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Editorial

The Ancient Artificial Leg of Capua: First 3D Print after 2300 Years

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Little detail has been reported about the ancient Capua leg, which was excavated in the winter of 1884/85 a few kilometers from the present-day Campanian town of Santa Maria Capua Vetere and dated to about 300 B.C.; the artificial leg was found in a stone-lined tomb next to a skeleton with part of its lower right leg missing. Indeed, one may almost find nothing substantially new about it since the 1920s [1–4]. However, a copy of the original from c. 1910 (Figure 1) still exists today. The original was destroyed in a German air raid on London in 1941; the copy is on display at the Science Museum, London, although it may not match the original completely, as historical photographs, sketches and notes made from the original suggest. On external inspection, one can hardly guess, let alone understand, the ingenious mind from which this artificial leg may have originated, when one considers the sophisticated wooden core for holding the remaining stump of the lower leg, even though it was already largely rotten in the original and therefore probably could not be reconstructed exactly in the 1910 copy: " . . . The artificial leg is full of little pieces of wood which once formed part of it." (Dr. Singer in [4]).

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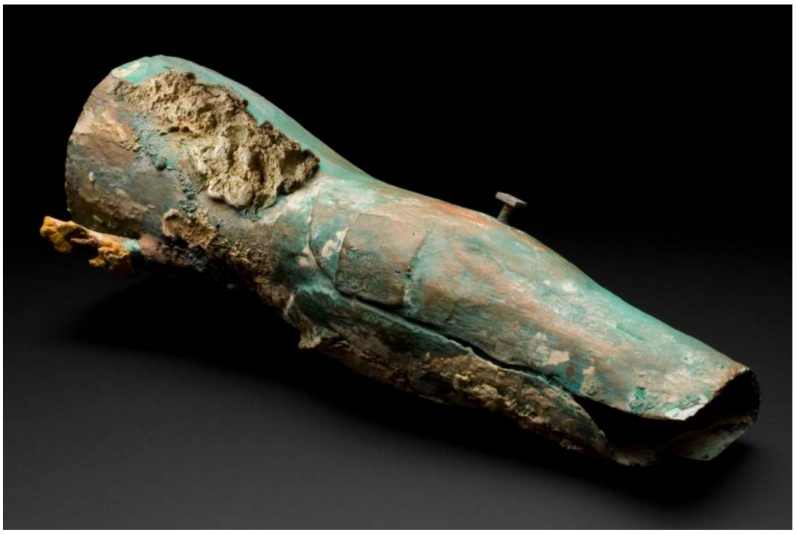

Figure 1. Copy of Roman artificial leg, London, England, c. 1910. Science Museum, London. https://wellcomecollection.org/works/kyjgqfuh (accessed on 15 July 2021). Attribution 4.0 International (CC BY 4.0).

Yet the Capua leg has been mentioned and featured again and again.

According to Lawrence Bliquez it is not clear if the Capua leg can correctly be called "Roman" and of which ethnic background its owner was: "Located in the rich southwestern plain still called Campania, the city of Capua was probably established by the Etruscans, the chief rivals of Rome in the early days of the Republic. Capua was Etruscan when, in

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the latter part of the fifth century B.C., control of the place was wrested away by a hardy Italic people called the Sabellians. In the course of the Samnite Wars in the last half of the fourth century B.C., the city eventually became a part of the Roman state. Thus, at the time this artificial leg was made, Capua was a city with a mixed population owing allegiance to Rome. Perhaps it is for this reason that the leg is often referred to as Roman, although its creator and its owner . . . were probably Etruscan or Sabellian, or a mixture of both." [5].

With this in mind, and considering that few details about the Capua leg have been published, we recently created a three-dimensional (3D) computer-aided design (CAD) reconstruction of the Capua leg using all available materials and adding mathematical–geometric assumptions and anthropometric data [6].

Meanwhile, we created a plastic 3D print of the prosthesis from this CAD reconstruction using the fused deposition modeling (FDM) technique and polylactic acid (PLA) filaments. To better demonstrate the structure, the original bronze sheath was split longitudinally, printed in two halves, and provided with an interlocking clip closure on the entire connection surface. The inner wooden core was printed separately so that it could be accurately inserted into the sheath. The 3D print thus consists of three parts that can be assembled and disassembled again (Figures 2–5).

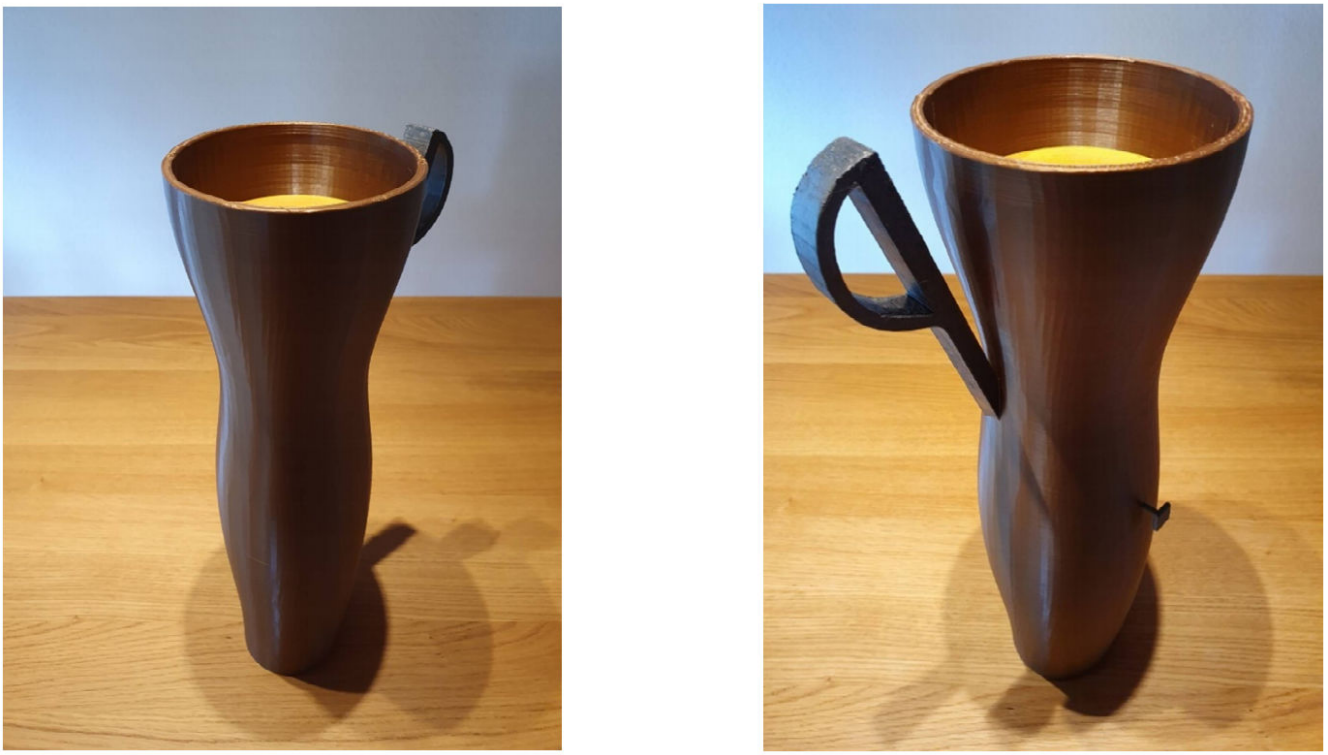
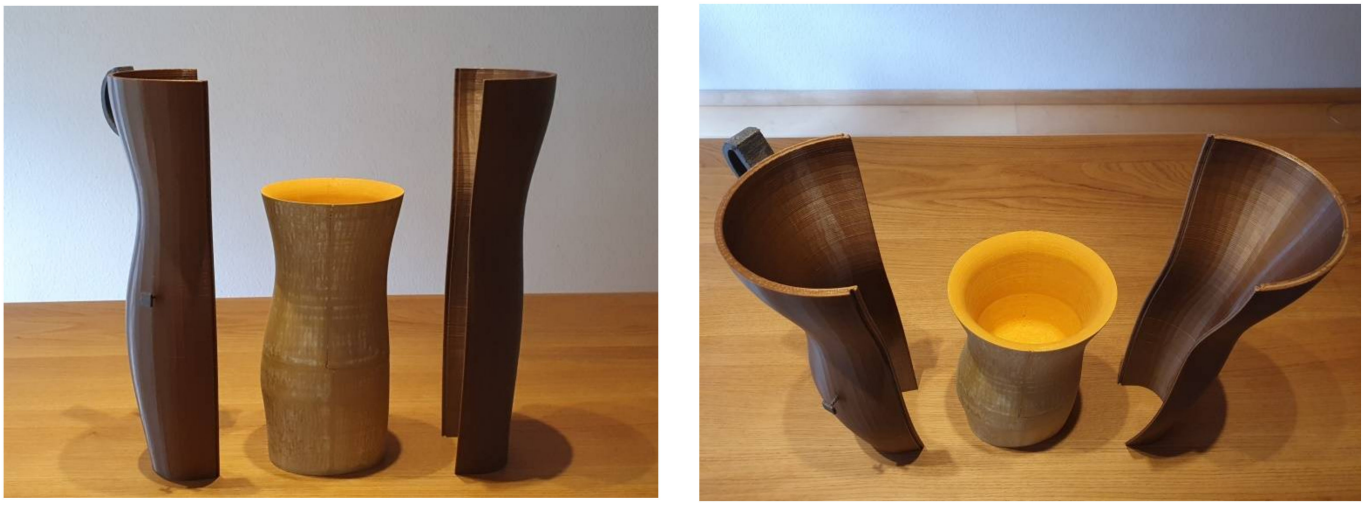


Figure 2. 3D print of the reconstructed Capua leg: (**a**) View from the front; (**b**) View from the back.

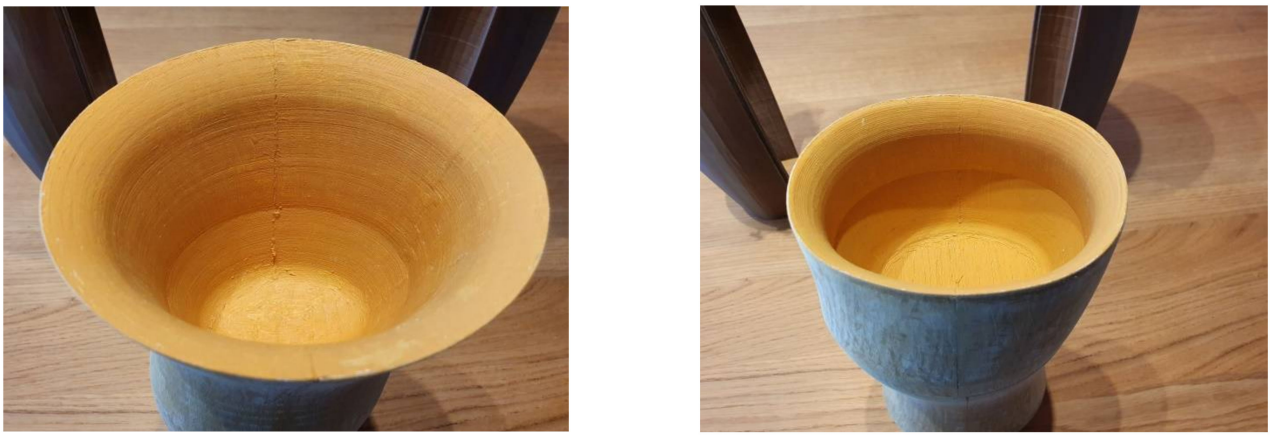
Despite the simple clip mechanism, the model proved to be extremely stable and robust. This model also makes it instantly obvious that the load acts exclusively on the inner wooden core—from above through the stump to be inserted and from below through an artificial foot, which unfortunately was not or was no longer enclosed with the tomb. It can be assumed, moreover, that the bronze sheathing served only an aesthetic purpose and the fastening to the thigh or hip was made by the eyelet and the hook made of iron incorporated into it. This connection could have been made with a leather strap, and there were probably more eyelets and hooks on the original [4]. In our opinion, it can also be deduced that the stump of the lower leg—and not the flexed and immobilized knee—was inserted at the top, which allowed the leg to move in the knee joint and brought advantages

for the gait pattern as well as making this artificial leg a real (and not just ornamental) utility prosthesis.



(**a**) (**b**)

Figure 3. 3D print of the reconstructed Capua leg, disassembled into its three parts: (**a**) View from the side; (**b**) View from the side above.



(**a**) (**b**)

Figure 4. 3D print of the reconstructed Capua leg, wooden core: (**a**) Looking into the upper part; (**b**) Looking into the lower part.

The creation of the 3D print model of the Capua leg not only seems to be helpful for understanding the functioning of this artificial prosthesis, but also opens up completely new ways of reconstructing archaeological finds. Unlike the museum exhibit, the 3D-printed Capua leg can now be easily picked up anywhere and displayed for teaching and research purposes without fear of destroying it.

In our model, the Capua leg appears not only as a simple workpiece, but also proves that people in antiquity must have had extensive knowledge of human physiognomy, mechanics and materials science in order to produce such an artfully crafted and well usable prosthesis. In the next step, we, therefore, plan to simulate the leg dynamically and then possibly subject it to a clinical trial to evaluate its current usability.

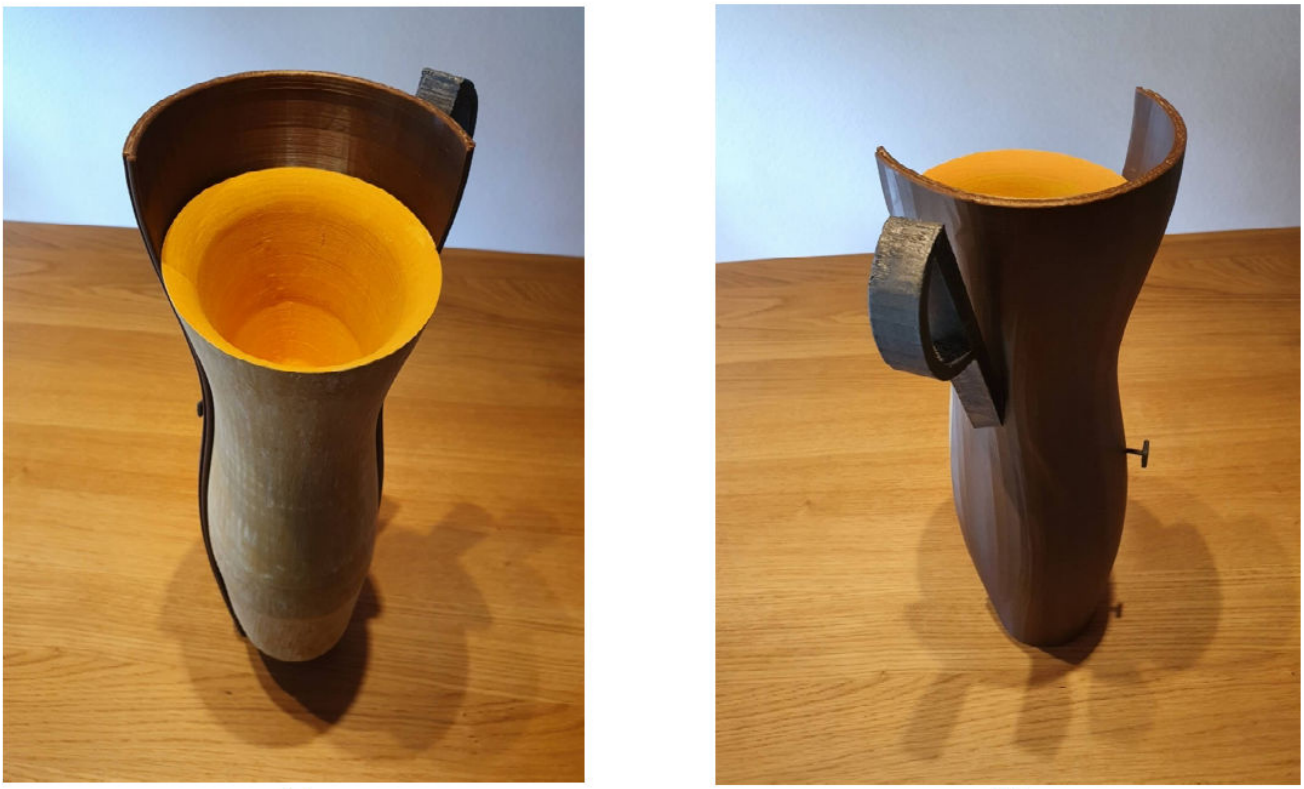


Figure 5. 3D print of the reconstructed Capua leg, wooden core and one half of the sheathing: (**a**) View from inside out; (**b**) View from outside in.

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Conflicts of Interest: The authors declare no conflict of interest.

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