Titanium mesh cranioplasty for patients with large cranial defects – technical notes

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Abstract

We propose to describe some personal points of view concerning the repair of large cranial defects using titanium mesh, and in this sense we present few cases. Also we expose the presurgical planning by 3D imaging acquisition with the radiologic digital system which allow a computer aided design for a precise measurement of the shape and the curvature of cranial defect.

Keywords: cranioplasty, titanium, computer-aided design, skull defects

Introduction

There are a lot of pathological processes with involve the cranium including calvarial and skull base anatomical regions, traumatic defects, congenital, iatrogenic injuries, septic and all this processes leave the cranial defects exposing in this manner the brain with the soft covers, dura mater and the skin layers and also the imperfection of the skull shape induce important variations in intracranial pressure especially in positional movements orto-clinostatism. We insist on the aesthetic aspect because these large defects have also an important cosmetic impact. Titanium (Ti22) was discovered in 1791 by William Gregor in England and is a soft metal, very resistant to corrosion, used in various alloys of iron, vanadium, aluminum, etc. Titanium is used especially in aerospace, military and increasingly more in medical prosthetics. Characteristic of this metal is the ratio strength / weight, pure titanium (unalloyed) has greater resistance to the same strength as steel and 45% less mass, so it is a soft metal, very resistant to mechanical forces and fully biocompatible and corrosion resistant. These properties make the material of choice today in cranial and spinal prosthesis.

Clinical cases

We simply want to show some cases admitted in our hospital with diverse cranial pathology who had bone defects of varying sizes and lack of bone that was solved by implantation of titanium mesh prosthesis .

Case 1. M. 25 yrs. Admitted after a head trauma with parieto occipital bilateral brain laceration with multiple comminuting fractures. In the first time the acute trauma surgery was needed and in the second time the cranial defects were corrected by titanium implants. We must emphasize that we have developed a preimplantation rotational 3D CT to assess the lack of bone size and curvature radius of the head and then, post implantation we realize a 3D verification to appreciate the correct position of prosthesis and its connection to

the plate bone by titanium screws. This technique was performed with SIEMENS AXIOM ARTIS system in a acquisition 3D rotational protocol with 60frames /sec on 20 seconds that means about 1000 frames which need reconstruction in special software . Figure 1, Figure 2

Case 2. F 38 yrs. Admitted after multiple intervention for septic problems, subdural empiema and osteitis with frontosinusal origin, presented three large cranial postoperative defects.

The correction intervention was made after 4 years from the septic episode after controlling the septic problems, imaging revealed that the risk is practically null. Underwent anterior eradication of septic foci, 3D exploration highlights accurately whether or not there are septic risk. Figures 3, 4, 5, 6, 7.

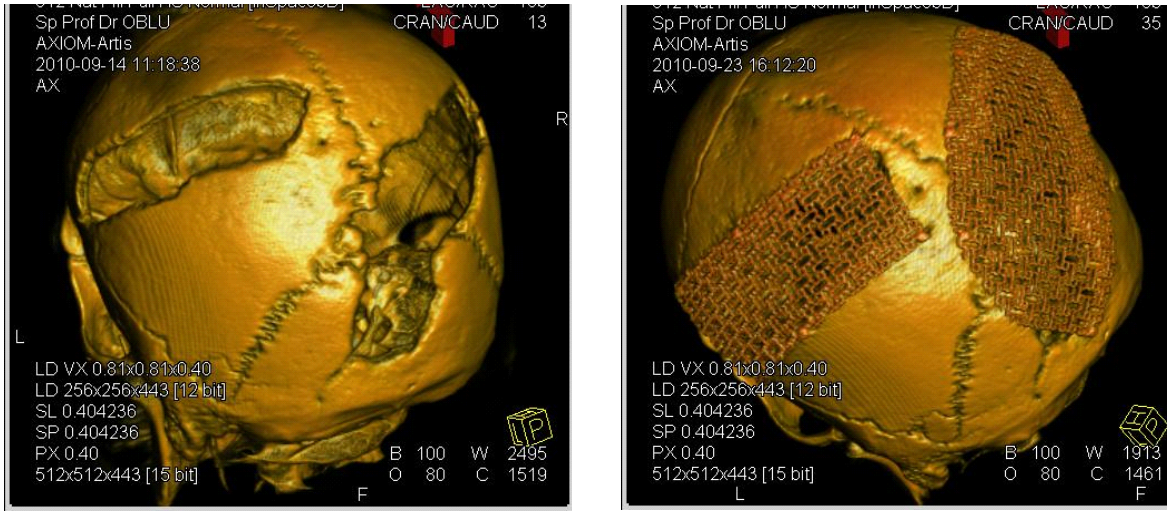
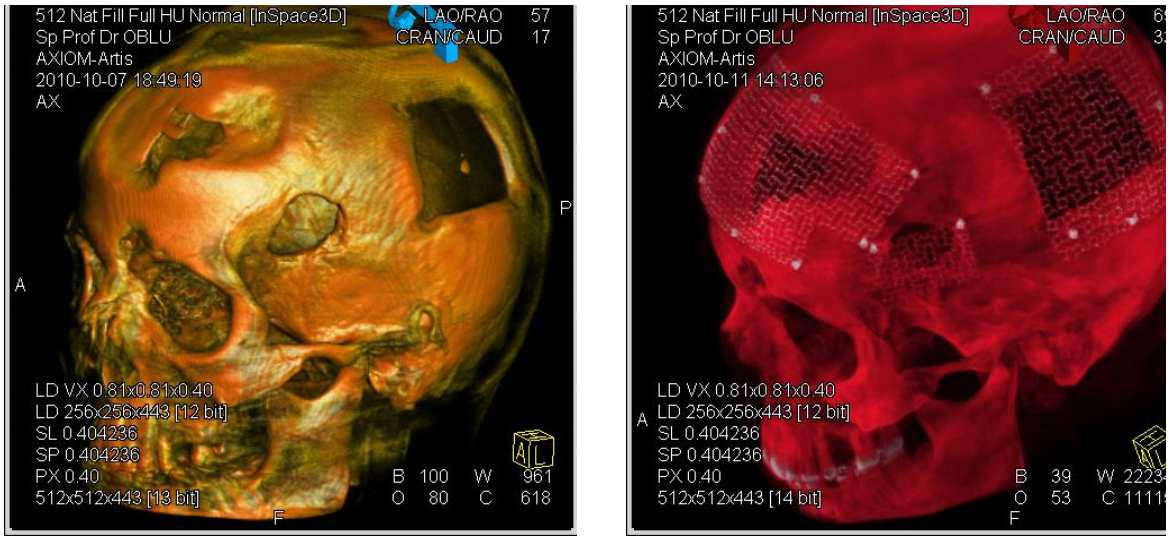
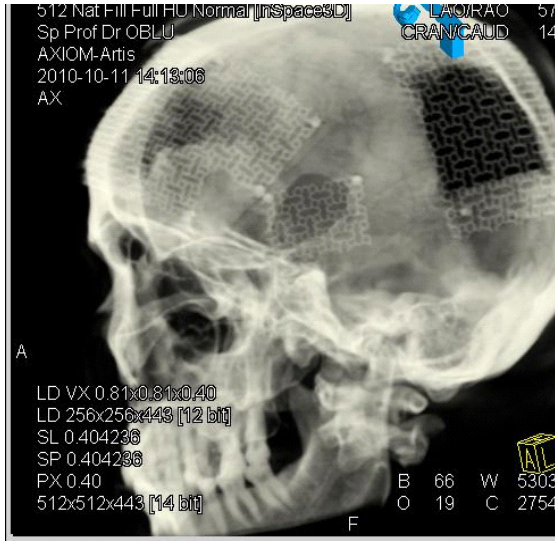
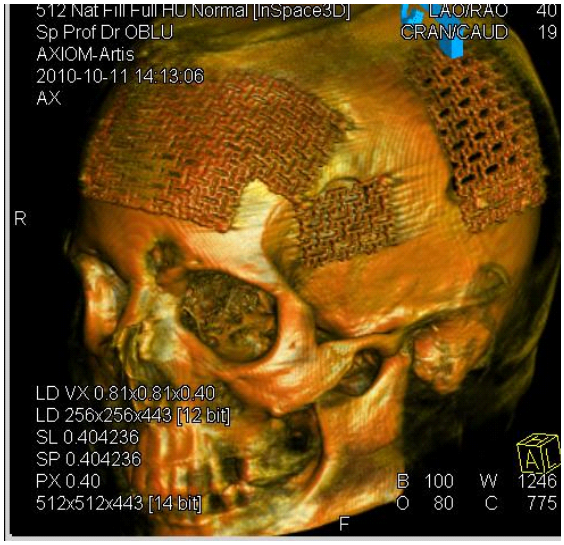
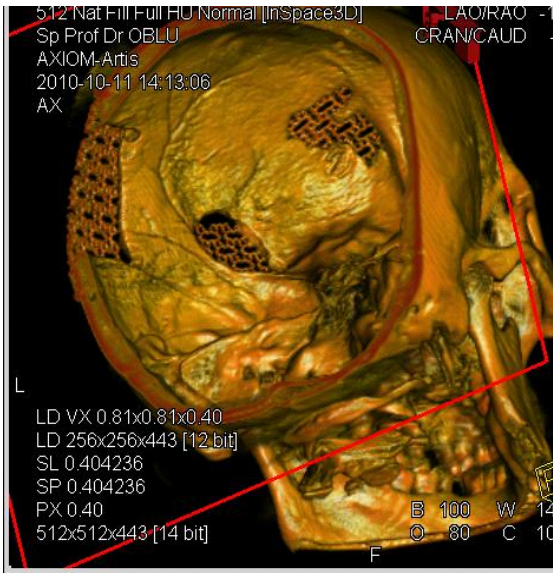


Figure 1, 2 3D aspects pre and post implants









Figures 3, 4, 5, 6, 7 first image present the preoperative aspect the others reveals the correct insertion of titanium prosthesis mesh and screws and also is the inside view to appreciate the endocranium

Discussions

The titanium is considerate the most compatible metal and can be easy integrated in the human body. Its biocompatibility make it the election material in joint replacement, dental and craniofacial implants. Usual the titanium is alloyed with aluminium or vanadium.

An interesting property of titanium is the possibility to osseointegrate in this way there are prosthesis from titanium migrated with osteogenic substances (polyvinyl lactic acid) in PLASMA spray.

Another property of titanium is the special radiolucency so the non ferromagnetic capacity permit the safe examination in MRI high field, useful for long term follow-up of the patients.

It should be added that very important that the properties titanium is compatible with MRI exploration (not ferromagnetic) and does not induce any major artifacts exploring the CT or MRI, by providing such accurate postoperative imaging (radiolucent). Osseous defects of various sizes and forms can be solved by attaching autologous bone fragments fixed with titanium plates and screws. It also shows that titanium plate are also elastic and has resistance well calculated to allow easy intraoperative modeling, establish appropriate curvature of the head.

Figure 8 Some aspects of the devices used during surgery sites. The fitting skull comes with special drills for every type of screw sizes and can control the insertion depth of bone

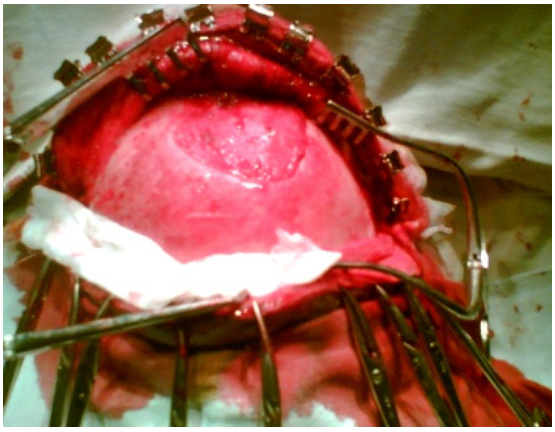


Figure 9 intraoperative aspect

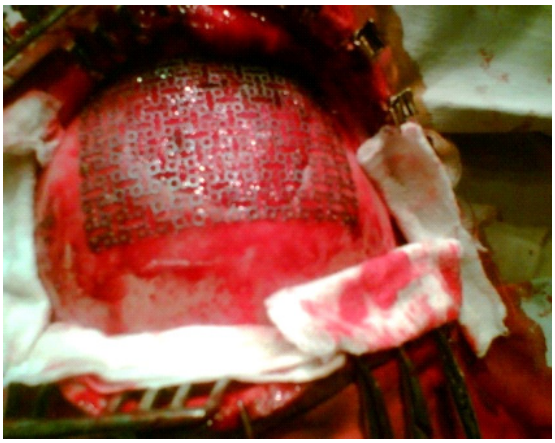


Figure 10 intraoperative aspect

Figures 9, 10 Titanium dynamic mesh prosthesis covers the whole area and is perfectly connected between bone and the basal region of bifrontal convexity.

Conclusions

In the neurosurgical pathology there are many processes that interested the brain and bone shell, for various reasons (postsurgical, traumatic, post-replacement process), require resection with restoration per primam or a subsequent time for remaining defect.

There are several principles: the implant must be stable, resistant to daily activities and possibly minor injuries, to effectively protect the brain, not skid spontaneous, to be perfectly biocompatible, does not interfere with voucher skin vasculature and not least to make a adequate cosmetic correction.

Now there are a variety of biomaterials that meet these goals. Of all the titanium site is best suited for cranioplasty . Surgical procedure is relatively simple but requires a well set up infrastructure and obviously a degree of skill. Basically so far I have not reported immediate or delayed complications. Is it true that high prices are often prohibitive, but the cost-effectiveness, ease of implantation process, significantly reducing operator time and duration of hospital stay makes it preferable.

Research News

After Fraunhofer Institute for Manufacturing and Advanced Materials IFAM, September 2010, a new titanium based material a foam like structure was created to replace injured bones. This new form of titanium presentation in medical practice will open a lot of possibility, in

bone pathology including vertebrae replacement. The technology involve open cell polyurethane foam saturated with titanium powder which make a material very close with human bone consistency.

Interests the authors declare no conflict of interests.

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