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GENERAL NOTIONS OF CRANIOPLASTY

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Abstract : The skull is a bony cavity that protects the brain. The skull is composed of four types of bones, namely, the cranial bones, facial bones, ear ossicles and hyoid bone, but two parts are more important: the skull and the mandible. In humans, these two parts are the neurocranium (brain shell) and viscerocranium (facial skeleton), which includes the mandible as its largest bone. The human cranium, the part that contains the brain, is globular and relatively large in comparison with the face. In most other animals the facial portion of the skull, including the upper teeth and the nose, is larger than the cranium. In humans the skull is supported by the highest vertebra, called the atlas, permitting nodding motion. In this paper we present the influence of neurosurgical procedures and materials to treat skull defects.
Key words : Cranioplasty, cranial implant, dentures, reconstruction, titanium implants, trauma.

1. INTRODUCTION ABOUT ANATOMIC PLACEMENT

Cranioplasty is a neurosurgical procedure performed to treat skull defects (Fig. 1)[1]. The operation reshapes or repairs irregularities in the skull.

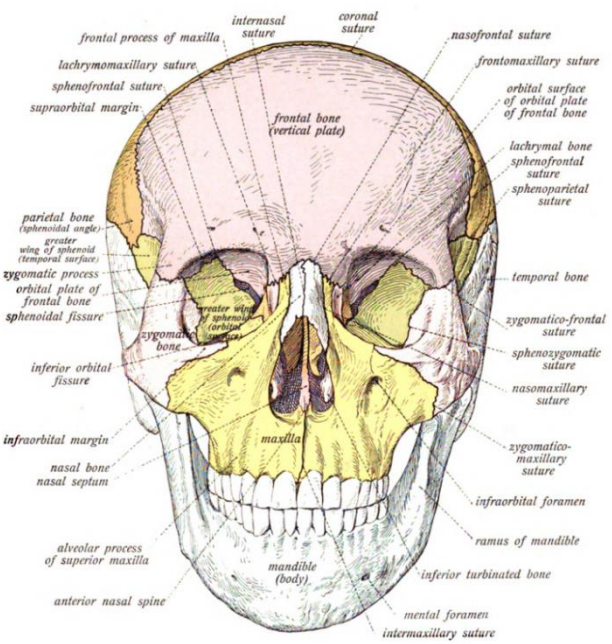

Figure 1 Human skull [1]

A cranioplasty is mainly done after traumatic head surgery or for aesthetic purposes. Surgery involves the use of either bone grafts or synthetic materials.

Cranioplasty is an important part of neurosurgery. It addresses cranial defects, which can result from injuries, congenital anomalies, infections, or when part of the skull is removed during neurosurgical procedures.

The loss of a body part significantly reflects on a patient's life. Not only does it have a huge influence on their physical and mental well-being, but it also hampers social integration, often reducing their expectations of returning to normalcy.

Cranial defects can result from trauma, illness, or birth defects. Repair of cranial defects is indicated to protect the underlying brain tissue, provide pain relief at the site of the defect, improve aesthetic appearance and minimize patient anxiety. Humans do not have the ability to regenerate a lost body part, but reconstruction can be achieved by prosthetic means and a multidisciplinary approach.

Cranioplasty is one of the oldest known neurosurgical procedures, dating back to 3000 î.Hr [2], [3], [4]. For centuries, various materials have been tried to cover bone defects, including coconut shells, bones from human and non-human donors, metals and, more recently, biosynthetic materials such as resins and ceramics [5]. The materials used for this type of intervention are constantly being developed [6], [7]. A new material used being polyether ether ketone (PEEK)[8]. “ PEEK can be processed using traditional methods such as compression moulding, extrusion, and injection moulding, among others. However, the crystallinity and, consequently, the mechanical

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properties of PEEK can be influenced by the processing conditions employed. PEEK can be processed in the temperature range of 370 to 420°C as a linear thermoplastic. Importantly, no corrosive gases are released during its production" [8]**.** This material is also used in orthopaedics [9].

2. TYPES OF PROSTHESIS AND ITS COMPONENTS

There are different types of cranioplasties, but most involve lifting the scalp and restoring the contour of the skull with the original cranial piece or a custom graft made from materials such as:

- Titanium (plate or mesh)
- Synthetic bone substitute (in liquid form).
- Solid biomaterial (custom prefabricated implant to exactly match the contour and shape of the skull) [10](Fig. 2)[11].

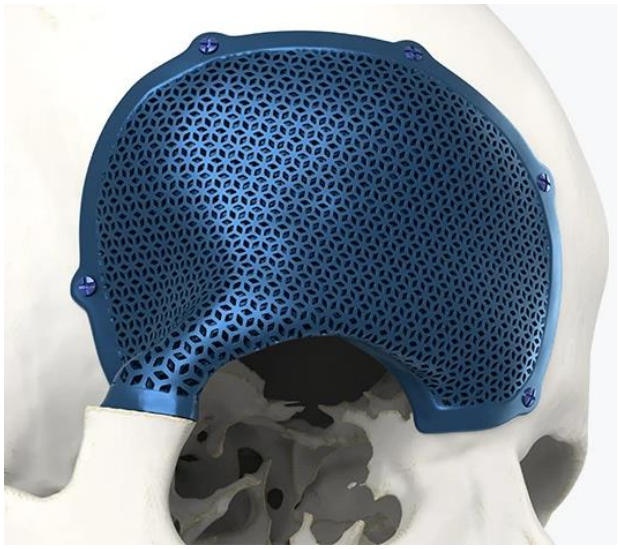

Figure 2 Cranial prosthesis designed in Materialise [11]

" Materialise Personalized Solutions are a comprehensive range of 3D-printed surgical splints, guides, and implants leading to a more predictable and accurate surgical outcome — all while increasing patient safety"[12].

3. TECHNOLOGIES OF DESIGN AND MANUFACTURE OF THE PROSTHESIS. MATERIALS USED

Usually, for very large defects, CAD/CAM systems are used to provide a prosthesis as easily customizable as possible. This is done,using data obtained through a scan of the damaged area [13].

Depending on the area where the damaged part is located and the purpose for which the 3D model is made, cranioplasty can be done using autogenous bone, alloplastic materials, including metals, thermopolymerizable acrylic, polyethylene and silicone [14]. These are commonly used materials for this type of prosthesis.

The materials used for this type of intervention are constantly being developed. PEEK (polyether ether ketone) is a new material which is also used in orthopaedics.

The manufacturing process for this type of prosthesis depends on the material used. For example, the production process of titanium bone plates is complex and requires high technical requirements, such as [15]:

1. Cutting and machining moulds (Fig.3)[15]
2. Precision stamping (Fig. 4)[15]
3. Precision forging (Fig. 5)[15]
4. Vacuum annealing treatment (Fig. 6)[15]
5. Delivery of blanks (Fig. 7)[15]
6. Precise processing (Fig. 8)[15].

Figure 3 Cutting and Machining Moulds

Figure 4 Precision stamping

Figure 5 Precision forging [15]

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Figure 6 Vacuum annealing treatment [15]

Figure 7 Delivery of blanks [15]

Figure 8 Precise processing [15]

Titanium has recently been used in the manufacture of cranial prosthetics. The manufacturing process for this type of prosthesis depends on the material used. For example, the production process of titanium bone plates is complex and requires high technical requirements. Plates that are 0,61 mm thick are suitable and its radiodensity allows most radiographic studies.

Many different types of materials were used throughout the history of cranioplasty [16]. With the evolving new biomedical technology, new materials are now available to be used by the surgeons.

An ideal cranioplasty material must have the following features:

- ✓ It must fit the cranial defect and achieve complete closure
- ✓ Radiolucency
- ✓ Resistance to infections
- ✓ Not dilated with heat
- ✓ Strong to biomechanical processes
- ✓ Easy to shape
- ✓ Not expensive
- ✓ Ready to use
- ✓ Still, there is no perfect material to fit all these criteria.

4. POSSIBLE COMPLICATIONS

- ✓
- ✓ Infection.
- ✓ Blood clot.
- ✓ Brain injury/damage.
- ✓ Pneumonia.

Complications that can be life-threatening after cranioplasty include [17] (Fig.9) [18], [19]:

- ✓ Hydrocephalus.
- ✓ Seizure.
- ✓ Stroke.

Figure 9 Complications with bony exposure both away from (A, C) and at the level of the incision (B).[17]

5. CONCLUSIONS

Cranioplasty is a common surgical intervention, but also a very complicated procedure. Post-cranioplasty complications are countless and sometimes can be serious enough to threaten life or justify a reoperation. That is why the reason is analyzed each complication in each patient, and attention is paid to small but basic surgical techniques in the prevention of undesirable postoperative events.

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