Dental Implant Electrical Stimulation Healing Device

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Abstract. There is an electrical stimulation device for dental implant healing, which is designed for dental patients who have been received an implant in their jaws during the three months of healing period. The device consists of adjustable constant current (or constant voltage) circuit, power supply (including DC or external AC power supply and transformer), MCU(Microcontrollers), wire and electrode, electrode fixed and connecting device, control panel and shell. When the dental implants have been implanted, the instrument facilitates osseointegration between the implant and the alveolar bone and healing of the implant and gingival tissue. There is the most advantage that we can adjust the corresponding constant voltage (50-1000mV) or constant current (10-200mA) and the loading time(10-60min) depending on the patient's alveolar bone condition.

Introduction

Currently, dental implant surgery is the focus of oral clinical medicine and oral basic medical research, so improving the healing level of gingival tissue and bone tissue is the main task facing doctors. [1,2] It is the key to dental implant success that bone marrow mesenchymal stem cells and periodontal stem cells migrating to the implant-bone interface and respectively depositing bone and forming junctional epithelium. [3]

DC simulation healing method has been widely used in the healing of fractures, the treatment of trauma, nerve growth. [4,5,6] Current studies have shown that a stable, slightly smaller, endogenous electric field (about 100-200 mV) is formed between the damaged tissue and the uninjured tissue after injury, and the field has a longer duration (a few weeks to several weeks), distributed within a few millimeters of the circumference of the damaged tissue, and the closer it is to the damaged tissue, the greater the intensity. [7] Previous studies have also demonstrated that constant new bone deposits are always produced at the negative potential, and the positive potentials tend to produce bone resorption. [8] This has revealed the importance of the shiftable charge to the bone growth process, and the idea of using electrodes to control and promote bone growth is proposed. [9] Studies on skin stem cells have also shown that epidermal stem cells move toward the cathode of an electric field under the influence of an electric field. [10]

Although there have reports of fracture healing instruments (E.g., the patents Nos. CN200610061732.7 and CN90100934.2), there instruments use DC stimulation to promote fracture healing, but these devices are either complicated and complex circuits, or cannot adjust the control output current and voltage, as a result, these instruments are difficult to operate and difficult to maintain, particularly for the elderly, and therefore these instruments are difficult to retrofit into instruments used for dental implants for wound healing.

In order to solve the above-mentioned problems, our group of researchers based on the relevant literature conducted a lot of bone marrow mesenchymal stem cells basic research in the DC micro-electric field to promote stem cell osteogenesis. Further we designed the dental implant electrical stimulation healing device. The device is largest characterized by the current and voltage constant and controllable, fewer components, simple, efficient, wide range of applicable people.
Mechanism

The tissue damage leads to the formation of an endogenous electric field in the lesion, which leads to the migration of the cell and the subsequent injury repair. Exogenous electric field can also play the role of the same or even synergistic acceleration of repair. The success of the dental implantation is whether the formation of osseointegration between the bone and the implant, so as to provide good stability of the upper part of the denture. DC micro-electric field can promote bone marrow mesenchymal stem cells migration, and accelerate its osteogenic differentiation, which can shorten the healing time and improve the planting efficiency. The design takes full advantage of this mechanism, through the microcontroller, built-in procedures and control panel, can provide continuous stable and adjustable voltage or current. Electrical stimulation through the loading device is connected to the implant healing cap and skin or mucous membrane, resulting in closed loop, forming a stable and adjustable potential difference at the implant-bone interface.

Design and Implementation

The composition of the instrument and the function of each part:

Power supply (1.1) for providing adjustable current and voltage for the adjustable constant voltage circuit and the adjustable constant current circuit, which can be connected to an external AC power supply and a transformer. Adjustable constant voltage circuit (1.4), for converting the power supply voltage into constant pressure and conducting to the electrode. Adjustable constant current circuit (1.2), for converting the current of the power supply into constant current conducting to the electrode. Adjustable constant voltage circuit and adjustable constant current circuit is composed of operational amplifiers, resistors, capacitors, diodes, transistors and other electronic components. Microcontroller (1.3) with built-in control program for controlling the output of constant current and constant voltage, is the core of dental implant micro-electronic therapy device.

Figure 1. Dental implant electrical stimulation healing device electrical module connection diagram.

1.1- Power supply; 1.2- Adjustable constant current circuit; 1.3- Microcontroller; 1.4- Adjustable constant voltage circuit; 1.5- Control panel; 1.6- Electrode

The control panel (1.5) is the peripheral controller of the device used to control the whole machine parameter settings, mainly to control the constant current and constant voltage output. Electrode (1.6)
comprises a cathode and an anode for conducting current to stimulate the skin used to conduct current, stimulate the skin and dental implants, can choose iron or copper. The electrode attachment device (2.1) fixes the cathode (2.3) of the dental implant electrical stimulation healing device to the dental implant stimulation cap (2.2) to avoid shifting. The device may be a conventional retention screw or a buckle, however the buckle is preferred. The anode (2.4) is fixed to a soft tissue such as skin or mucous membrane, so that a closed circuit is generated, and the anode is favorable for bone resorption. In order to close cathode and dental implant healing cap, isolate saliva, avoid the tongue and buccal soft tissue affect the role of the electrode, the dental impression silicone rubber or dental wax was packed around the cathode electrode (2.3) and the dental implant.

Conclusions
The design is based on a large number of experimental data of micro-electric field stimulating stem cell osteogenesis, so it has a solid theoretical basis. The use of the instrument can fundamentally ensure the dental implant-wound healing. Moreover, the operation is simple, short course of treatment, the effect is obvious. The device can significantly improve the migration rate of stem cells to improve stem cell, increase the ability of stem cell osteogenic differentiation, which can significantly shorten the bone healing period after implantation and improve the survival rate of the implant. And according to the different conditions of alveolar bone of patients we can set the appropriate intensity and mode of electrical stimulation, so the device is suitable for a wider range of people.

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References
