The art of medicine

The ancient origins of prosthetic medicine

Wandering among the cases on the fifth floor of the Science Museum in London, UK, my attention was drawn to the greenish tinge of an artificial leg. It is a plaster copy of one rescued from a wealthy "Roman" burial in Santa Maria di Capua Vetere (the site of modern Capua). The bronze and wooden original was housed in the Royal College of Surgeons, London, but was destroyed in the bombing raid in 1941. Its wooden core had been hollowed out, possibly to attach a foot or metal rocking peg and was probably suspended from the body by leather straps attached to a bronze waist band. Thanks to the detailed examination done in 1920 by the German medical historian Karl Sudhoff, and to the paper published by Walter von Brunn in 1926, this unique classical prothesis was literally brought back to life.

Other burial sites in Europe have also revealed early examples of extremity prosthetic devices. At Bonaduz in Switzerland, a man (5th–7th century AD) appears to have been buried with an artificial right foot. Analysis of the remnants and surrounding earth suggest it was a leather pouch stuffed with some form of vegetable material such as hay or moss. It had been reinforced with a wooden base attached by iron nails. Another foot, this time made from wood and bronze, has been found in a Frankish grave in Griesheim (7th–8th century AD). The lower part of the left leg was missing, and the foot seems to have been attached to a wooden extension as far as the knee. A drawing of a reconstruction in a book by Alfred Czarnetzki and colleagues shows how it may have been strapped to the stump.

Early evidence of prosthetic devices may also be found painted on ceramics but often artistic styles of the period



The Greville Chester toe made of cartonnage

in question cause difficulties in interpretation. In addition, translating texts can also be fraught with problems. Although we can read Pliny's account of the so-called iron "hand" of Marcus Sergius Silus, the great-grandfather of Cataline, and Herodotus' description of the wooden foot belonging to Hegesistratus of Elis, the diviner for the Persians in the battle of Plataea, such protheses may be just complete fiction. The Capua leg, belonging as it did to a man living around 300 BC, provides tangible evidence, albeit now in the form of a replica, of perhaps the earliest prosthetic device. Or does it?

Visit the Egyptian Galleries of the British Museum in London and you come face to face with another "prosthetic" device: the Greville Chester toe. This time we have the original artifact, exquisitely crafted in cartonnage (a type of papier mâché of linen soaked with animal glue and coated with tinted plaster). The toe was originally acquired in 1881 from the Reverend Greville Chester, one of the museum's principle scouts working in Egypt. Apparently discovered in Thebes, near present day Luxor, it is in the shape of the right big toe and portion of the right foot. It is skilfully crafted and at one time carried a false nail. Several areas show clear signs of wear. Eight holes on the inner left side have distinct signs of rubbing. Four holes on the outer right side have been filled in and are to some extent hidden by the addition of paint, perhaps a refurbishment made in ancient times. It is likely that the two sets of holes were used either to attach it onto the foot or perhaps to fasten it onto a sock or sandal. Furthermore, other areas where the top coat has cracked and fallen away seem to correspond to the position of the knot and strapping of a typical ancient Egyptian sandal. Between 1989 and 1992, an extensive scientific investigation was undertaken by the British Museum. Based on the spin characteristics of the linen it was then dated to before 600 BC. Described by Nicholas Reeves as a "rare and important object" he also classed it as "one of the earliest working prostheses to have been identified from the ancient world".

Andreas Nerlich and colleagues' account of a second ancient Egyptian false big toe, again from the Theban necropolis, was reported in 2000. Fortunately, this example was fastened onto the right foot of the female owner, who was identified as Tabaketenmut from around 950–710 BC and was the daughter of a priest. Tabaketenmut may have had diabetes which could have caused ischaemic gangrene in the toe. The stump subsequently healed without the need for stitches. This artificial toe, now in the Egyptian Museum, Cairo, was made in three sections, two of wood, the third possibly of leather. Holes have been drilled, through which a series of marlin hitches secures one section to the other. Like the Greville Chester toe, it too has eight lacing holes on the inner edge with four on the outer. Important aspects of its

design reveal how the carver seems to have been conscious of the anatomy and function of the foot. The inclusion of a hinge perhaps was intended to mimic the flexion of the metatarsophalangeal joint. Deliberate chamfering on the front edge shows an attempt to avoid rubbing against the navicular bone on the top of the foot, and the underside of the toe is flat for stability. Nerlich and colleagues described it as "possibly the oldest known intravital limb prosthesis".

Such statements about both of these artificial toes may indeed be justified. Nonetheless, there is plenty of evidence from mummified remains to show that the ancient Egyptian embalmers made every attempt to reinstate the completeness of the physical body before burial. The body could be moulded in plaster, packed with mud, sand, linen, butter, or soda. Even sawdust was stuffed between the skin and muscle to reform the contours, and false eyes, noses, and often genitals were added. Where limbs were missing generally poor imitations were added, of linen, reed, mud, and resin. Spells inscribed on the walls of ancient Egyptian royal tombs (known as the Pyramid Texts, c. 2375 BC), spells decorating the inside of coffins (the Coffin Texts, c. 2055 BC), and mortuary texts written on papyrus (the Book of the Dead, c. 1550 BC) all refer to the importance of "reassembling" and "reuniting" the body to enable "revitalisation" to take place in the Afterlife. This was seen as a prerequisite to the mystical reanimation expected in the next world. The two artificial toes described here are far more sophisticated in both design and appearance than any of these embalmers' restorations. Perhaps Reeves, Nerlich, and their co-workers were therefore correct in considering these as functional to the living.

To be classed as true prosthetic devices any replacement must satisfy several criteria. The material must withstand bodily forces so that it does not snap or crack with use. Proportion is important and the appearance must be sufficiently lifelike as to be acceptable to both the wearer and those around them. The stump must also be kept clean, so it must be easy to take on and off. But most importantly, it must assist walking. The big toe is thought to carry some 40% of the bodyweight and is responsible for forward propulsion although those without it can adapt well. To accurately determine any level of function requires the application of gait analysis techniques involving integrated cameras and pressure devices placed along a walkway. In the case of ancient artifacts the rarity and delicate nature of the object precludes this laboratory approach, so the logical solution is to test a replica. In so doing, further issues must be resolved. The artifact was originally made to fit the ancient owner, so while keeping true to the design, individual adjustments to fit volunteers become necessary. Today the prescriptive process in making a prosthetic device involves standard protocols laid down by professional national and international governing bodies. It would seem reasonable to assume that whoever made such devices in ancient times would have also discussed the fit and feel in consultation with their "patient".



An ancient Egyptian false toe found on a female mummy buried near Luxor The strapping in the foreground bound it onto her foot

Certainly, a dense hard wood would withstand the rigours of wear better than cartonnage, but how well each could assist the wearer to walk now becomes a key factor in determining whether they can be truly classed as prosthetic.

My own research used two volunteers with similar amputation sites and suggested that replicas of both ancient Egyptian false toes performed extremely well. Neither design should be expected to be completely efficient in emulating the flexion of the normal left big toe when pushing off. However, high efficiency was recorded by one volunteer when wearing the replica cartonnage prothesis and also when wearing the wooden one (both worn with replica Egyptian sandals). More importantly, no significant elevation in pressure under the sole was recorded although both volunteers found the articulated wooden design to be especially comfortable.

No such testing has yet been reported using the replica of the leg found in Capua. Until this is done we may continue to question whether this particular example can also rightly be considered a true prosthetic replacement. Both artificial toes are exceptionally rare objects. By using experimental archaeology combined with cutting-edge techniques more familiar to rehabilitation and sports clinics, we may just have the evidence to suggest that nascent prosthetic science was beginning to emerge in the Nile valley many hundreds of years earlier than in ancient Capua. Perhaps now attribution for the first glimmers of this branch of medicine should be firmly laid at the feet of the ancient Egyptians.

My research applying gait analysis techniques to replica Egyptian artificial big toes was undertaken at the Centre for Rehabilitation and Human Performance Research Gait Laboratory, University of Salford, UK, in collaboration with Dr Glyn Heath, School of Health, Sport and Rehabilitation Sciences, University of Salford, UK.

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Further reading

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