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Napoleon's second life

A. Gebhardt[1*], J. Kessler[2], J. Recardo[3], and J. Ritz[4]

[1] *Department of Mechanical Engineering and Mechatronic, Aachen University of Applied Sciences, Aachen, Germany*
[2] *University of Applied Sciences Niederrhein, Krefeld, Germany*
[3] *Hospital Carlos Andrade Marín, Quito, Ecuador*
[4] *Lecturer Global Family Firms, Munich Business School, Munich, Germany*
[*] *Corresponding author, email: gebhardt@fh-aachen.de*

Abstract: Within the last 30 years Additive Manufacturing (AM) has become an important method for the treatment of craniofacial injuries. This is true for the direct application of AM made implants as well as for its indirect application via counter casting. Many successful cases have been published. But little is known about the long-term behavior, especially if applied on loaded implants and older people. The report is a 10 years study about a 64 years old planter that suffered from a severe head injury. After several treatments he finally got an AM implant made from Titanium and recovered successfully.

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I. Introduction

Additive Manufacturing [1] today is a frequently used valuable tool for the design of craniofacial implants [2]. Because of its perfect fit and a reduced time in the operational theater.

In most cases the main aspect is the successful surgery after trauma and the clinical report is closed when this goal is achieved. Little is known about the long-time situation of the patient.

I.I. The case

On December 5, 2009, the Planter and Banana Farmer Hermógenes Napoléon Gavilánez Guerrero (called just Napoleón), suffered from a severe accident. Working at his plantation at Guayaquil, Ecuador, a non-secured swinging crane hook hit his head. It did not only damage the left side of his scull but pressed the entire scull at the side panel of a lorry and caused a second smaller but also severe trauma at the right side of his skull (See Fig.1).

At the hospital of Guayaquil Medical first aid was given instantaneously and the patient was stabilized. On December 7, the patient was ready for a Decompressive Craniectomy. It was done by Dr. Alberto Valarezo the same day and the removed bones were kept sterile. Six weeks later, on January 6, 2010 the patient was stable and the bone structure removed during Craniectomy was replaced.

Within the following days Napoleon at first recovered well. But quickly his convalescence slew down and he increasingly showed symptoms like a severe headache of rapid onset, vomiting, decreased level of consciousness, fever, and frequent seizures. Especially the limbs of his right side were influenced.

An osteomyelitis was assumed. After some discussions (Guayaquil is on sea-level and Quito is on almost 3000 m), the patient was brought to Quito, the capital.

Figure 1: 3D reconstruction of the trauma caused by the accident.

There osteomyelitis was confirmed and another Craniectomy was done in order to remove the re-implanted bone structure again.

Figure 2: Shrunken part of Napoleon's scull

First, the patient recovered quickly. His disorders slightly improved but did not disappear. Then the uncovered area of his skull started to shrink and to cave in increasingly. Fig.2. Obviously, an implant had to be done. The medical

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doctors at Hospital Carlos Andrade Marín, Quito, already had some experiences with additively made implants that preferably came from the US and were made from plastics.

The main (left) implant was very big and curved. It crossed the boundaries of two skull quadrants and almost touched the two others. Therefore, an intensive discussion arouses about the implantability of it in general and of the stability of the plastic material in particular.

II. Material and methods and further treatment

That time Johannes Ritz a German bound Ecuadorian and lecturer at the Munich Business School contacted the Aachen University of Applied Sciences. From prior contacts he knew about our capability to make medical implants from Titanium. With Dr. Ricardo, the doctor in charge at the Hospital Carlos Andrade Marín, Quito, it was decided to make a two-parts Titanium implant for Napoleon. He sent a CT scan. From it a 3D-reconstruction and a 1:1 scale Stereolithography scull model was made.

At this time, it was already possible, to design an implant digitally using reverse engineering methods without a prior Stereolithography model and feeding it directly to a metal printer. Because of the dimension of the implant, we choose the classical way and manually formed it from wax (in order to counter-cast it later from Titanium) and fit it directly to the skull replicated by Stereolithography. Fig. 3. This procedure can be regarded as standard. The process is described in [2], Figure 4.35 and corresponding text. The characteristic properties are evaluated and discussed in [2], chapter 3.8, page 276-287. The Fibrocytes that are responsible or growing in can bridge approximately 0.5 mm distance. Therefore, accuracy is not a problem (see: [2]).

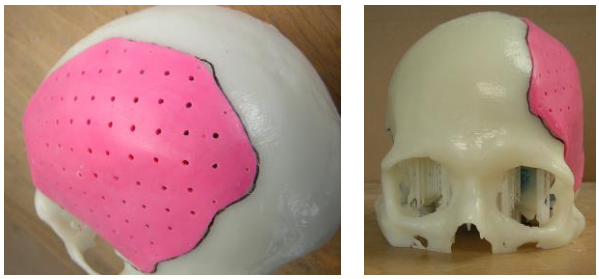

Figure 3: Wax implant fit in the Stereolithography scull.

As an advantage, the model is an excellent communication basis between the medical doctors and the technical staff. Regularly we send the model and the wax implant to the responsible doctor for approval, but with respect to time we did the conversation by mail, based on pictures.

As a disadvantage of this method the skull must be scaled to compensate the shrinkage of the casting and to consider geometric effects. Consequently, two Stereolithography skull models are needed; a scaled one (approx. 3-5% plus) to fit the wax implants, and another 1:1 scale one to check the final fit of the cast Titanium implants. The implants were cast by NRU-GmbH, a German specialist in Titanium casting and certified using scanning electron microscope, SEM, and energy dispersive X-ray, EDX according to international standards. Therefore, unwanted reactions with the surrounding tissue were avoided. The implants were sent to Quito, sterilized and implanted by Dr. J. Ricardo. There occurred no problems, neither during nor after surgery.

III. Results and discussion

Napoleon recovered slowly but steadily. He had to face a couple of drawbacks but step by step he got back almost all of his communication skills. His motional abilities re-developed. Considering his severe trauma and his two years lasting treatment, it was a kind of a miracle that he shared the pool with his grandchild at the years-end of 2011 (see Fig. 4). At this time a lot of improvements were stated:

- Recovery of his right-side mobility.
- Improvement of his communication- and language skills.
- An important improvement of his general behavior.
- A better quality of live, with much more independence (he can drive his car...).

Figure 4: Napoleon and his grandchild at the years-end of 2011.

But not just for him but for all related cases it always is the question if the result is enduring. Therefore, it was great news, that approximately 10 years later, at New Years Eve of 2020, Napoleon was dancing with his daughter. Dancing is a hard test for his mental and musculoskeletal system – indeed he is dancing into his second life.

IV. Conclusions

The case proves that even severe damages of big areas of the scull can be treated successfully using additively made implants and that Titanium is a perfect material that gives the stability and that shows the long-term chemical resistance the durability needed. Finally, the case shows that a long-time treatment even of older people is successful.

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Author's statement

Authors state no conflict of interest. Informed consent has been obtained from all individuals included in this study. Ethical approval:The research related to human use complies with all the relevant national regulations, institutional policies and was performed in accordance with the tenets of the Helsinki Declaration.

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