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Evolving functions of plasters and patches in health care: The historical progress of classical medical devices

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Abstract. Plasters are devices useful for protecting wounds so as to avoid and prevent their contact with dirt and microbiological agents in order to accelerate the healing process. Already about 2500 years B.C., in Mesopotamia, clay tablets were adopted for the management of wounds. The ancient Sumerians combined fir resin and pine resin together with beer and flour to produce a healing paste that was to be applied on the human skin. In the last hundred years, plasters have undergone a substantial evolution passing from their initial physical role of coverage and protection to their current multiple effects and functions. Nowadays the variety of plasters and patches is qualitatively and quantitatively particularly ample. On qualitative grounds, they range, just to cite some examples, from classical coverage plasters to transparent ones for visually monitoring wounds, from drug-containing plasters to heating patches for back and muscular pain, from sleep aid patches to nicotine ones. On quantitative grounds, it has been calculated that at present hundreds of patches are available on the market to face the wide spectrum of medical challenges that are daily posed to health personnel. The case of a particularly recent device, the diabetic patch, is very interesting because on the one hand it demonstrates the usefulness and flexibility of advanced technology applied to common diseases and, on the other, it provides a perspective on the potential future applications of "classical" medical devices in the different contexts of the monitoring of health conditions, the management of health disorders and the treatment of specific diseases. (www.actabiomedica.it)

Key words: plasters, patches, history of medicine, medical devices, wound care, medical humanities

Introduction

In the context of modern medical devices, advanced equipment and complex instruments first come to mind. Yet the history of medicine clearly indicates that simple tools dating back to a century ago, namely adhesive plasters and patches, continue to remain fundamental for appropriate health care.

Plasters are, at a basic level, devices useful for protecting wounds so as to avoid and prevent their contact with dirt and microbiological agents in order to accelerate the healing process. In the last hundred years, however, plasters have undergone a substantial evolution passing from their initial physical role of coverage and protection to their current multiple effects and functions.

The remote past

In the past, wet-to-dry dressings were largely used for wounds which required debridement. Already about 2500 years B.C., in Mesopotamia, clay tablets were adopted for the management of wounds. The ancient Sumerians combined fir resin and pine resin together with beer and flour to produce a healing paste that was to be applied on the human skin. The ancient Egyptians pioneered the use of fat, vegetable

substances and honey to obtain combinations useful for the protection from infections. Honey was also used by itself, given that its anti-inflammatory and antiseptic properties were already known in the distant past. Sixteen hundred years B.C. linen strips, soaked in oil or grease and covered with plasters, were used to cover wounds (1,2).

In Chinese Traditional Medicine forerunners of "medicated" plasters, called *Gou Pi Gao*, were used in the form of a sticky herbal paste spread over a backing of leather which, in turn, was originally made of the skin of dogs. The resulting resinous plaster was so hard that heat was needed to soften it before topic application for the treatment of joint pain.

The Hippocratic school, particularly active in ancient Greece in the V and IV centuries B.C., commonly used vinegar to cleanse open wounds and proposed wrapping dressings around wounds to prevent further damage. Furthermore, Hippocratic physicians washed ulcers with wine, then softened them with olive oil and eventually dressed them with fig leaves; they also used wool boiled in water or wine as a bandage (1,3).

In the first century A.D., to protect injuries, Roman physicians used silver, lead and spice ointments, including mint, thyme and saffron. The philosopher and physician Galen of Pergamum (129-216), by many considered the father of pharmacy and a genuine opinion-maker of his time, instituted the compound combination of herbal drugs in dosages and his cold cream, prepared as an oil and water emulsion and later called *Ceratum Galeni*, was well known in antiquity.

The less remote past

In the XVIII century Henri François Le Dran (1685-1770), a French surgeon and fellow of the Royal Society, used vinegar, egg albumen and clay powder to soak bandages for fracture immobilization, as is carefully described in his famous treatise *Observations de chirurgie* (1731).

In the second half of the XIX century the British surgeon Joseph Lister (1827-1912), generally considered the founder of antiseptic medicine and a pioneer in health care prevention, began treating his surgical gauze with carbolic acid. The consequence of this intervention was a notable reduction, from 1866 onward, of the number of episodes of sepsis and gangrene in the Royal Infirmary of Glasgow, Scotland (4).

Another important milestone was a compilation written in Latin and called German Pharmacopoeia (1872), which described dozens of adhesive products (*emplastra formulae*); among these was the *emplastrum adhaesivum*, which contained lead oxide, oleic acid and colophony, and the *emplastrum adhaesivum anglicum*, namely, patches with water-soluble adhesives (5).

In 1886 the brothers James, Edward and Robert Wood Johnson founded the Johnson & Johnson company, developing antiseptic bandages and producing sterile dressings and gauze. Two years later they elaborated the first medical emergency kits for injured railroad workers, containing sterile gauze, bandages and dressings (6).

In the twentieth century the United States inventor Earle Dickson (1892-1961) noted that his wife, Josephine Knight, often hurt herself while cooking; after having observed that the gauze put on her wounds with tape did not remain on her fingers for long, in 1920 he began to collocate squares of gauze at intervals on a roll of tape. Subsequently, in 1921, the first hand-made adhesive bandages were put on the market: their original format was 3 inches wide and 18 inches long. Three years later Johnson & Johnson put this original idea into production and developed plant and machinery to produce bandages on an industrial scale (7).

In Italy the chemist and pharmacist Achille Bertelli (1855-1925) established, in 1884 in Milan, the A. Bertelli & Company, in order to realize chemical, cosmetic and pharmaceutical products, including the well-known plaster bearing his name. This was a large patch useful, in its inventor's intentions, for the treatment of back pain, chest pain and kidney pain. In 1914 the Italian pharmacist Umberto Dotta started to experiment adhesive formulas for wound dressings; among his first creations were corn plasters and zinc oxide adhesive bandages.

During World War II, in the forties, millions of adhesive bandages were shipped from the United States of America to the front lines in Europe, inserted in the soldiers' first aid kits (8).

The more recent decades

In the fifties new technologies were developed and the diffusion of plastics led to the elaboration of impermeable plasters.

In the sixties hypoallergenic plasters were projected specifically for individuals with sensitive skin (9).

From the seventies onward other types of plasters were introduced in health care, among them elastic therapeutic tape. This kinesiology tape is an elastic cotton strip with an acrylic adhesive producing activating and inhibitory effects targeted principally to reduce disability and to contain the pain deriving from athletic injuries and other physical disorders (10). Transdermal nitroglycerin patches, adopted to treat the cardiac condition called *angina pectoris*, were developed in the USA in the seventies and marketed in the eighties. Their added value resided in the fact that they could release the cardiovascular drug over an extended period of time, and this invention paved the way for the subsequent commercialization of patches containing a variety of different medications (11). From the seventies to the eighties, both scopolamine patches and nasal strips were invented. Scopolamine transdermal patches were approved by the USA FDA in 1979 for the prevention of motion sickness. Nose patches are adhesive strips put on the nose to widen the nostrils and increase the airflow towards the upper respiratory airways.

In the eighties nicotine patches were developed. These devices furnished a controlled release of nicotine through the skin, constituting a form of nicotine replacement therapy aimed at reducing withdrawal symptoms in (former) smokers (1,7).

In the nineties many kinds of medicated plasters appeared. Following the pioneer nitroglycerin patches, they are devices containing drugs incorporated in adhesive materials applied to the human skin. Local anesthetics, such as lidocaine, non steroidal anti-inflammatory drugs and other therapeutic principles are released by medicated plasters directly in the affected area and absorbed by the skin. The knowledge that the transdermal delivery of the hormone melatonin during day-time hours may increase plasma melatonin and favour sleep, has led to the production of sleep aid patches, another kind of recent device.

Between the end of the XX century and the beginning of the third millennium adhesive heating plasters were introduced, providing a comfortable and discreet means for applying heat to specific painful districts of the human body.

At the beginning of the XXI century the first contraceptive patches were approved. They are transdermal patches that, applied to the human skin, release synthetic progestogen and oestrogen hormones to prevent pregnancy.

Conclusions and perspectives

The variety of medical devices called plasters and patches is today qualitatively and quantitatively particularly ample. On qualitative grounds, they range, to summarize some of the uses and functions described in this contribution, from classical coverage plasters to transparent ones for visually monitoring wounds, from drug-containing plasters to contraceptive ones, from heating patches for back and muscular pain to sleep aid patches, from nitroglycerin transdermal patches to nicotine ones. On quantitative grounds, it has been calculated that at present hundreds of plasters and patches are available on the market to face the wide spectrum of medical challenges daily posed to health personnel.

Recent research achievements include other original models of patches. Among them, multilayer electrospun patches for the slow release of natural oily extracts, used as dressings to boost wound healing (12). These advanced medical devices derive from electrospinning, an innovative manufacturing strategy adopted to elaborate patches from continuous nanoscale fibres endowed with modular chemical and biological properties.

A further achievement are wearable microneedle patches, that provide an easy-to-manage and minimally invasive approach to effective disease diagnosis and, more in general, to real-time health monitoring. In effect, these tools permit continuous and precise sampling of biological parameters such as electrolytes and lactate while, even more recently, microneedle arrays have been integrated with porous structures targeted to perform sweat-based analyses (13).

Recent evidence shows that the use of classical devices such as allergy patches can be empowered by artificial intelligence, whose integration into patch testing for allergic contact dermatitis may potentially decrease inter-observer variability and consequently standardize diagnoses (14).

Last but not least, the case of diabetic patches appears to be of particular interest, given that they are monitoring devices constituted by sensors placed on the human body in order to automatically and continuously measure blood glucose levels in a non-invasive way, thus allowing increased comfort and independence for diabetic people (15).

Diabetic patches are therefore, on the one hand, the demonstration of the usefulness and flexibility of advanced technology applied to common diseases and, on the other, a perspective on the potential future applications of the medical devices called plasters and patches in the different contexts of the monitoring of health conditions, the management of health disorders and the treatment of specific diseases.

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