Porous Scaffold Implantation for Bone Fractures Healing

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Abstract

The objective of this research was to evaluate the efficacy of Low Level Therapy of Continuous Diode Laser on porous Hydroxyapatite-Chitosan–Collagen scaffold implantation by daily clinical observation, weekly radiographic findings and histopathological examination at the end of 3rd, 6th, 9th and 12th weeks after surgery. Fifty Healthy adult rabbits of both sexes were used to induced diaphyseal Femur and to remove about (1±0.05 cm) of bone, as empty space filler.

Keywords: Hydroxyapatite-Chitosan–Collagen, histopathological examination, Scaffold, Radiographic findings.

Introduction:

Bone grafts / implantations are widespread in veterinary medicine and a popular procedure for the therapy of multiple fracture problems [1-4], such as delayed union and non-union, or may be used in the therapy of pathological fractures [5-8], also used as a framework for the stabilization, healing and filling of bone cavity defects [9-11].

Methodology:

Fifty adult local breed rabbits of both sexes weighing approximately 1.500-1.750 kg. 1±0.05 cm of bone length were surgically separated from femoral diaphysis under general anesthesia using a mixture of Xylazine hydrochloride at a dose of 17.5 mg/kg. B.W. and ketamine hydrochloride at a dose of 25 mg / kg. B.W. The skin, subcutaneous tissues and fascia lata opened, the vastus lateralis and biceps of the femoral is muscles dissected bluntly, exposed the femoral diaphyseal and separated the muscle around the femoral bone, 1 cm of length of the diaphysis bone removed by the electrical saw with the dripping of the standard sterile saline for bone cooling, the empty space filled with scaffold bony implantation (Hydroxyapatite-Chitosan–Collagen). All the operated animals divided to five equal groups. The control group of 10 rabbits lifted for normal healing process without laser irradiation, while the treatment groups of 10 rabbits which exposed for single continuous diode laser at 850 nm at 4 point at the lateral aspect of the thigh region for 5 minutes at 72
hours interval at the dose (148.4 J/cm²). All the animals injected with penicillin streptomycin intramuscular for 3 days post operation.

**Results:**

The radiological finding in the treatment group revealed early new bone formation at the end of 1st week post operation, while in the control group the new bone formation started at the end of the 2nd week post operation, the callus formation increase in size and opacity for the later weeks until bridge formation to joined the femoral fragments along the xeno bony implantation in the end of 3rd and 4th weeks post operation in treatment group, while in the control group the bony bridge formatted at the end of the 6th week post operation, the later weeks the callus stopped in formation and the remodeling phase started until the end of the 12th weeks post operation (figure (1)). Radiological results in the laser group demonstrated the presence of a high density of callus formed around the implanted bone implant in the femur with a high radioactive density between the ends of orthopedic implant and femur compared to the amount of callus formed in the control group. These results were identical and supportive to the results of histopathological examination, where the treatment group indicated the presence of density in the formation of mature bone barriers towards the implant and the occurrence of bone fusion between the implant and the animal bone where the bone barriers were relatively few voids that were full of tissue vascular bonding with the presence of bone cells to build up the bone, with observing the beginning of the formation of lamellar bone through the formation of the Havercian canal compared with the control group where the bone barriers formed had relatively large voids and the presence of a quantity of the vascular non-transformed tissue into mature bone barriers.

The activity of osteocytes as a result of stimulation by exposure to lasers due to activity in secretion and release of enzyme phosphatase, which leads to increased calcium precipitation and increase in the strength of the new bone formed. The laser has a direct impact on the expansion and formation of blood vessels in addition to stimulating the formation of collagen fibers, which in turn affected the improvement of the attachment of the implant and animal bone, penetration of bone cells and blood vessels into the implant, increased bone fusion and the transformation of the dead bone into a relative live bone.

![Figure (1): Radiological finding for all groups.](image-url)
The histopathological examination at the end of 6th weeks post operation in treatment groups revealed increase in the trabecular bone formation, seemed mature and wide and well mineralized with little cavity within the trabecular bone, while in the control groups, thin and less mineralization with large cavity inside the trabecular bone formation. At the end of 12th weeks post operation in the treatment groups mature trabecular bone formation, well mineralized, widening and lamellar bone formation circling the bony device and partially bone incorporation, the empty osteocyte lacuna of the bony device filled with osteocytes and blood vessels invaded the haversian canal, while the control groups the trabecular bone thin, less mineralized with many cavity, not converted to lamellar bone some of the empty lacuna within the bony device still not filled with osteocytes, with increase in the diameters of the haversian canal. All the physical and mechanical analysis done and the results revealed that the treatment group more dense and hardness than the control group and when exposed to pressure and heat to analyzed the fracture tolerance the results showed that the treatment group more resistant to pressure and can tolerate the fracture test more than the control group (figure (2)).

![Histopathological examination at the end of 6th weeks post operation](image)

**Figure (2):** Histopathological examination at the end of 6th weeks post operation.

**Conclusions:**

**Low Level Therapy of Continuous Diode Laser** promote the partially bony incorporation of the scaffold bony implantation with the recipient femoral bone and can successfully fill the empty space, support the weight after removing the internal fixation methods, with no body rejection.

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