EFFECT OF REPEATED DEBRIDEMENT AND IRRIGATION ON FRACTURE HEALING

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INTRODUCTION: The traditional management of Grade III open fracture includes repeated debridement and irrigation of the open wound and stabilization of the fracture. However, washing out the fracture hematoma delays the early healing process of stable fractures. Because delayed union and non-union are serious complications, the effect of repeated debridement and irrigation on fracture healing process was investigated.

MATERIALS AND METHODS: Twenty-one rabbits received unilateral, transverse, mid-tibial, 3-mm gapped osteotomies. Three-millimeter width of periosteum from both proximal and distal fracture ends was denuded. The osteotomy site was thoroughly washed with 40 ml of saline solution and then closed. Fractures were stabilized with double-bar external fixators (Control: Group I). For the study groups, the osteotomy sites were reopened, and rewashed with 40 ml of saline solution on the 3rd day (Group II), or on the 4th day (Group III). For Group IV, the osteotomy sites were washed consecutively on the 1st and 2nd days. The fracture healing was evaluated with weekly radiographs and peripheral quantitative computerized tomographs (pQCT). Five consecutive transverse sections (3rd section located at the center of gap, 2.5 mm interval) of the pQCT images were taken. Areas of callus and compact bone, and mineral content at the gap as well as in the 12.5 mm long bone segment were measured and normalized to those of the contralateral intact tibia. Animals were euthanized at 10 weeks post operatively if fractures were healed radiographically, otherwise, they were euthanized at 15 weeks post operatively.

RESULTS: In Group I (control), all six osteotomies healed radiographically between 5 to 8 weeks. In Group II, in contrast, five out of the six osteotomies healed radiographically between 6 to 8 weeks, and one had not healed by week 15. In Group III, two out of the five osteotomies healed radiographically at 8 and 9 weeks, and 3 had not healed by week 15. In Group IV, although all four osteotomies had formed small amount of medullary callus, but none of them had bridged with mineralized callus by week 15. All of the non-bridged osteotomies exhibited resorption of the cortical bone ends beginning at 7 to 8 weeks after osteotomy and they exhibited atrophic non-unions at 15 weeks (Fig. 2). At 10 weeks, the average total mineral content in 12.5 mm bone segment, including 3 mm gap, of Group I increased to 119 % of the intact bone value, in contrast, mineral content of Group IV decreased to 75 % of the intact bone value (p<0.0001: Group I vs. IV, Fig. 2). Average mineral content at the gap of Group I reached to 108 % of the intact bone value, in contrast, Group IV reached to 1 % of the intact bone value (p<0.0001: Group I vs. IV). Average dense bone (>890 mg/cc = cortical bone density) area at the gap of Groups I and II increased to 63 % and 43 % of the intact bone value, respectively, in contrast, Groups III and IV reached to only 3 % and 0 %, respectively (p<0.001, Fig. 3).

DISCUSSION: This study demonstrated that repeated debridement and irrigation removes hematoma and bone marrow from the fracture site thereby reducing the osteogenic stem cell population and retarding the fracture healing process. The healing process, callus formation and remodeling, was more retarded if debridement was more frequent or more delayed. Persistent rigid stabilization of fractures with gap provides stress shielding and hinders formation of bridging callus. Consequently, a long duration of non-bridged callus stage leads to cortical bone resorption, causing atrophic non-unions. The results of the study suggest that repeated irrigation and rigid immobilization may be associated with the development of atrophic non-union. If multiple debridement and irrigation is necessary for controlling infection in treatment of open fractures, early prophylactic treatment, such as bone grafting, should be performed and persistent rigid stabilization should be avoided. In addition, a repeated debridement and persistent immobilization method can be utilized for developing clinically relevant delayed or atrophic nonunion animal models.

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