Assessing the potential of mathematical modelling in designing drug-releasing orthopaedic implants

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ABSTRACT

Orthopaedic implants (OI) have been in use for many years and have allowed for greater healing of bone and restored mobility for patients the world over [1]. Examples include fixation pins and screws to stabilise fractures and replacement joints, such as prosthetic hips and knees. However, their usage does come with problems. For instance: the foreign body response often causes localised inflammation and pain for the patient; the surface of OI can harbour bacteria which can result in infections post-surgery and; there is the challenge of ensuring satisfactory osseointegration. It has been suggested that the controlled release of drugs (anti-inflammatories, antibiotics, analgesics) and other therapeutics (growth factors) may be a potential solution to these challenges. There are many experimental examples in the literature that examine drug release from various different types of OI. One of the main challenges however, is in designing devices which are capable of adequately controlling the release.

Many of the experiments in the literature focus on how to load a drug into a sample material/prototype implant. Whether this is done via coating the implant with a pure drug layer, or with a polymer mixed with drug, or even via filling hollow portions of the device with drug, controlled release is necessary. A drug concentration that is too high may cause toxic effects whilst a concentration that is too low would not exhibit the desired therapeutic effect. Repeated experimentation (especially where in-vivo studies are required) can be very costly and so we propose that a combination of mathematical modelling and experiments is required to help design the enhanced OI of the future. A mathematical model can help identify key drug release mechanisms and uncover the rate limiting processes; allow for the estimation of values of the parameters controlling the system; quantify the effect of the interaction with the biological environment; and aid with the design of optimisation strategies for controlled drug release [2]. In this talk we review some of the latest experiments aimed at enhancing our knowledge of drug release from OI and discuss a preliminary mathematical model of a prototype antibiotic releasing pin [3].

REFERENCES

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