Nonunions. Surgery and low-intensity ultrasound treatment

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Chapter 7

Discussion
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This thesis is aimed at investigating some specific surgical interventions of nonunions and the effects of low-intensity pulsed ultrasound on bone healing. It is not meant to be a rewrite of the famous book by Weber\textsuperscript{14} on the surgical principles of treating a nonunited bone. The stabilization of an ununited bone is of paramount importance. Biomechanical factors, such as varus deformation in femoral neck nonunions, play an important role. The dislocating varus forces can be transformed into compression at the nonunion site by a subtrochanteric valgisation osteotomy. Furthermore, biological factors are also important to achieve bone healing.

In general, osteosynthesis using a plate and screws is sufficient to fix nonunions of the long bones. Diaphyseal femoral\textsuperscript{13} and tibial\textsuperscript{9} nonunions can effectively be treated by reamed, intramedullary nailing. The advantage is earlier walking with full weightbearing. However, shortening and malrotation, which can occur after intramedullary nailing, can usually be avoided using plate osteosynthesis.

In scaphoid nonunion it is necessary to create stability and viable bone tissue. Osteosynthesis and bone grafting are the standard treatment for scaphoid nonunions. We found that osteo-arthritis developed whatever the treatment. The damage to the cartilage probably occurs during the initial trauma to the scaphoid. The surgical treatment of a symptomatic nonunion is nevertheless worthwhile. None of the operative techniques used was superior to any other. If symptomatic osteoarthritis develops an arthrodesis is the next step in nonunion treatment.

The treatment of a painful disabling midshaft clavicular nonunion is normally surgery with the use of plate and screws, with or without a bone graft. The overall bone healing rate is between 95 and 100\%. However, the incidence of brachialgia is underestimated. In the series, described in this thesis, the incidence of preoperative brachialgia was 45\%. We were particularly alert to symptoms of brachialgia. The better results of operative treatment using the wave plate technique are due to no recurrence or to no development of brachialgia. The logical explanation seems to be that the callus formation occurs under the wave plate away from the brachial plexus. The study was flawed in that it was not randomized thereby introducing some bias. For instance, we may have been more meticulous in our operative technique near the brachial plexus with the wave-plate osteosynthesis. However, surgical technique was standardized and all operations were performed by experienced orthopaedic surgeons. The cases of postoperative brachialgia with standard osteosynthesis were not selectively the first patients treated for a clavicular nonunion. Surgeons were aware of the problem of callus formation near the brachial plexus from the beginning of the study.

In the Netherlands low-intensity pulsed ultrasound has recently become available for
treatment of patients with a nonunion. Based on the effect of ultrasound in diaphyseal and metaphyseal fractures, with its shortening of the time to healing of 30-40%, the effectiveness of this specific signal has been established. The study of Emami et al., which showed no effect of low-intensity ultrasound in reamed internally fixed tibial fractures, has some flaws. First, the number of patients needed for sufficient statistical power would exceed the 32 patients used in the study. Second, the ultrasound treatment period was 2.5 months compared to 4.5 months in other studies. The tibial fracture was treated using reamed intramedullary osteosynthesis, thereby introducing other potential forms of bone stimulation (i.e. stabilization and bone graft). Thirdly, it is not known whether the patient and fracture characteristics were comparable and evenly divided between the active and placebo group. The statement that the presence of metal (osteosynthesis) might influence the effect of low-intensity ultrasound is subverted by experimental work and the study presented in Chapter 6.

The exact mechanism of action of low-intensity ultrasound is not known. The micromechanical force of the ultrasound signal might influence cell activity, vascularity and angiogenesis. In our in vitro experiment, presented in Chapter 5, direct stimulation of calcifying chondrocytes and osteoblasts was seen. To further investigate this effect, a subsequent study histomorphometry of the rudiments is being undertaken.

Based on the studies described in this thesis, application of low-intensity ultrasound should be considered in patients, who have a higher than normal chance of developing a nonunion after fracture or osteotomy. Patients with diabetes mellitus should be offered the opportunity to address ultrasound bone growth stimulation principally to prevent a Charcot deformation in case neuropathy occurs. Smokers should be told that they have a higher incidence of nonunion development and that ultrasound treatment is one possible way of decreasing the negative effect of smoking on bone healing. Generally every patient should be aware of the possibility of enhancing fracture healing through external daily application of low-intensity ultrasound.

Further experiments on the effect of pulsed low-intensity ultrasound include the effect on ingrowth of uncemented (total hip) implants, cartilage, spinal fusion, and dental application.

References


