Extracorporeal Shock Wave Treatment of aseptic, atrophic nonunions – an in vivo study using an animal model

Joerg Hausdorf1,2, Markus Maier1, Kenji Takahashi3, Thomas Tischer4, Volkmar Jansson1
1Orthopaedic Department, Ludwig-Maximilians-University, Munich, Germany; 2Institute for Surgical Research, Ludwig-Maximilians-University, Munich, Germany; 3Orthopaedic Department, Chiba University, Chiba, Japan; 4Department of Sportstrauumatology, Technical University Munich, Munich, Germany

Introduction: The delayed healing or nonunion of bone is a common problem as it occurs in 5 - 10 % of all fractures. Septic nonunions will always need to be operated on to eliminate the source of infection. Hypertrophic nonunions just need to be stabilized and they will mostly unite. But the treatment of the aseptic, atrophic nonunion is a clinically relevant problem, because of its biological inactivity. The current treatment is accompanied by an extended surgical procedure including resection of necrotic bone and bone grafting and so causing a large amount of stress, hospitalization and a long time work incapacity for the patient. The Extracorporeal Shockwave Therapy (ESWT) is a possible non-invasive treatment, as recent clinical trials show. In basic research the application of extracorporeal shock waves has shown to enhance new bone formation in healthy bone. It was also shown in vitro and in vivo, that ESWT is able to release local acting bone- and vascular growth factors as TGFβ1, BMP's 2, 3, 4 and 7 and VEGF. Therefore we investigated the in vivo effect of a single dose shock wave treatment on nonunions in a rabbit model.

Materials and Methods: 16 female NZW rabbits were taken into the study. After performing the osteotomy to the tibia and fixing it with an external fixator the animals were kept for 8 weeks before shock wave treatment with 0.5 mJ/mm² was applied to the treatment group, the control group received a sham treatment. In the course of the following 4 weeks there were measurements of the bone-metabolism using scintigraphy, X-rays were taken, bone growth factors and mineralization markers (TGFβ1, bFGF, VEGF, Osteocalcin) measured in the serum and finally the histological examination.

Results: The treatment group showed a significant increase in bone metabolism in the scintigraphy, the radiological and histological classification showed especially for the formation of callus a significant difference between the control and the treatment group. Concerning the blood samples we saw a clear increase in VEGF up to 7 days after shock wave treatment, which was scarcely not reaching significance, the other blood parameters just showed tendencies to a elevated production of growth factors in the treatment group.

Discussion: We could show for the first time that extracorporeal shock waves are able to induce bony healing in a standardized atrophic nonunion model. This was supported by a strong increase in bone metabolism, measured by scintigraphy. So in our opinion extracorporeal shock waves should be the first choice to treat non unisons and in the future more clinical studies are needed to bring this method into the mind of trauma surgeons.