



Prosthetics in antiquity—An early medieval wearer of a foot prosthesis (6th century AD) from Hemmaberg/Austria



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ABSTRACT

Even though the earliest prosthetic devices date to the Ancient Egyptian Empire and iconographic sources attest their use in the Greco-Roman world, archaeological evidence for this practice prior to 2nd millennium AD is very scant. In 2013, a skeleton dating to the Frankish period (6th century AD) was excavated at the Hemmaberg in southern Austria. The middle adult male was missing his left foot from above the ankle. In its place, an iron-ring and wooden remains were recovered and interpreted as a prosthesis replacing the lost foot. This represents one of the oldest examples of prosthetic limb replacement associated with the skeleton of its wearer in Europe to date.

Analysis through macroscopic assessment, radiography and CT-scanning revealed healing of the lesion even though it may have initially been complicated by osteomyelitis. Atrophy of the left lower leg further indicates immobilisation and suggests survival of several years. Osteoarthritis in the knees and shoulder girdle provides tentative indications towards the functionality of the prosthesis, perhaps aided through a crutch. These findings are set against the historic, archaeological, bioarchaeological and social context of the man in order to discuss whether removal of the foot was due to medical, punitive or traumatic causes.

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1. Introduction

1.1. Amputation and prostheses in antiquity

In modern clinical practice, amputation, defined as any kind of intentional, traumatic (violent or accidental) or disease-related removal of a limb or part thereof (Karriem-Norwood, 2014), and consecutive therapeutic replacement by prosthesis represents a common form of surgical treatment of medical conditions such as severe infections, diabetes or compound fractures (Marshall and Stansby, 2008). Archaeological and paleopathological evidence for amputations predating the 2nd millennium AD are not very common (Bloom et al., 1995; Verano et al., 2000; Buquet-Marcon et al.,

2007; Dupras et al., 2010; Zäuner et al., 2013), thus little is known about their antiquity. Despite their extensive medical knowledge, the body of medical papyri from ancient Egypt holds no unambiguous references to amputations or limb replacements (Nunn, 1996). The earliest skeletal evidence for intentional removal of a forearm was documented in an individual dating to c. 2000 BC by Brothwell and Moller-Christensen (1963). While initially interpreted as a form of punishment, other authors later argued that such a practice would have been highly unlikely as it would have reduced the work force and thus claimed that it represented a medical intervention (Aldred, 1964). However, new finds of a pit filled with cut-off hands at Tell el-Dab'a dating to around c. 1700 BC indicate that such punishment was indeed carried out in ancient Egypt (Forstner-Müller et al., 2011). Further early examples of potential limb removal, dating to the first half of the 2nd millennium BC were found at Deir el-Beyrsha (Dupras et al., 2010) and more clearly suggest that amputation as a form of medical treatment was already known to the ancient Egyptians. The earliest written reference to remove a gangrenous limb is found in the work of the roman encyclopaedist Celsus dating to the 1st century BC (Sachs et al., 1999),

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attesting to the fact that it was indeed an established medical practice.

By far the most common form of amputation in modern clinical studies in non-industrialised countries is the accidental loss of limbs or parts thereof. Amongst the main reasons are farming accidents involving animals or machines, vehicle accidents or falls from great heights (e.g. [Al-Turaiki and Al-Falahi, 1993](#); [Jabeen and Malik, 2015](#)). In the past, people would have likely been exposed to the risk factors leading to accidental amputations as well and one can assume that these injuries were not uncommon. Consecutively, the relative absence of archaeological evidence therefore seems surprising. However, prior to the development of strategies to stop extensive bleeding in the 17th century AD, as well as ways to avoid consecutive infection of the wounds, amputations may have been lethal in the majority of cases. Thus, if they led to death immediately, recognition in skeletal human remains could be problematic; particularly in poorly preserved skeletons. Therefore the scarcity of early evidence for amputation may well be attributable to issues of preservation and difficulties in identification.

The oldest known examples of artificial replacements of limb parts were found associated with Egyptian mummies from Thebes ([Reeves, 1999](#); [Nerlich et al., 2000](#); [Finch, 2011](#)) and are replacements of the big toe. While the wooden toe of Tabaketenmut held in the Egyptian Museum in Cairo dates between c. 1065–710 BC, the Greville Chester toe, now part of the collection of the British Museum in London was made from cartonnage and pre-dates c. 600 BC. Traces of wear on both examples indicate that the toe was indeed worn during lifetime ([Reeves 1999](#); [Finch 2011](#)) and not simply an addition by the embalmer to reinstate the completeness of the body—a prerequisite to ensure revival of the body in the afterlife and a practice well evidenced in ancient Egypt during the later 1st millennium BC ([Gray, 1966](#); [Giuffra et al., 2006](#)).

Beyond ancient Egypt, the earliest evidence comes from written sources referring to an arm prosthesis made of iron belonging to the Roman general Marcus Sergius Silus (3rd century BC, [De Libero 2002](#)). However, the theoretical discourse and probably the practical application of technical aids go back much further. Greek mythology refers to physical disability and the replacement of limbs, such as prostheses and crutches, of the god Hephaistos. The physical weakness of the god was the prerequisite for his specialization in blacksmithing and the associated technical and medical development of prostheses in general ([Erlach, 2000](#)).

Iconographic evidence of leg prostheses were found on an italic vase from the 4th century BC, as well as in gallo-roman mosaics, bearing testimony to the fact that it was an accepted medical practice in the Rome ([Brunn, 1926](#); [Baker, 2013](#)). From archaeological contexts, the earliest example found to date is the prosthesis of lower leg made of a wooden core covered with a bronze sheeting from a Roman burial (c. 300BC) excavated at Santa Maria di Capua Vetere in 1884/85 ([Brunn, 1926](#)). Unfortunately, the leg which had been acquired by the Royal College of Surgeons in London was destroyed in a bombing raid in 1941 and only a cast is preserved in the Science Museum today ([Finch, 2011](#)). No details are known about the individual who wore the prosthesis, thus it remains unclear whether the prosthesis was indeed functional or—like many of the Egyptian examples—simply of aesthetic purpose ([Bliquesz, 1996](#)). A second example of similar age, radiocarbon-dated to the 3rd century BC, was recently reported by [Li et al. \(2013\)](#) in the Chinese site of Shengjindian. Made from wood, the prosthesis was intended to replace the lower leg. In contrast to the Capua leg, the skeleton of the wearer could be studied bioarchaeologically, revealing details about the underlying pathology and functionality of the prosthesis. Heavy wear of the prosthesis along with the absence of signs of muscle atrophy in the affected leg suggests that the prosthesis was fully functional and the man continued an active life.

Archaeological, iconographic or historical evidence for prosthetic replacement of limbs or limb parts remains very scarce until the 16th century ([Kahlow, 2009](#)). While to date, there are only three known examples of prostheses of the foot or leg, arm replacements dating prior to c. 1600 are still absent from the archaeological record. This is perhaps related to necessity, because while the functions of the arm can always be fulfilled by the other healthy hand, the consequences of loosing of a leg or foot are far more severe and would have largely restricted movement and mobility. A man found in Bonaduz, Switzerland (5–7th century AD) was buried with an artificial foot, comprising a leather pouch with a wooden sole fixed with iron nails ([Baumgartner, 1982](#)). The foot had been removed entirely by cutting through the ankle joint (exarticulation as opposed to amputation which refers to the removal of parts of a long bone). Considerable osteomyelitis with a lack of atrophy was interpreted as an indication of death within a year after the injury. It appears unlikely that the prosthesis could have been used for walking because in being fixed to the remaining stump of the lower leg, it would have come off immediately. Moreover, the active osteomyelitis affecting the bone edges would have made any kind of pressure placed on the foot highly painful. A second leg prosthesis was found associated with an old adult male burial at Griesheim, Germany (7–8th century AD) whose left lower leg had been amputated below the knee ([Czarnetzki et al., 1983, pp. 91–92](#)). In this case, only the foot made from bronze was preserved and how it had been fixed to the upper leg remains unclear. Atrophy of the left femur indicates that the amputation had been survived for a longer period of time, but despite the prosthesis, use of the diseased leg had been restricted. This paper presents a newly discovered third example of a foot prosthesis associated with an Early Medieval burial from the cemetery at Hemmaberg in southern Austria dating to the 6th century AD and will discuss it in its archaeological, palaeopathological, historical and social context.

1.2. *The Hemmaberg*

The archaeological site of Hemmaberg is located on a low hill (842 m) in the county of Carinthia in southern Austria near the border with Slovenia in the foothills of the Karawanks. Systematic archaeological excavation and research has been carried out by F. Glaser for the Landesmuseum Kärnten since 1978, revealing use of the place since the Neolithic period (e.g. [Glaser, 1982](#); [Glaser, 1997](#); [Ladstätter, 2000](#)). Its most intensive phase of activity dates between the end of the Roman Empire and the Early Medieval period (4th–7th century AD) when several churches were constructed on the Hemmaberg, turning it into an important centre of early Christian pilgrimage.

The individual presented in this study was discovered during renewed excavations in 2009. Work took place at the summit in the north of the post-medieval church dedicated to St. Hemma and Dorothea ([Eitler and Reiter, 2009](#); [Eitler, 2013, 2014](#)). This building was first mentioned between 1498 and 1512 AD, but had a predecessor building in Late Antiquity. In close vicinity, the excavations revealed a small but distinctive cemetery of 29 graves ([Fig. 1](#)). Even though radiocarbon dating has not been carried out for the cemetery, based on the stratigraphic location, burial customs and the small number of grave goods associated with the skeletons, they can be dated into the brief time period of the Frankish reign of the area between the defeat of Ostrogoth Empire in 536 AD and the movement of pagan Slavic groups c. 600 AD into the area ([Wolfram 2003, pp. 65–66](#)). The individuals were buried in simple, rectangular and east–west aligned graves. Due to the underlying geology at the hilltop most of the pits were only shallow and sometimes carved into the bedrock. Characteristic of Christian funerary customs, only a few individuals were buried with objects of clothing, weapons or tools. Systematic bioarchaeological excavation is yet

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