ELECTRICAL STIMULATION OF ALVEOLAR BONE

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While the bioelectric parameters in long bone have been studied in some detail, electrical effects on alveolar bone growth have not been defined. In the present study we have explored the effects of three distinct levels of constant, controlled direct current on alveolar bone regeneration in rabbit mandible, after surgical creation of an intrabony defect. Three experimental groups received current levels of 0.1, 1.0 and 10.0 μamps, delivered through silver electrodes, to portions of the body of the mandible located deep to the masseter muscle. A cathode was inserted into a surgically created intrabony defect on one side of the mandible and an anode was inserted into a defect on the other side. A constant current electric generator was placed subcuteneously at a point posterior to the cervical vertebrae, and sutured to the fascia of the area. All animals received electric current for 14 days, then were sacrificed. Five hours prior to sacrifice the animals received an injection of tetracycline, a fluorescent antibiotic which unites with the inorganic matrix during the mineralization phase of bone growth. After sacrifice, the mandibles were bisected at the mandibular symphysis, and fixed in 10% formalin for 5 days.

Histological examination of the regions around the intrabony defects showed laydown of bone in regions adjacent to the defect. This new bone appears fluorescent due to incorporation of tetracycline, indicating that this new bone is in an active state of mineralization. The degree of fluorescence appears to be consistant with the degree of osteoid formation.

The data indicate that alveolar bone and long bone respond similarly when stimulated with small amounts of electric current, and that it may be possible to develop a bioelectrical method for regeneration alveolar bone which has been lost through disease or trauma.

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Attempts to link electricity with biological processes are scattered throughout the scientific literature beginning with Galvani's work aimed at determining electrical field effects upon his own body, and continuing through the present time. Much work has been done demonstrating electrical effects on developing systems (1), (2), (3), on regenerates (4, 5), (6), (7), (8), (9), in de-differentiation (10), (11), in wound healing (12) and in tumors (13), (14), (15), (16), (17), (18).

Bone has best lent itself to bioelectrical investigation and its piezoelectric (19), (20), (21), (22), pyroelectric (23), ferroelectric (24), electret (25) and semiconductive properties have been investigated in detail. Data from such studies led biologists and clinicians to employ small amounts of electric current in stimulation of osteogenic activity in long bone of several species of animals, including human beings (26), (27), (28).

Few studies (29), (30), (31) have been done on the effects of bioelectricity on the craniofacial skeletal system, and no studies to our knowledge have been done on the alveolar complex where the nature and amount of electric power was controlled to any extent. We therefore report our study of the effects of direct electric current of constant amounts of .1u amp., 1.0 u amp. and 10 u amps. on bone regeneration in the rabbit mandible after surgical creation of intrabony defects.

Sixteen young male rabbits (1200 - 1200 gm) were used for this study. The parameters used to assess stimulation of bone growth are gross observation, tetracycline incorporation and histological observation.

Surgical Procedures

Animals were anesthesized prior to surgery with a combination of Thorazine (2.0 mg/kg), Nembutal (10 mg/kg), and Ketamine (50 mg/kg). After anesthesia, a two c.m. vertical incision was made in the skin superficial to the cervical vertebral region. Cannulae were run through the deep fascia on both the left and right sides of the neck in an anterior direction to a point just posterior to the masseter. Teflon coated electrodes were run through the cannulae to the masseter. A longitudinal incision was then made in the belly of the masseter, the muscle fibers were separated and the mandibular bone deep to the masseter exposed. With the use of a dental handpiece, intrabony defects 5 mm deep and 1.0 mm in diameter were created. The electrodes were then glided anteriorly, deep to the masseter, and the bare tip of the electrode was inserted into the defect, noting which side was the cathode and which was the anode. The electrodes were sutured to the periosteum of the mandible, and to the soft tissue posterior to the masseter. Care was taken to leave enough electrode wire so as to allow the animal to have free head movement. All skin incisions were sutured closed, the animals were taken to their quarters, and were maintained on their normal diet throughout the duration of the experiment. Control rabbits received the same electrode placement as experimental animals, but no current was allowed to pass through the control electrodes.

The 14th day after surgery was chosen as an end point of this study because enough time would elapse to allow for significant bone growth to occur, and although our electrodes had the capacity to generate constant current for periods greater

than 14 days, we felt that we could better rely on the constant current production over this period. On the 14th day post surgery, 5 hours prior to sacrifice (10:00 a.m. tst) each animal received an intraperitoneal injection of tetracylene, a binder to the mineralizing process of bone formation, at a correlation of 50 milligrams per killogram of body weight (32). Animals were then sacrificed at 3:00 p.m., the electrodes, wires and mandibles were dissected out from the rest of the face. The mandibles were made clean of all soft tissue, bisected at the mandibular symphysis, and fixed in a 10% formalin solution. Each electrode system was tested for its activity with a Keithly microairmeter.

Analysis of Bone Growth

Control mandibles showed no new alveolar bone growth save for a very small amount around the edge of the surgically created bony defect.

All animals which received electric current demonstrated bone growth. Cathodal stimulation seems to be most effective in terms of mass of bone produced. Although anodal stimulation showed some bone growth, there also appeared to be some destruction of bone away from the bony defects. Fluoresence microscopy demonstrated tetracyclene in the newly formed bone, indicating that active mineralization was taking place prior to sacrifice. Histological preparations indicated that the electrically stimulated bone had a normal appearance.

The data indicate that all three current levels were effective in stimulation of mandibular alveolar bone. The ability to direct alveolar bone growth could be very important in clinical dentistry.

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