125 years of developments in dentistry, 1880–2005

Part 3: Dental equipment and materials

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INTRODUCTION

The Industrial Revolution affected many aspects of 19th century life, especially in the arts, sciences and manufacturing. Dentistry was no exception. It was summed up well by Huia Masters Pickard as "the era of gaslight and the spirit lamp, the foot engine and the chip blower, of the black cast-iron chair with ratchet back and upholstered in crimson plush, the red glass spittoon and small, rather ornate mahogany cabinet, and the all-pervading smell of iodoform".[1] It was in the Victorian period that the basis was laid down for present-day clinical dental care. A large number of developments were modifications of industrial processes. Many could not happen until the introduction and use of electricity, which led to more complex surgery equipment.

DENTAL ENGINES AND DRILLS

Three-quarters of a century of progress covered the advance from finger-rotated drills to the modern engines and high speed drills. Developments went from simple hand power, hand power plus machine, machines operated by clockwork or treadle foot power to automatic power (Fig 1). Major improvements could only happen following the introduction of electricity to power equipment. It was also essential for lighting and heating. The ways in which dentists rely on electricity became very apparent during the power cuts of the 1960s which brought most surgeries to a standstill.

Some developments would be instantly recognisable by yesterday's dentists, many of them less so. For example, a recent *BDJ* advertisement highlighted an electronically-controlled mobile dental treatment unit (Lysta's MU 1001) which can be easily assembled and taken apart before carriage in a roller case. Victorian dentists would have been staggered to see such an invention.

The American George F Green experimented with the use of electricity for engines and was engaged by Samuel Stockton White to devise and perfect electric dental devices. By 1871 they had developed a self-contained motor and dental handpiece, the first electric engine for the profession. Although followed by others, most were too heavy to hold and expensive to run but they provided an impetus for more successful developments (Figs 2 and 3). In the same year James Morrison invented a foot-powered pedal or treadle drilling machine. Manufactured industrially by the American S S White Company it soon faced criticism. Use of the foot pedal was held responsible for fallen

Fig. 1 George Harrington's clockwork drill nicknamed 'Erado'.

Fig. 2 Advertisement for Shaw's dental engine

Fig. 3 Claudius Ash catalogue entry for Shaw's dental engine

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arches and flat feet. Within seven years Ash and Sons of London offered a hydraulic motor for this purpose. In 1874 Elliott's suspension type engine was introduced, while 1885 saw the simple switch replaced by a foot activated starter. A further advance came in 1892 with development of a reverse motor and treadle rheostat outfit. In 1893 the motor was enclosed in a metal sphere. By the 1920s the dental engine drove a cord which in turn rotated the interior of a handpiece and thus the attached bur. It was mounted on a folding bracket which was often attached to a wall. By 1936 special gears allowed speeds of up to 24,000 revolutions per minute.

There were many changes over the years. 1950 saw a major advance; the introduction of an air-abrasive drill where a jet of abrasive alumina powder was propelled onto the teeth by carbon dioxide with no vibration or pressure – similar to a sand-blasting machine. Although not very good for cavity preparations as the Cavitron it was used for the ultrasonic removal of calculus from teeth. It was quickly overtaken by water turbines. In 1957 John Victor Borden's high speed air turbine drill was a sensation at Rome's International Dental Congress. An even greater advance came in 1961 when improved air bearings appeared. A Siemens hand-held micromotor followed in 1965 to make caries removal much easier. However, in addition to clinical innovations, they also allowed surgery design to be more versatile.

TOOTH CUTTING AND DENTAL INSTRUMENTS

Before 1870 enamel and dentine were cut mainly using excavators, chisels and hand-rotated burs. Initially made from stainless steel they were difficult to keep sharp. The problem was partly overcome at the end of the 19th century by the use of carborundum discs and stones for grinding and then diamond burs. By 1930 rotating diamond discs were in use.

The introduction of foot drills in 1871 changed everything. Between 1880 and 1930 they were in common use, handpieces generally rotating at 200 to 300 revolutions per minute.[1] More speed and less vibration came with the introduction of electrical drills which were invaluable for the preparation of large cavities and crowns. The air-abrasive, water and air-bearings removed vibration and pressure but friction at high speeds produces heat which damages the pulp so cool water sprays were needed.

Amongst the advances in dental instruments were movements from carborundum stones to diamond tools, from steel to tungsten carbide, from occasional washes with a rubber bulb to a continuous flow of water from instruments connected to the water supply, and from cotton wool to simple saliva ejectors and then vacuum aspirators to keep the mouth dry.

SOME OTHER ELECTRICAL ADVANCES

Nowadays we take for granted the use of electricity to provide surgery lights to see patients and their mouths, heaters to keep the surgery warm and to power a number of instruments. The following advances were made in the 1870s onwards: 1877 the electo-magnetic mallet; 1883 double-induction motor battery for dental surgery use; 1884-5 electric lantern, mouth lamp and a carbon cell battery for operating them and a storage battery for general use; 1883 lamps produced in Germany small enough for use in the mouth; 1890 mouth illuminator; 1919 diathermy for use in the treatment of pyorrhoea. 1884 saw the first use of an electric lantern to illustrate a lecture to the BDA.

DENTAL CHAIRS AND UNITS

The S S White Company produced a range of dental chairs. In 1871 they delivered the first all-metal 'Harris' chair, with a simple hand cranking mechanism to adjust the height of the chair and head and foot rests. The following year saw their 'Morrison' chair, the first fully adjustable chair with compensating seat and backrest, plush upholstery, claw-shaped feet and 'fussy' decoration. 1877 saw the 'Wilkinson' chair, the first with a hydraulic foot pump to move it up and down, removable armrests and even a child's seat.

In 1883 Adam Schneider of Berlin founded a company to construct dental chairs. By 1890 he marketed his first electric drilling machine but it could not be manipulated into every position. He overcame the problem in the following year and simultaneously developed a number of attachments, for example the cautery and warm air blower. At his suggestion the motor and low current instruments were mounted on a floor stand. Thus the first dental unit had been developed by 1891. Together with a massive leather chair and a huge spittoon it was popular in Europe but such an expensive set-up could not be afforded by most British dentists.

In the early 20th century many British towns and cities, including parts of London, had no electricity (Fig 4). As a substitute some dentists used lead/acid batteries. The foot drill was still in vogue. 1883 saw the first electric light used in a dental surgery. The advent of such lights revolutionised surgery design as dentists were no longer reliant on the chair facing natural light. It was thus possible to have even more complex surgery equipment. The 1920s brought everything together on the left side of the chair as a single unit, a problem for some left-handed dentists. This situation remained until the late 1960s, meaning that the author occasionally had to almost sit in the spittoon during some operations. The advent of air turbines with attachment to compressors via air sockets in several parts of the room made it possible to have several configurations for the

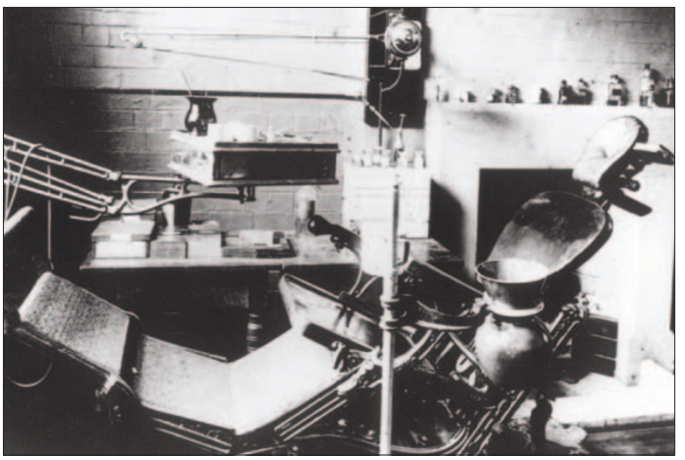

Fig. 4 Unidentified dental surgery c 1900

equipment. It became easier for the dentist and nurse to sit on opposite sides of the chair, with the patient lying back. Thus began the era of four-handed dentistry.

In 1910 Claudius Ash introduced a special metal backed chair on which poor children in London could be treated. It made it easier to clear the chair of vermin after a child departed.[2]

IRRADIATION AND DENTAL RADIOGRAPHY

In 1895 Wilhelm Conrad Rontgen discovered x-rays and within a few months Reiniger, Gebbert and Schall began the first commercial production of an x-ray apparatus in Germany. The first x-ray pictures of teeth were taken in 1896 by Walter Konig, a Frankfurt physicist. He was soon followed by Otto Walkoff as the first dentist to take dental radiographs although no suitable film material was yet available. Reiniger, Gebbert and Schall introduced the 'Record' as the first dental x-ray unit in 1905. In the following years their products were expanded by the inclusion of dental patient chairs. They eventually became the Siemens AG Company. By 1899 radiography had been introduced to England, when the first x-ray picture of a hand was taken in Newcastle. By 1914 Bennett's Science and practice of dental surgery included a 15-page chapter on dental radiography by Charles Alexander Clark of the Royal and National Dental Hospitals. Over the years dental radiology developed rapidly, initially based on films, later on computer screens. Without them many clinical diagnoses of mucosal, periodontal, dental and orthodontic problems and thus treatments would have been impossible.

In 1929 radium was used to treat oral cancer. By the 1960s lasers, an advanced light source, came into dental use.

FILLING MATERIALS

In the early years dentists used tin and cohesive gold. Amalgam was introduced later to become the most commonly used restorative material world-wide over many years. Countless early users produced such poor results that between the 1830s and 1890s there was an 'amalgam war' in the USA. In his 1840 opening address to the world's first dental college, in Baltimore, Chapin A Harris said it was "one of the most abominable articles for filling teeth that could be employed".[3] In 1845 the American Dental Association pressed its members to sign an agreement not to use it. However by 1880 amalgam was commonly used in the UK. In 1871 Charles Tomes was able to test for shrinkage and expansion of amalgam by means of specific gravity tests. Until the 1950s amalgam was produced by mixing the alloy and mercury in a pestle and mortar. They were later inserted into a capsule in the surgery and mixed electronically. In both cases any excess mercury was squeezed out by hand through a cloth. Later the mixture came in sealed capsules to prevent mercury poisoning.

From about 1860 cohesive gold was also used (Fig 5). Layers of gold foil were inserted into cavities and welded together by pressure from hand and later mechanical spring-loaded pluggers. In 1892 pneumatic hammer attachments were produced for the new dental engines.

Silicate cements were introduced in 1908 as more aesthetically pleasing than amalgam and gold for anterior teeth. Acrylics and composites came later. A major breakthrough came in 1955 when Michael Buonocore described an acid-etch technique. More recently we have seen the increased use of white filling materials for posterior teeth.

Fig. 5 Cohesive gold foil advert

VITAL PULPOTOMY DRESSINGS

Not all practitioners believed the pulp was capable of repair. In 1866 W H Allen suggested that a full cure was not possible as the pulp lay in a hard unyielding box of dentine.[4] Nevertheless there were some attempts at treating exposures of the pulp from caries or during

instrumentation. In 1866 W H Atkinson strongly suggested amputation of the projecting cornua of exposed pulp (pulpotomy) and covering the remains with a temporary filling until it was healthy.[5] He thought that saturating the cavity with creosote before placing a filling would help to preserve the vitality of the remaining pulp tissue. In 1883 F A Hunter used an unusual mixture which included one pint of Sorgum molassum and one pound of droppings from English sparrows for capping the pulp.[6] He claimed a 98 per cent success rate but it is doubtful if he conducted a randomised controlled trial!

The second half of the 19th century did produce some more rational ideas. Importantly, in 1866 G F Foote said the best covering was a blood clot.[7] In 1896 Charles Tomes described a rare case of spontaneous healing of a widely exposed pulp.[8] Histological examination showed the pulp had stayed vital and a "cauliflower shaped mass of shiny ivory" had formed around dentine splinters - which we now call a dentine bridge. In a message we would endorse today Tomes felt that no strong or caustic medicament should be used as it might prevent this process. He also left a clot *in situ* and covered it with fibrin or gelatine. In 1921 C Davis advocated an aseptic technique followed by a non-irritant dressing, the exact composition being unimportant.

B W Hermann in 1930 used calcium hydroxide as a biological wound dressing to promote healing.[9] He introduced Calxyl, probably the most widely used dressing ever. It was 1938 before G Teuscher and H Zander demonstrated histologically the formation of a complete bridge of secondary dentine as a response to calcium hydroxide.[10]

IMPRESSION MATERIALS

Accurate impression materials are essential for satisfactory inlays, crowns, bridge abutment preparations and dentures. By 1906 softened beeswax was going out of fashion, to be replaced by Godiva or Stent composition or Plaster of Paris.[11] In fact Charles Stent had, in 1857, first tested combinations of different types of waxes to see which ones hardened at mouth temperature. Occasionally gutta percha was used but as with composition there was shrinkage and distortion unless left to harden, in which case they could not be removed from undercuts. The materials were used in impression trays made of Britannia metal, porcelain, German silver and sometimes silver and vulcanite. After use they were cleaned and re-used, a long way from the disposable plastic trays now used routinely. Plaster of Paris was an excellent early impression material. It was mostly used for edentulous mouths as it accurately reproduced the tissues. However plaster broke when pulled out of undercuts. Any liquid plaster mix dropped onto the tongue was likely to cause wretching. Composition was used mostly for partial dentures.

An advance came in 1925 when hydrocolloids based on agar-agar were introduced as reversible impression materials. A World War II shortage of agar led to the development of more easily manipulated irreversible hydrocolloids (alginates) from brown algae. Both of them allowed the production of more accurate plaster models as undercuts could be reproduced. Thus the subsequent wax templates for denture bases could more accurately follow the contours of the mouth, aiding retention of the final denture. There were similar improvements for making wax patterns for inlays and crowns.

In 1955 S L Pearson of Liverpool produced elastic impression materials from synthetic rubber. Later came resin based materials. Zinc oxide used in close fitting trays and to reline existing dentures provided more accurate impressions of fitting surfaces.

DENTURE BASE MATERIALS

In 1880 vulcanite was commonly used in the production of dentures. It was made by Charles Goodyear from India rubber (caoutchouc) juice heated with sulphur to harden it. Improvements to this material in 1864 by John Cummings led to the founding of the Goodyear Dental Vulcanite Company. Licences for its use were distributed in the USA but the high associated fees for its use led to lawsuits and the shooting to death in 1879 of Josiah Bacon, head of the organisation.[12] By 1881 dentists could use this hard rubber without fees. Celluloid was tried in 1880 but it required great expertise so went out of fashion. Later came glyptal and vinyl resins, Methacrylate esters were invented by Walter Brauer of Germany in the 1920s and came into dental use in 1930. They were first used in England in 1935 as Kallodent which was produced thermoplastically. In 1936 Paladon could be polymerised in the surgery by mixing liquid monomer and powdered polymers; a major improvement. Although acrylic resin provided a major step forward by the late 1930s it only came into general use in World War II when there was a shortage of rubber from the Far East. Later came polymethacrylates, epoxy resins, nylons, polystyrenes, polycarbonates, chlorinated polyethers and polyformaldehydes.

Cast gold was an early metal base. The introduction of chrome cobalt in the 1940s allowed the production of skeleton partial dentures which were stronger and much more comfortable for patients.

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