical than religious.†

Although it is interesting to thus speculate upon the reasons why these operations were performed, the chief object of this paper is to review the methods which have been practiced and the instrument used to open the living human skull and so these reasons cannot be considered at greater length.

Today craniotomy is still performed in a most primitive manner in Northern Africa and among the Islanders of the South Pacific. The Shawiya surgeons of Algiers burn out a piece of scalp with a red hot iron ring mounted on a wooden handle, and then after drilling a few holes through the bone gradually saw out a disc. The operation may be completed at one sitting but is often performed in stages, a little sawing being done each day until the bone disc comes away. It sometimes takes the surgeon fifteen to twenty days to remove a disc about the size of a penny. Great care is taken to protect the brain and its membranous coverings, and to avoid the sutures since these are believed to be the patient's destiny written by the hand of Allah.[47,48] In the South Pacific also the skull is opened in an even more primitive manner for such conditions as headache and giddiness, for fractures, and even to promote longevity,[23] the bone being scraped out with a piece of glass. Shark's teeth were at one time used as the cutting tool

* In a visit paid to this museum in June 1929, I was unable to corroborate this. The openings appeared too irregularly placed in regard to the motor cortex and to be placed indiscriminately over the vault of the skull.

† Owing to the courtesy of Sir Arthur Keith and Mr. R. W. Burne of the Staff of the Royal College of Surgeons Museum in London, I have recently examined 14 specimens of primitive trephining from Peru. Two of the specimens show that the operation had apparently been performed for fracture. The size of some of these openings is considerable, and in several skulls two openings have been made. Several of the openings traverse the midline but evidence of healing shows that the superior longitudinal sinus had not been fatally damaged during the operation. There is no example of suboccipital craniotomy, and as far as I am aware no neolithic specimens from any part of the world afford examples of trephining in this frequent site of operation today. The Peruvian skulls have been trephined in front, over the sides and at the back. One skull shows evidence of infection and suppuration.

but today these have been replaced by glass.[30] The Museum of the Royal College of Surgeons of England contains two Melanesian skulls with defects in them due to operations performed in this rude manner, and from the fact that the bone edges show healing it is evident that these patients both survived the operation and lived for some time afterwards.*

FIG. 1. MEDIEVAL CRANIOTOMY.

FIG. 2. MEDIEVAL CRANIOTOMY.

PART II. TREPANS OR TREPHINES

It is possible, I think, that the more perfect methods of trephining practised by the hippocratic surgeons had a direct and continuous descent from the primitive operations of the stone age.

—SIR CHARLES BALLANCE.

These are instruments which produce a cutting action by rotation. Examples are in use today, and although from the etymological point of view they would perhaps be better called trepans they are more commonly described as trephines.†

The trephine is a very ancient instrument. Hippocrates (*ca.* 400 B.C.) who had almost certainly obtained his knowledge from several sources, one of which was probably Egyptian,[19] described this instrument and laid down rules for its use, but to what literature he may have had access, is not known since pre-Hippocratic Greek medical writings have perished. It must not be thought that trephining was the only method used by the Greeks for opening the skull because Percival Pott[86] tells us that in some cases "the piece of cranium intended to be taken away was surrounded with perforations made at small distances from each other, and the interstices were cut through by chisel and mallet or by means of a scalper." This operation recalls a form of craniotomy occasionally practiced by the neolithic surgeons and by primitive races today (*vide* Section 1).

Hippocrates described the crown trephine (modiolus) which in consisting of a saw having a circular motion parallel to the plane of the skull is similar in principle to instruments in common use today. In referring to the method of using the

* Specimens numbered 1172–11 (New Britain), and 1172–62 (New Ireland). The museum also contains other specimens from New Ireland 1172–63, 64, 65 and 66 and a "Trephined Anglo-Saxon skull," specimen 373–1, the history of which is not related.

† Trepanning. (Gr. *trypannon*, an augur.) Trephining. (L. *tres*, three, and *finis*, end, a word introduced by Woodall early in the seventeenth century when he gave the trepan a handle.) I am much endebted to Dr. Wilson Parry for calling my attention to the significance of these words.

trephine he mentions the desirability of occasionally plunging it in water to prevent the instrument becoming over-

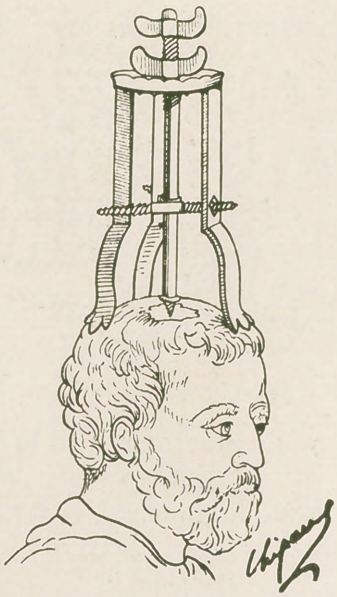

FIG. 3. MEDIEVAL CRANIOTOMY BY MEANS OF A MOUNTED TEREBRA. (FIGS. 1, 2, 3 AND 5 FROM CHIPAULTS' OPERATIVE SURGERY OF THE NERVOUS SYSTEM.)

heated. Apparently several sizes of trephine were employed in his time because he mentions a small instrument for use in head injuries in young people.

In Galen's time (*ca.* 130 B.C.) the crown trephine appears to have been displaced by a gimlet type of instrument (terebra). This pointed trephine had a collar (abaptista) to prevent damage to the brain and its investing membranes by undue penetration through the bone. Apparently the distance of the collar from the point varied in different instruments so that a series of these trephines was kept in order to perforate thick or thin skulls.[19]

Evidently the Greek surgeons performed extensive craniotomies on certain of their patients because Paulus of Aegina[5] (early 7th century A.D.) refers to perforating the bone with these protected drills (abaptista) and then removing the bone not whole but in pieces with chisels.

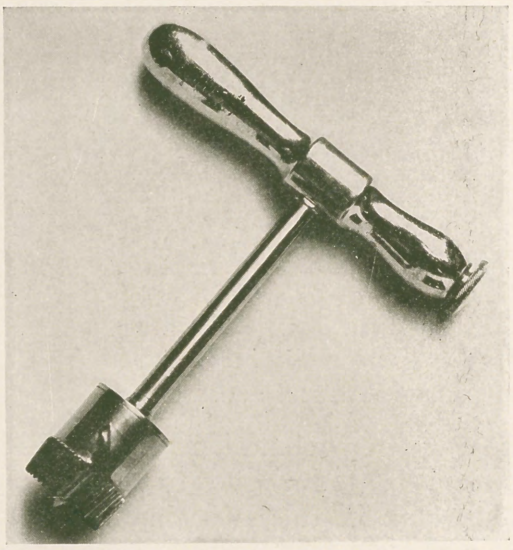

FIG. 4. SIR VICTOR HORSLEY'S TREPHINE, IN USE TODAY.

Over twelve hundred years after Galen, Guy de Chauliac (1363), apparently ignorant of the crown trephine, was still using the guarded gimlet type (abaptista)[45] (Fig. 3). The crown trephine appears to have been rediscovered by Bertapaglia in the fifteenth century and it was in use by Jean de Vigo in 1517.[19] It is interesting to note the way in which the crown type of instrument was made to bite the skull to commence cutting the bone disc. Celsus[5] (*ca.* 30 B.C.) refers to a removable center pin which is the device adopted in modern trephines such as Horsley's (Fig. 4), but in Jean de Vigo's time male and female instruments were used, the male trephine having a fixed center pin and being discarded for the female instrument as soon as the saw had commenced to cut into the bone. Although Horsley's trephine today is operated by hand with a screw motion, in the time of Celsus the trephine was driven by a

throng, and following the re-introduction of the crown instrument, Berengar of Carpi in 1535 attached a brace to it to quicken and facilitate its action.[6] (Fig. 5). Recently (1928) a brace driven perforator with an adjustable collar to prevent undue penetration has been introduced into cerebral surgery by H. S. Souttar of London and may be regarded as a return of the terebra abaptista driven by a brace.[104]

FIG. 5. TREPHINING BY MEANS OF A CROWN INSTRUMENT DRIVEN BY A BRACE. (17TH. CENTURY.)

In the works of "that famous chirurgion, Ambrose Parey,"[135] several trephines are depicted and described, also a "gimlet or piercer to perforate the scull before the setting to of the Trepan: A crown trephine and brace are illustrated fitted together and taken apart, and another instrument is shown with two triangular bits and a pin to hold them in the stocke." Still another illustration shows "a desquamatorie or scaling trepan" which closely resembles the modern brace and center bit (Fig. 6).

Towards the middle of the eighteenth century the crown trephine was improved somewhat by making the cutter slightly conical instead of perfectly cylindrical, in this way contributing to the ease with which the bone disc could be elevated after cutting through the skull, and while cutting the bone lessening the chances of damaging the underlying membranes covering the brain. This modification can be seen by comparing the trephine made by Savigny with that designed by Sir Victor Horsley. Savigny's instrument, introduced about 1798,* had a barrel of cylindrical pattern (Fig.7) while that of Sir Victor Horsley which remains in use today resembles a truncated cone (Fig. 4).

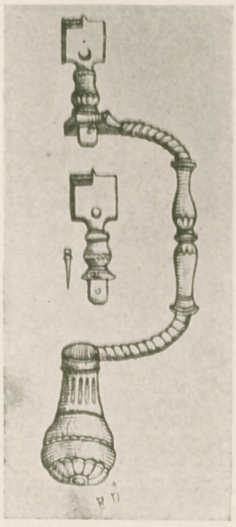

FIG. 6. BRACE AND CENTER BIT TREPHINE OF AMBROISE PARÉ.

Both crown and gimlet trephines have thus been in use with only minor modifications for over two thousand years, but while the crown type of

* Three good specimens of this instrument can be seen in the Museum of the Royal College of Surgeons of England. They are catalogued as K 14, K 15, K 16 in the instrument room.

instrument was lost for some time, it eventually reappeared and today is in more common use than the gimlet

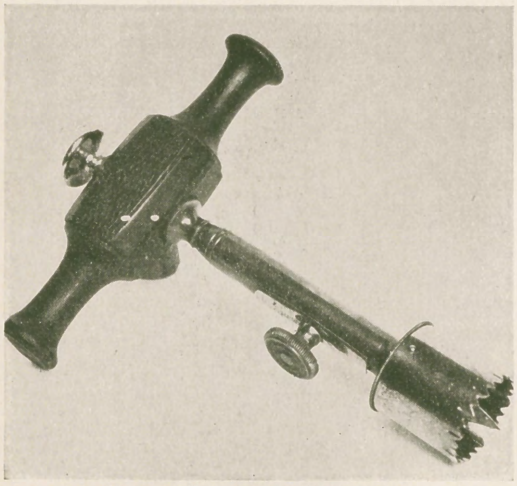

FIG. 7. SAVIGNY'S TREPHINE.

or center bit type of instrument. From the time of Hippocrates trephining appears to have been carried out for surgical rather than thaumaturgic reasons. Fracture of the skull however was not the only indication for the use of the trephine. Hippocrates trephined and decompressed to relieve failing vision, the result of rising intracranial tension, in much the same way that a modern decompression is performed for the same purpose, and Celsus[5] (*ca.* 30 B.C.) recommended trephining for meningeal hemorrhage without fracture of the skull. But, as mentioned in the previous section, the object of this paper is rather to describe the methods and instruments used for opening the skull than to discuss in detail the reasons for operating. Trephining was very readily resorted to in the sixteenth and seventeenth centuries for we read that as a result of a fall from his horse Philip of Nassau was subsequently trepanned by "Henry Chadborn, Surgeon in Nymegan," no less than twenty-seven times.[136]

PART III. SAWS

The past is always with us, never to be escaped; it alone is enduring; but, amidst

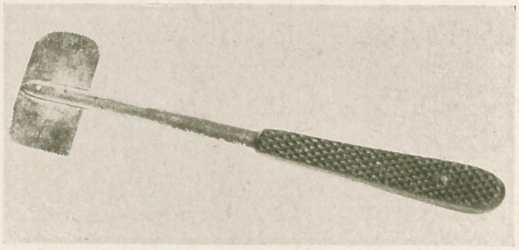

FIG. 8. HEY'S SAW.

the changes and chances which succeed one another so rapidly in this life, we are apt to live too much for the present and too much in the future.

Aequanimitas—OSLER

The crown trephine may be regarded as a modified continuous hand saw bent on its flat into the form of a circle. Saws of many varieties have been used in cranial surgery, the most primitive being the serrated shark's teeth and jagged pieces of flint and obsidian referred to in Part I of this paper. Following the introduction of metal saws, two kinds of saw were evolved. The first and simpler of these was the hand saw, the second the circular or disc saw which, since it required some driving mechanism to operate it, may be called the mechanical saw.

The Hand Saw. The best known model of the hand skull saw is that widely called Hey's saw (Fig. 8) and used about 1780 by Mr. William Hey, F.R.S. of Leeds, He, however was not the originator, for in his "Practical Observations in Surgery"[46] published in 1803, and in a chapter dealing with fracture of the skull he thus writes of this saw:

It was first shewn to me by Mr. (now Dr.) Cockell, an ingenious practitioner, at Pontefract, to whom the public is

indebted for the discovery, or revival, of this excellent instrument. A saw, formed on the same principle, is represented in

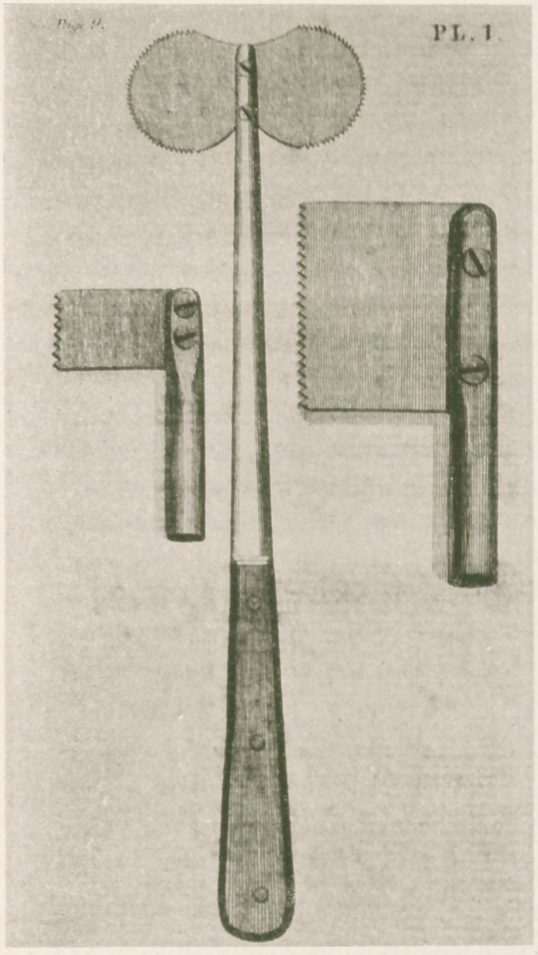

FIG. 9. PLATE TAKEN FROM WILLIAM HEY'S "PRACTICAL OBSERVATIONS IN SURGERY." 1803. THE SAWS ARE THOSE REFERRED TO BY HEY IN A CHAPTER ON "FRACTURES OF THE SKULL."

Scultetus's armamentarium chirurgicum; but I understood Dr. Cockell to say, that the instrument which he shewed me was of his own invention, and that he had used it with great advantage in extensive fractures of the skull. Dr. Cockell's saw had a semicircular edge, as represented in the annexed Plate, where the size of the figure is two-thirds of the real dimensions of the instrument. But the edge may be made straight (as is shewn in the Plate) or of any degree of convexity which may be thought most useful.

There is a footnote stating that the saws represented in this Plate (*vide* Fig. 9) were made by Mr.

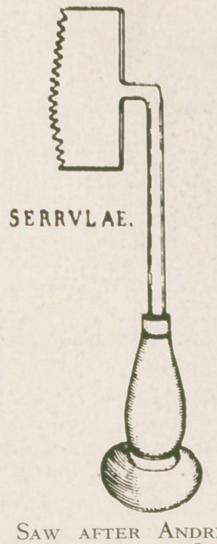

FIG. 10. HAND SAW AFTER ANDREA 'OF CRUCE. (FROM CHIPAULT'S OPERATIVE SURGERY OF THE NERVOUS SYSTEM, 1894.)

Savigny in London. But long before the time of either William Hey of Leeds or Mr. Cockell of Pontefract, saws of this type had been used for opening the skull. Ambroise Paré[135] depicts several which he describes as "saws fit to divide the scull"* and these closely resemble Hey's saw, and Andrea a Cruce[24] has a picture of a saw which is also very similar to that of Cockell and Hey (Fig. 10).

Although Hey was not therefore the inventor of the saw named after him he did draw attention to this type of saw and emphasized its advantages in cranial surgery, and as Sydney Smith says, it is not the man who first says a thing, but it is he who says it so long, so loudly and so clearly, that he compels men to hear him: it is to him that the credit belongs. So far as his own country is concerned, then, the credit of thus

* *Vide* reference to Ambroise Paré on p. 509. The illustration occurs on p. 345 of Paré's works.

emphatically demonstrating the value of hand skull saws belongs to William Hey of Leeds.

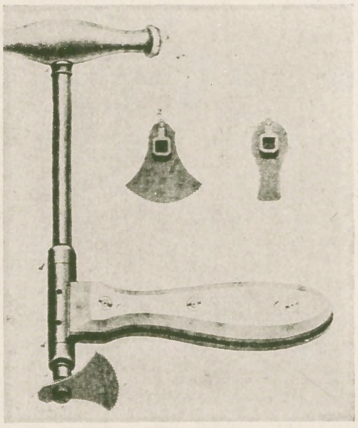

FIG. 11. PROF. THAL'S ROTATION SAW. (FROM *Edinb. M. & S. J.*, 1823.)

On March 1, 1878 at a meeting of the Surgical Society of Ireland, Dr. L. Bigger showed a saw like Hey's but with teeth also on the concave side so that both the convex and concave sides of the cutting blade could be used. In claiming advantages for hand saws such as Hey's and his modification of it, Bigger said:

> . . . various attempts are to be found in the records of ancient armamentaria, of very near approaches to the short saws brought into use by that excellent surgeon, Mr. Hey of Leeds. He, practising in a district where powerful machinery was continually causing fearful fractures and injuries, felt that the trephine was not always competent to fulfil the intentions of the surgeon and he designed the saws known by his name.

During the discussion which followed the presentation of Dr. Bigger's paper, the President of the Society, Robert McDonnell, F.R.S., agreed with Mr. Richardson, one of the speakers, that "there had been a good deal of claim for novelty for surgical saws which had long been in use for instance by ivory turners for cutting round corners and so on."[162]

It seems highly probable that small saws mounted on handles were in use for many purposes long before Bigger, Hey, Cockell or even Ambroise Paré drew attention to them.

Mechanical or Rotation Saws. Early in the nineteenth century a number of circular saws variously mounted and driven came into use for cutting bone, and some of these were applied to cerebral surgery. The simplest of these instruments was that of Prof. Thal,[137] first surgeon to the Copenhagen Hospital for the Poor (Aemindelig). A description of Thal's saw with a plate (Fig. 11) appeared in the *Edinburgh Medical and Surgical Journal* for January 1, 1823. From the plate it can be readily seen how the instrument worked: blades either completely circular or sections of circles and of various sizes could be fitted to a shaft which was rotated by one hand of the surgeon, while his other hand supported the whole instrument by a handle upon which was mounted the main bearing through which the shaft passed. Apparently Thal was both ingenious and versatile because in 1823 Prof. Howitz commenting upon this saw observed, "In its present form, the whole instrument has also been executed by the inventor, who is almost as skilful in such workmanship as his countrymen acknowledge him to be in the principal object of his studies."[137]

Numerous other disc saws, all however more complicated than that of Prof. Thal, appeared at this time but of these not one has survived to be used in cranial surgery today, that is to say they have all been complete failures. Some proved little more than inventor's toys and never came into

use at all, others had an ephemeral existence; all proved either too cumbersome or too complicated or dangerous and inefficient for general usage. Some very ingenious mechanical saws were produced, however, and an examination of some of these in the instrument collection in the museum of the Royal College of Surgeons in Lincoln's Inn Fields proves a fascinating occupation.

In May 1808 Mr. Machell,[63] a surgeon of Wolsingham, communicated to the *Edinburgh Medical and Surgical Journal* a description and a drawing of a circular bone cutting saw.[63] An editorial note commenting on the saw reads as follows: "We have examined it, and we think it remarkably ingenious. It is so far as we know the first contrivance whereby a circular saw is enabled to cut deeper than its semi-diameter, an advantage of incalculable importance in the operations for which it is intended." Figure 12 is taken from the plate of Machell's saw, and an example of the instrument can be seen among the collection previously referred to, in the Museum of the College of Surgeons.*

Machell considered his saw specially suitable for clearing the ends of old ununited fractured bones, but it is conceivable also that attempts to use the instrument for cranial surgery may have been made, because he refers to the value of a joint "which will allow of the conveyance being formed into different angles, which is frequently particularly necessary in applying the annular saw to the convexity of a patient's head, as in cases of fractures of the cranium,"[63] and again, "at the end of the forceps I have added two small points, which are found very useful in applying the saw to the cranium."[63]

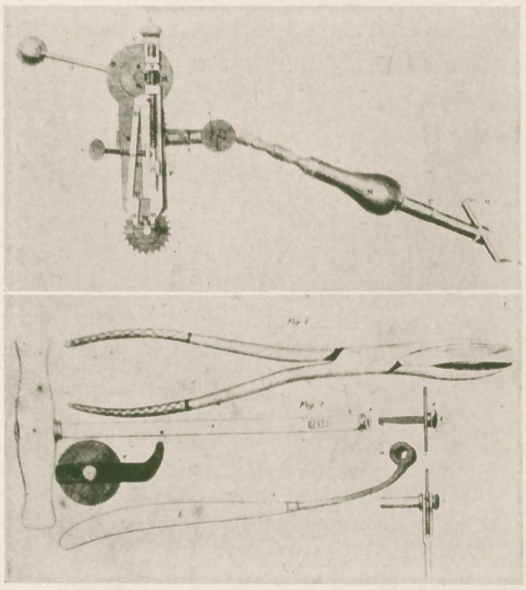

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FIG. 12. MACHELL'S SAW. (FIGS. 12 AND 13 FROM *Edinb. M. & S. J.*, 1815.)
FIG. 13. SAW AND BONE NIPPERS OF MR. GRIFFITH

In 1815 Charles Griffith, Surgeon to the Forces, produced a circular saw which in conjunction with "a new form of bone nippers" was communicated to the *Edinburgh Medical and Surgical Journal* by Dr. R. Hall[138] of the Detached Military Hospital at Chelsea with the following rather ponderous introduction:

> The military practice of surgery, embracing a greater variety of casualty than any other, owing to the fortuitous passage of balls through, or their lodgement in, every part of the body, urging military surgeons occasionally to the exertion of their inventive faculties, for the purpose of preserving life, relieving pain, or avoiding as much as possible, a too sanguinary use of the knife, it becomes, I think, a duty which they owe to their profession in general, to make public such matters as they have reason to believe may prove of public utility.

Mr. Griffith refers to the possible

* Specimens, K 53, K 54, and also K 55 which is a modification of a Machell's saw by the addition of forceps to hold the bone.

use of his saw in cranial surgery but there is no record that the instrument "proved of public utility." (Fig. 13.)*

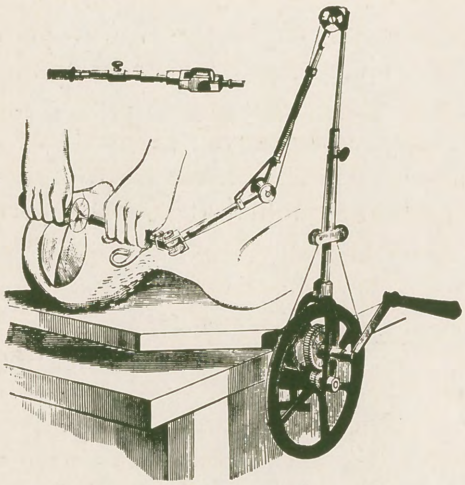

Fig. 14. Sir Victor Horsley's Saw. (Figs. 14–16 by Courtesy Messrs. Mayer & Phelps.)

About the time of the appearance of the saws of Machell and Griffith, a number of mechanically operated disc saws were produced in France but none seems to have become established as a practical instrument for use in cranial surgery.

The mechanical saws that have been referred to were devised for cutting bone generally, and although it was thought by the designers of certain of them that they might be used for opening the skull not one of these saws was especially designed for this purpose nor did any come into use in this way.

The great pioneer of cerebral surgery, the late Sir Victor Horsley, realised the desirability of having a rapid mechanical method of cutting through the cranial bones, and his biographer, Stephen Paget, writes:[143]

> . . . So early as 1887 he added, to the use of the trephine and the bone cutting forceps, the use of a minature circular saw driven by a Bonwill's surgical engine [Fig. 14]. This was apparently the first mechanical saw designed for the special purpose of opening the skull but apparently Horsley did not find the instrument very successful, and it was not very long before he abandoned it. Sir William Macewen in Glasgow was using a circular saw for performing craniotomy about the same time as Horsley was using his in London, but Macewen was not pleased with this method of opening the skull and cautioned against the use of circular saws for the purpose.

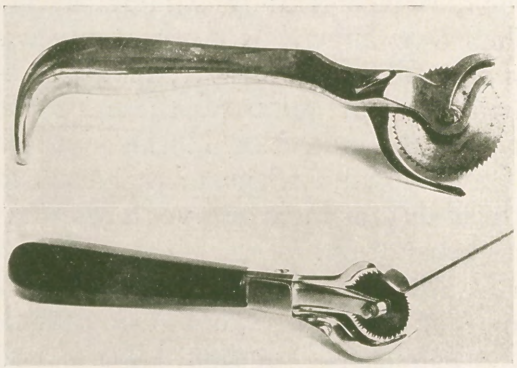

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Fig. 15. Doyen's Saw.
Fig. 16. Van Arsdale's Saw.

Doyen in Paris introduced a circular saw for cranial surgery in 1897* (Fig. 15) and in the same year William Waldo Van Arsdale, adjunct professor of surgery at the New York Polyclinic, published a paper entitled, "Remarks on Temporary Resection of the Skull by a New Method with a Report on Three Successful Cases."[111] This new method consisted of the use

* The museum of the Royal College of Surgeons of England contains 3 examples of Machell's saw, specimens K 53, K 54, K 55, and examples, specimens K 51, K 52, of formidable clockwork driven instruments, the diameter of the saw of one of these being 4¾ inches.

* I am indebted to Messrs. Meyer and Phelps for kindly lending me the saws from which figures 14, 15 and 16 are made and for kindly writing to Messrs. Collin of Paris for me about Doyen's saw. The following reply was received. "*Nous avons l'avantage de vous faire connaître que la scie du Dr. Doyen a été construite par nous et présentée à la Société de Chirurgie vers l'année* 1897."

of a specially constructed disc saw which Van Arsdale had presented (Fig. 16) to the New York Surgical Society the year previously when he also published an account of the instrument.[110]

Horsley's, Doyen's and Van Arsdale's saws were all driven by surgical engines connected to the driving spindles of the saws by flexible cables.

It is interesting to note that of all these varieties of skull saws, the only one to remain in use today is the simple hand instrument known as Hey's saw.

PART IV. FURTHER ADVANCES IN TECHNIC: THE FORMATION OF BONE FLAPS.

I feel the great thing in this world is not so much where we stand, as in what direction we are moving.

—OLIVER WENDELL HOLMES

By the historical method alone can many problems in medicine be approached profitably. For example the student who dates his knowledge of tuberculosis from Koch may have a very correct, but he has a very incomplete appreciation of the subject.

—SIR WILLIAM OSLER

One of the greatest advances in the method of opening the skull for surgical exploration of the brain and its investing membranes was that made in 1889 by Wilhelm Wagner of Königshütte.

In 1864 Ollier had suggested an osteoplastic resection of the skull, his idea being to lift up a piece of the skull adherent to a flap of soft parts,[22] but it was not until 1889 that Wagner first adopted this principle when operating upon the living subject.

On November 23 of that year, Wagner reported the case of a patient upon whom he had performed osteoplastic craniotomy, and entitled his paper "On temporary resection of the vault of the cranium in place of trepanation."[115] The operation had been performed on October 3, 1889 upon a laboring man aged twenty-seven, who was unconscious following a blow on the side of the head, and who two days after the accident developed signs and symptoms pointing to intracranial hemorrhage from the left middle meningeal artery. Wagner, who had previously experimented upon cadavers with the object of producing a bone flap attached at its base to the soft parts so that the flap could be turned down, a reasonably large area of the brain exposed and the flap subsequently replaced, now performed his operation for the first time on a living subject. A large bone flap was chiselled out and turned down with its base attached to the scalp, the bleeding meningeal artery secured and the flap replaced. Wagner's patient died twenty-four hours later, but the operation had introduced a new technic in the surgical exposure of the brain, and it was not long before other and more successful attempts were carried out. Osteoplastic craniotomy has now come to be known as Wagner's operation.[139]

At the time of his original description Wagner stated, "I only use small strong chisels and elevators. Perhaps some form of circular saw could be constructed which could be set in motion after the manner of a dentist's drill with which it would be possible to work more quickly and accurately." He added a word of warning against the hammering necessary for chiselling, and the liability to cerebral concussion from hammering the skull is of course obvious.*

Wagner was apparently unaware of Horsley's circular saw because he concluded his suggestion to use such

* Gorodiski, Ein Vorschlag zur Trepanation, Erlangen, 1893, commenting upon this states that for this reason the use of hammer and chisel for opening the skull was deprecated by Galen about 200 A.D.

an instrument by stating that he did not know of such a saw, and then when his paper was in print added a footnote, that Richter had told him of a circular saw constructed by Collin of Paris and used by Péan and Ollier.[115] This was apparently Doyen's saw to which reference has been made in the previous section.

Circular saws as constructed towards the end of the nineteenth century, however, did not prove very helpful in performing osteoplastic resections of the skull, and the most useful instrument introduced for this purpose was the wire saw of Leonardo Gigli of Florence. This instrument, now universally known as the Gigli saw, was first described in 1894[39] and rapidly came into general use. It consists of a flexible roughened wire operated by detachable handles at either extremity, and serves to cut through bone in much the same way that a plain wire cuts through cheese. The saw is used to divide the intervening bridges of bone separating trephine or other openings made into the skull, and is similar in action to certain old chain saws which were introduced in the eighteenth and nineteenth centuries for cutting long bones.

Gigli saws are in use today not only for performing osteoplastic craniotomy but also for cutting through bony bridges, the situation of which renders the application of other saws hazardous or difficult. Cutting bone flaps from the skull by means of these saws is tedious and the wires may jam or break, but the procedure is a safe one.

The production of osteoplastic flaps is an essential part of cerebral surgery today, and since Wagner's time the chief advances in the methods of opening the skull and in the instruments for the purpose have been in the direction of improving the technic of performing this operation. Many craniotomes have been invented to facilitate the Wagnerian operation, but none so far has been sufficiently successful to supplant Gigli's saw completely and relegate it to places similar to those held today by the saws of Thal, Machell, Griffith and others to whom reference has been made.

At the seventh Congress of the International Society of Surgery held in Rome in April 1926, Dr. A. Jentzer of Geneva, suggested cutting bone discs completely from the skull and replacing these later. He showed and demonstrated the action of an elaborate instrument which he had designed for this purpose, and which consisted of a central trephine around which other trephines fitted concentrically so that a series of cuts could be made through the skull, and discs of various sizes removed and preserved until the completion of the operation when they could be replaced in the gap in the bone.

Most surgeons however still prefer to perform the Wagner operation of turning down a bone flap attached to the soft parts, and the problem which this type of operation presents is how best to make the linear cuts through the bone. Forceps such as those of De Vilbiss have been used, electrically driven instruments which punch out a groove through the bone in much the same way that a pneumatic drill cuts a groove through a hard road, have been introduced by Dr. De Martel* of Paris and others, and an ingenious instrument has quite

* The instrument which I have seen used by Dr. De Martel in Paris appears to have had a precursor manufactured by De Vilbiss of New York and pictured by Terrier, *Gaz. hebdom. de med. et chir.*, 31: 573, 1894.

recently been designed and used by Mr. H. S. Souttar of London. This instrument is operated by hand and

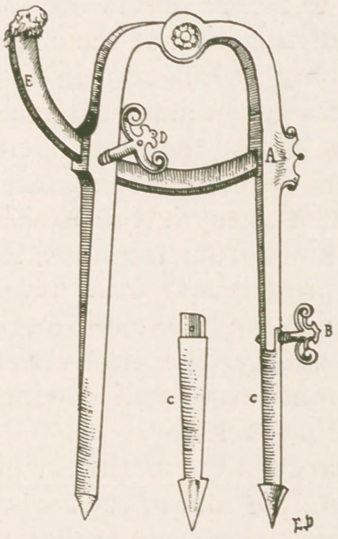

FIG. 17. AMBROISE PARÉ'S SKULL COMPASS. (COURTESY PROF. R. DOBBIN.)

by swinging round an expanding mandril fitted through an opening in the center of the proposed bone flap cuts a flap which is part of a circle.[104] Mr. Souttar's craniotome is particularly interesting inasmuch as it is a modern counterpart of a similar type of instrument described by Ambroise Paré in 1634 as "a paire of cutting compasses to cut forth the scull"* (Fig. 17), and well illustrates the tendency for certain discoveries of our forefathers to be lost for a time and rediscovered many decades later.

Mr. Souttar's instrument consists essentially of a hand driven cutting tool acting from a center pin. In 1893, Sir William Arbuthnot Lane, then assistant surgeon to Guy's Hospital, read a paper on "The applicability of the parting tool or angular gouge to the surgery of the skull," and for opening the skull advocated the use of two carpenter's parting

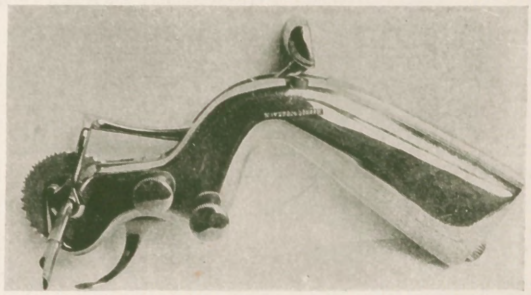

FIG. 18. THE "SKULL PLOUGH," A MODERN ELECTRICALLY DRIVEN CRANIOTOME.

tools of different gauges and so ground that one was more suited to the thicker dense skull of the adult, and the other to the less resistant skull of the child.[53] In the following year J. S. Pyle published a paper "On opening the cranial cavity with a new set of instruments."[96] The instruments were hand operated cutting tools and a report of a case was included in his paper, but today these hand operated tools have, except in the case of Souttar's mechanical craniotome, almost completely disappeared from cranial surgery.

Doyen's, Van Arsdale's and other circular saws have not been successful for performing osteoplastic resection of the skull, and an examination of these instruments shows that the reason for their failure appears to be the difficulty of engaging a power driven saw with the skull while at the same time adequately protecting the brain and its membranes from injury. An attempt has been made to get over this difficulty in a recent instrument by the introduction of a cutting action capable of accurately controlled biplanar movement in relation to a guard for the brain and its membranes (Fig. 18).* It remains for

* I am much indebted to Prof. R. Dobbin of Cairo, for drawing my attention to this ingenious instrument and for very kindly sending me drawings of it. I have since compared them with the original and written to Mr. Souttar pointing out to him the similarity between his and Paré's instrument.

* The Skull Plough, a new instrument for cutting cranial bone flaps (Fig. 18). Reported

time to classify this instrument either with those of Thal, Machell, Griffith, Horsley, Doyen and Van Arsdale, or with the more successful saws of William Hey and Leonardo Gigli.

Conclusion

In this account of craniotomy and the instruments used to perform it, an attempt has been made to show how from the very earliest times man has operated upon the skulls of his fellows, using at first sharp stones or shark's teeth* to cut an opening through the bone, then various metal instruments in the form of trephines and saws; how with progress through the ages these became elaborated so as to facilitate the cutting process and make it more rapid; how certain of the elaborations failed while others evolved, and how with the wide application of mechanical power, power driven instruments in certain cases supplanted those operated by hand. Certain of these instruments had an ephemeral existence almost as transient as Jonah's gourd, which "came up in a night, and perished in a night," others remained for relatively long periods ultimately to pass away or become so modified as to be no longer recognisable, while still others have persisted and are in use today.

Throughout this, as in most stories of development, two tendencies are apparent, first that certain ideas and methods may recur over long intervals, so that the discoveries of our forefathers become lost for a time and reappear long years afterwards, and secondly that the toil and trials of one generation may become the commonplace of the next, sometimes abruptly sometimes so insidiously as frequently almost to escape observation.

The distribution of the operation of craniotomy with respect to time, territory and the stage of development of races shows that the operation is common to many countries and to different stages in the development of mankind, from the unwritten past to the present and from savagery to civilization, and that the methods of, and probably the motives for, its performance have varied widely with cultural progress.

The story of the methods which man has practiced and of the tools, which, throughout the ages, he has used for opening the skulls of his fellow men, not only throws odd shafts of light on the condition of races at various stages in their evolutionary progress, but also affords fleeting glimpses of progressive stages in the social development of civilized man, "a tool using animal," as exemplified by the nature of his tools.

In glancing back at these stages, however, it must not be forgotten that progress is only rarely made by sudden steps; more often it is along a gradient so gentle as to be almost imperceptible and between the stages there are many intermediate ones that tend to be overlooked. We may do well to remember what Carlyle has said about history in general:

> The most important part is lost without recovery, and, as thanksgivings were once wont to be offered for unrecognised mercies, look with reverence into the dark untenanted places of the past, where in formless oblivion many of our chief benefactors, with all their strenuous endeavours, lie entombed.

and in this spirit I conclude this brief account of the history of craniotomy.

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by Lambert Rogers on July 24, 1929 to the Surgical Section of the British Medical Association at its annual meeting in Manchester.

*As is well known, sharks' teeth are serrated.

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