Lessons Learnt from Götz of the Iron Hand

Andreas Otte

1. Introduction

Recently, we reported the three-dimensional computer-aided design (3D-CAD) reconstruction of the first “Iron Hand” of the famous Franconian knight, Götz von Berlichingen (1480–1562), who lost his right hand by a cannon ball splinter injury in 1504 in the War of the Succession of Landshut [1–8]. In this early passive hand prosthesis, the artificial thumb and two finger blocks could be moved by a spring mechanism in their basic joints and released by a push button.

A second “Iron Hand” was developed many years later, in which the fingers could be passively moved in all joints. In most illustrations of Götz, the second “Iron Hand” is shown, although he is said to have mostly used the first hand because of its robustness and easy usability in everyday activities. We also studied the 1815 publication of the Basel copper engraver Christian von Mechel (1737–1817) who illustrated and described the second “Iron Hand” and its sophisticated mechanics, containing two useful aquatint etchings in a scale of 1:1 [9].

2. 3D-CAD Reconstruction of the Second “Iron Hand”

Today, we would like to share with you our new 3D-CAD reconstruction of the finger mechanics of the second “Iron Hand” based on the Mechel plot (Figure 1). In this reconstruction, you can observe how a chain reaction is triggered in the body of the artificial hand after the locking lever is actuated, in which the angled hook of the proximal phalanx jumps out of the opening, and thus releases the locking of the middle phalanx, which also jumps up and releases the locking of the distal phalanx when its angled hook jumps out.

Figure 1. 3D-CAD reconstruction of the finger mechanics of the second “Iron Hand” of Franconian knight Götz von Berlichingen.

Thus, with one press on the locking lever button, the finger jumps from the preset flexion (Figure 2) to extend (Figure 3) in all joints.
Figure 2. Detail of the 3D-CAD reconstruction of the finger mechanics; the hand is in the flexed position.

Figure 3. Detail of the 3D-CAD reconstruction of the finger mechanics; the hand is in the extended position.

3. Lessons Learnt

What can we learn from Götz?

1. This ancient hand prosthesis has very complicated mechanics;
2. The very detailed Mechel publication does not explain every detail of the hand and is not quite 1:1 in scale.
3. When printing the parts with a multi-material polymer printer, the levers and springs of the finger mechanism broke after only a few seconds, while the polymer replica of the first hand still functions perfectly after years of constant use. This indicates
that not all prosthetic hand designs are suitable for 3D polymer printing: Especially for such fragile parts, such as those inside the second prosthetic hand, a CAD-based computerized numerical control (CNC) fabrication from metal should be considered. In fact, the original hand in the museum of Jagsthausen, Germany, is also made of sheet alloy. Information on the stability, and thus the choice for the appropriate material, can be simulated in advance, e.g., with a dynamic finite element method (FEM) analysis.

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**References**

1. Weinert, O.; Otte, A. 3-D CAD-Rekonstruktion der ersten “Eisernen Hand” des Reichsritters Gottfried von Berlichingen (1480–1562) [3D CAD reconstruction of the first “Iron Hand” of German knight Gottfried von Berlichingen (1480–1562)]. *Arch. Kriminol.* 2017, 240, 50–58.

2. Otte, A.; Weinert, O.; Junk, S. 3D-Multimaterial Printing—Knight Götz von Berlichingen’s Trendsetting “Iron Hand”. *Science*. Eletter from 2 December 2017. Available online: https://www.science.org/do/10.1126/comment.702964/full/ (accessed on 5 August 2022).

3. Otte, A.; Weinert, O.; Junk, S. 3-D CAD-Rekonstruktion der erstens “Eisernen Hand” des Reichsritters Gottfried von Berlichingen (1480–1562): 1. Fortsetzung: Funktionsprüfung mittels 3-D Druck. [3D CAD reconstruction of the first “Iron Hand” of German knight Gottfried von Berlichingen (1480–1562)—First continuation: Function test by means of 3D print]. *Arch. Kriminol.* 2017, 240, 185–192.

4. Otte, A. Invasive versus non-invasive neuroprosthetics of the upper limb: Which way to go? *Prosthesis* 2020, 2, 237–239. [CrossRef]

5. Weinert, O.; Otte, A. 3-D CAD-Rekonstruktion der ersten “Eisernen Hand” des Reichsritters Gottfried von Berlichingen (1480–1562)—2. Fortsetzung: Funktionsprüfung eines Umbaus zu einem sensomotorischen, controllergesteuerten intelligenten Fingersystem. [3D CAD reconstruction of the first “Iron Hand” of German knight Gottfried von Berlichingen (1480–1562)—Second continuation: Functional test of a conversion to a sensorimotor, controller-controlled intelligent finger system]. *Arch. Kriminol.* 2019, 243, 126–132.

6. Otte, A. Smart neuroprosthetics becoming smarter, but not for everyone? *eClinicalMedicine* 2018, 2–3, 11–12. [CrossRef] [PubMed]

7. Otte, A.; Hazubski, S. Die erste “Eiserne Hand” des Reichsritters Gottfried von Berlichingen (1480–1562): Weitere 3-D CAD-Rekonstruktionen. [The first “Iron Hand” of German knight Gottfried von Berlichingen (1480–1562): Further 3D CAD reconstructions]. *Arch. Kriminol.* 2020, 246, 207–210.

8. Otte, A. 3D Computer-Aided Design Reconstructions and 3D Multi-Material Polymer Replica Printings of the First “Iron Hand” of Franconian Knight Gottfried (Götz) von Berlichingen (1480–1562): An Overview. *Prosthesis* 2020, 2, 304–312. [CrossRef]

9. Otte, A. Christian von Mechel’s Reconstructive Drawings of the Second “Iron Hand” of Franconian Knight Gottfried (Götz) von Berlichingen (1480–1562). *Prosthesis* 2021, 3, 105–109. [CrossRef]