On the mechanical behaviour of PEEK and HA cranial implants under impact loading

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ABSTRACT

When critical conditions are met, falls or accidents in sporting activities can result in brain swelling which, when important enough, is accommodated by a decompressive craniectomy [1]. In this intervention, the surgeon removes part of the skull. After diminution of the swelling, a prosthesis is often used to replace the missing skull flap [2]. The patient then needs to go back to active life, thus potentially submitting their head to future impact loadings, a risk additionally exacerbated by a more likely predisposition for epileptic events. The work presented herein deals with the mechanical behaviour of cranial implants under impact loading [2]. The study was carried out on polyether-ether-ketone (PEEK) and macroporous hydroxyapatite (HA) prosthesis. In order to analyse the suitability of both implants, a finite element head model was developed from magnetic resonance imaging data comprising scalp, skull, cerebral falx, cerebrospinal fluid and brain tissues, with a cranial implant substituting part of the skull. The mechanical behaviours of the human tissues and both biomaterials are studied and their constitutive models are provided. A numerical comparison of the effectiveness of PEEK and HA in a) avoiding failure and b) preventing traumatic brain injury is presented. The results show the strong dependence of the implant suitability on the mechanical properties and nature of the material employed, highlighting the need for a patient-specific material choice. Finally, a new methodology is proposed for the risk evaluation of implant failure in case of impact over a wide range of impact conditions.

REFERENCES

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