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بعض الوثائق الأصلية تالفة

Electric Stimulation Of Bone Healing

Essay submitted for
Partial fulfillment of the Master Degree
In Orthopaedic Surgery

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Introduction

Introduction

Fracture healing is a specialized type of wound healing response in which the regeneration of bone leads to a restoration of skeletal integrity. While the process of fracture healing is usually considered to be biologically optimum, the healing of 5 to 10 per cent of the estimated fractures is delayed or impaired. The cause of the impaired healing is often unknown. However, problems with operative and non-operative interventions, such as inadequate mobilization of the fractures, distraction of fracture fragments by fixation devices or traction, repeated manipulations or excessive early motion of a fracture, or excessive periosteal stripping and damage to other soft tissues during operative exposure, interfere with healing and may cause a delayed union or a non-union.

In 1841, **Hartshorne** reported on a patient who, in 1812, had had a non-union of the tibia that had been treated with "shocks of electric fluid passed daily through the space between the ends of the bones" for six weeks. A subsequent report by **Lente**, (1850) described three non-unions that had healed after treatment with galvanic current for ten minutes three times a week for several weeks. However, despite these early successes with electric stimulation, no additional advances were made in the use of this treatment until 1953, when **Yasuda** demonstrated new-bone formation in the vicinity of the cathode (negative electrode) when a current in the microampere range was applied continuously for three weeks to a rabbit femur. He also found that, bone or any collagen containing tissue, possess one electrical feature in common: when they are mechanically distorted (strained) by an applied mechanical stress they develop *piezo* (pressure) *-electric* (surface

potential) effect because the mechanical distortion of strain displaces some electrons towards the compressed surfaces (negative) and away from the stretched surfaces (positive). In 1966, **Friedenberg** and **Brighton** described another kind of electrical potential in bone: the bioelectric or steady-state potential. This type of potential is electronegative and occurs in non-stressed bone in areas of active growth (metaphysis) and repair.

On the basis of these findings, clinicians and scientists around the world began to study, the effects of electricity on bone. In 1971 **Friedenberg et al.** reported the healing of a non-union after the use of direct current and, in 1974, **Bassett et al.** reported on the use of electromagnetic stimulation in the treatment of non-unions.

By 1976, at least 119 articles describing the effects of different forms of electricity on the growth and repair of bone had appeared in the world literature.

Although a variety of electrical stimulation devices have been developed, each can be categorized as one of three types: constant direct-current stimulation with the use of percutaneous or implanted electrodes (semi-invasive/invasive), time- varying inductive coupling produced by a magnetic field (non-invasive), or capacitive coupling (non-invasive). In direct-current stimulation stainless steel cathodes are placed in the tissues and electrically induced osteogenesis exhibits a dose-response curve in relation to the amounts of current that was delivered. Currents below a certain threshold result in no formation of bone while those above a certain threshold lead to cellular necrosis. In electromagnetic stimulation, an alternating current produced by externally applied coils leads a time-varying magnetic field that, in turn, induces a time-varying electric field in the bone. In capacitive coupling, an electrical field is induced in bone by an