25 years of the Development of a Remote Fracture Monitoring System

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Introduction

The natural healing process of long bones creates callus as a product of inter-fragmentary movement; the callus mass builds until the movement comes to rest. At this point the bone is healed. However, there are complications and congenital issues that could delay this process. When treating a human with, say, a fractured tibia the surgeon has a variety of choices of treatment regime. Stable fractures (those that do not shorten under axial loading) are treated in plaster-of-paris casts; unstable fractures are treated surgically using external fixation or internal fixation. But they are all bound by the same questions: is the fracture healing as it should? Is the fracture heading towards a non-union? Is the fracture healed and is it time to remove the fixation? At present, all of these questions are answered by examining patients at regular clinics.

Typically a patient suffering say a tibial fracture, would be required to visit about 4-6 clinics over a period of several months. However this is a cumbersome approach; it involves transportation to and from hospitals, and dictates the use of resources to staff clinics. As an example, for the tibia, the surgeon would start to assess healing after about 7 weeks. This involves examination of x-ray images and physical manipulation of the fracture. Of course, in between clinics the patient is self diagnosing by observing for infections etc. The clinic therefore is a synthesis of a variety of data to decide whether the fracture healing is progressing 'normally'. In the early stages the decision concerns how the healing is progressing and whether there are any complications (such as mal-union, infection or non-union ensuing). In the latter stages the decision concerns whether the fracture is healed or not. In both cases early intervention of any complication is of paramount importance. In the case of early detection of a complication the benefits are self evident. In the case of fracture healing detection a patient's fracture could be considered healed one day after their last clinic. Being missed by one day, the fixation could be in place for a number of weeks longer than it need to be; or the patient cannot return to normal activity for longer than necessary. Any improvement in the situations described above would realise cost benefits for the healthcare provider and personal benefits for the patient.

The authors proposed a system, in the early 1990s, that incorporates sensors, data logging, transmission and analysis of data, and personalised (secure) data presentation that, in the first instance, can be used to monitor the progression of healing of a fracture tibia but which can be used as a platform for the monitoring of a variety of clinical outcomes away from the hospital / clinical environment. Modern communication technology has facilitated its development to the present day embodiment, which is able to provide quantifiable advantages.

The advantages of remote monitoring are as follows:

- Reduction of the number of clinics a patient needs to attend (indeed it is possible to eliminate the need for any clinics) this reduces burden on the healthcare provider and on the patient themselves;
- Reduction of the number of bed-days patient needs to attend, this reduces burden on the healthcare provider and on the patient themselves;
- Ability to monitor progression of healing with a view to the capture of complications as quickly as possible;
- An ability to transmit and present data such that the surgeon / clinician is able to compare progression against 'norms';
- An ability to transmit and present data such that the patient can see their progress against norms and thus have:
- the opportunity to be motivated.

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