Effects of Carbon Dioxide Laser on Induction of Bone Formation in Rat Tibiae

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The CO₂ laser has two opposing biological effects, inducing clear morphological changes in irradiated tissues: tissue vaporization and activation. High-level reactive laser therapy (HLLT) irradiation results in hyperthermia and tissue vaporization. Conversely, low-level reactive laser therapy (LLLT) irradiation stimulates cell proliferation and differentiation. Recent studies have reported that low-level CO₂ laser therapy induces new bone formation, suggesting that LLLT can be generally applied in GBR for the promotion of bone regeneration and in implant therapy for oral rehabilitation. However, the biological mechanism of CO₂ LLLT in bone tissue remains unclear. The purpose of this study was to examine the effects of CO₂ LLLT on bone cell function during bone induction. For this purpose, CO₂ laser-irradiated rat tibial bone tissue was analyzed histochemically and molecular biologically. On the third experimental day, bone marrow cells had accumulated just beneath the cortical bone of the laser-irradiated left tibia, and expressed osteopontin protein. On the fifth experimental day, woven bone composed of osteoid matrix was observed immediately beneath the laser-irradiated cortical bone, but bone marrow cells in the right tibia that had undergone dental bur-induced injury showed no changes. On the third experimental day, bone marrow cells in the laser-irradiated left tibia showed a higher level of osteopontin mRNA expression than that in the right tibia with dental bur-induced injury. Interestingly, osteocytes in the cortical bone were stained by anti-Lef-1 antibody at 3 h through 3 days after laser irradiation. However, the intensity of staining of osteocytes in the left tibia with anti-LEF-1 antibody decreased with the progression of bone formation until the fifth day after laser irradiation. On the other hand, osteocytes in the left tibia could not be stained with anti-SOST antibody until the third day after laser irradiation, but were stainable with the progression of bone formation from the fifth day after laser irradiation. These results suggest that CO₂ laser irradiation induces bone formation, and osteocytes have an important signaling function for the control of bone formation. This indicates that the Wnt canonical pathway in osteocytes is initially involved in the laser irradiation-induced mechanical signaling cascade in bone remodeling.

Key words: CO₂ laser, osteocyte, mechanical stress, Ief-1, sclerostin

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