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Design and implementation of a magnetic stimulator for osseointegration after implant placement

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ABSTRACT: This paper relates to an implant osseointegration stimulation device using magnetic stimulation for early stabilization after implant placement. Dental implants are highly demanded for their aesthetic and functional properties in edentulous areas where teeth have been lost after treatment. Bone integration after implantation is very important, because there is no gingival sulcus like natural teeth on the implant and bone tissue surface, and it is attached in a band shape..

It was focused on the fact that magnetic stimulation is applied to patients undergoing implant placement, which affects the blood flow deep into the body and deep into the bone, thereby lowering the expression of cytokines that induce bone resorption (IL-1 α, IL-1 β, IL-6, OPG, PGE2), and greatly affects the blood flow and bone to facilitate implant placement.

When a cell responds to magnetic stimulation, depolarization of the transmembrane potential of the cell membrane is induced, an electrochemical reaction occurs in the culture medium and tissue environment, and electrochemical reaction by-products such as OH groups are generated and the pH increases due to electrolysis at the cathode among the electrodes, and the reaction by-products directly induce depolarization of the transmembrane potential of the cell. Therefore, if magnetic stimulation is supplied to the blood flow to the bone cells, it affects the iron in the red blood cells, disintegrates the clumped red blood cells, activates the blood's mechanism of action, promotes the ion effect, normalizes blood circulation, and increases oxygen efficiency, which helps activate osteoblasts. It not only affects the proliferation and differentiation of bone cells, healing and regeneration of bone tissue, but also increases the activity of periodontal tissue cells such as periodontal ligament cells and gingival fibroblasts, facilitating the regeneration of lost periodontal tissue.

KEYWORDS Implant, implantation, osseointegration, magnetic stimulator, osteoclast, bone cell

I. INTRODUCTION

Periodontal ligament tissue is a tissue that secretes cytokines as a result of mechanical stimulation by continuous occlusal force, and receptor activator of nuclear factorκB ligand (RANKL) and macrophage colony stimulating factor (M-CSF) produced by osteoblasts are required for osteoclast precursor cells to differentiate into mature osteoclasts[1]. On the other hand, osteoprotegerin (OPG), which acts as a decoy receptor for RANKL, is released from osteoblasts and inhibits osteoclastogenesis[2].

The composition of the crevice fluid at the site of implant placement is different from that of normal teeth, and the changed composition of the crevice fluid affects the bone remodeling of the implant placement site and surrounding tissue[3].

Therefore, magnetic fields have the advantage of penetrating deep into the body, so they can affect bone treatment by allowing blood to flow deep into the bones as well as the blood flowing to the cells[4].

The absorption and production of osteoblasts and osteoclasts continues 24 hours a day, and 10% to 30% of bone is regenerated per year[5]. The cell balance is regulated by hormones and other chemical components, but this balance collapses with age[6].

Therefore, if magnetism is supplied to the blood flow to the bone cells, it affects the iron in the red blood cells, causing the clumped red blood cells to disperse[7]. The blood's mechanism of action becomes active, ionic effects are promoted, blood circulation becomes normalized, oxygen efficiency is increased, and it plays a role in activating osteoblasts[8]. Factors related to osteoblast differentiation and activity include parathyroidhormone (PTH), core binding factor α1 (Cbfa1), leptin, bonemorphogenetic protein (BMP), interleukin-1 (IL-1), IL-6, and IL-11[9].

Factors related to the differentiation and activity of osteoclasts include receptor activator of nuclear factor κB (RANK), RANKL, OPG, c-fos, nuclear factor κB (NF κB), IL-1, tumornecrosis factor (TNF), prostaglandin E2 (PGE2), PGE2, and matrix metallo proteinases (MMP)[10].

When magnetic stimulation is applied to the blood flow to bone cells, it affects the iron in red blood cells, causing the clumped red blood cells to break apart[11]. The blood's mechanism of action becomes active, ionic effects are promoted, blood circulation becomes normalized, oxygen efficiency is increased, and it plays a role in activating osteoblasts[12].

II. Materials and Methods

Osteointegration results from an imbalance between osteoclasts and osteoblasts, and absorption and production processes continue 24 hours a day. 10% to 30% of bone is regenerated per year, and the balance of cells is regulated by hormones and other chemical components, but this balance collapses with age. It lowers the expression of IL-1 α, IL-1 β, IL-6, OPG, and PGE2, and affects blood flow and bone through a magnetic field to facilitate implant placement[13].

Therefore, if magnetic stimulation is supplied to the blood flow to the bone cells, it affects the iron in the red blood cells, causing the clumped red blood cells to break apart and the blood's mechanism of action to become active[14].It helps to activate osteoblasts by promoting the ionic effect, normalizing blood circulation and increasing oxygen efficiency.

Osteoblasts synthesize bone matrix components such as type I collagen, ALP, osteocalcin, osteonectin, and osteoopontin, secrete enzymes, and are regulated by the sequential expression of various bone-related genes[15]. It is an enzyme that is an important component of hard tissue and whose expression increases during proliferation and differentiation of mineralized tissue. When magnetic stimulation is performed, the activity of ALP, which is related to the differentiation of osteoblasts, increases and the expression of osteocalcin19), a bone protein component involved in bone calcification, increases[16].

VEGF, a vascular endothelial growth factor involved in angiogenesis, has been reported to promote bone remodeling by inducing bone-destroying cells, and the increase in VEGF expression during magnetic stimulation treatment suggests that angiogenesis may be closely related to bone healing[17].

Accordingly, this study was conducted to solve the above-mentioned problems by providing magnetic stimulation to implant patients to affect the blood flow deep in the body, including the blood flow deep in the bone[18]. It was focused on lowering the expression of bone resorption-inducing cytokines (IL-1 α, IL-1 β, IL-6, OPG, PGE2) and greatly affecting blood flow and bone to facilitate implant placement[19]. Therefore, if magnetic stimulation is supplied to the blood flow to the bone cells, it affects the iron in the red blood cells, disintegrates the clumped red blood cells, activates the blood's mechanism of action, and promotes the ionic effect[20]. This relates to an implant bone fusion stimulation device using magnetic pulses for early settlement, which helps to activate osteoblasts by normalizing blood circulation and increasing oxygen efficiency[21].

III. System Composition and Principal

Osseointegration is important for the fixation of implants. The implant and bone tissue are combined in the form of osseointegration, and osseointegration between the implant and the alveolar bone affects the success rate of the implant. When magnetic stimulation is applied to a patient with implant placement, it affects the blood flow deep within the bone, causing a cellular response, inducing depolarization of the transmembrane potential of the cell membrane, and causing an electrochemical reaction in the culture medium and tissue environment[22].

It was designed to lower the expression of bone resorption-inducing cytokines (IL-1 α, IL-1 β, IL-6, OPG, PGE2) and to influence blood flow and bone to facilitate implant placement[23].Magnetic stimulation not only affects the proliferation and differentiation of bone cells and the healing and regeneration of bone tissue, but also increases the activity of periodontal tissue cells such as periodontal ligament cells and gingival fibroblasts, and is intended for clinical use in the regeneration of lost periodontal tissue[24]. It consists of a stimulation pulse driving part (Analog part), a microcontroller part, and a Bluetooth module. In order to implement the stimulation pulse, the portable type is used in the form of a mask cap on both jaws, and the medium type is configured as a system and uses titanium-related materials attached to the stimulation area[25].

The expression of OPG, a cytokine that inhibits the proliferation and activation of osteoclasts, has a direct effect on the activity of osteoclasts in dental implant osteointegration stimulators[26]. The expression of OPG at the implant placement site is similar to that of adjacent

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teeth, and the increased expression of OPG, a factor that inhibits osteoclast differentiation, helps the surrounding tissues of the implant placement site to exhibit active bone remodeling activity. Technically, data transmission between the microcontroller and the Bluetooth module is UART communication, the transmission speed is 115,200bps, the transmission speed of the Bluetooth asynchronous channel is 723.2kbps, and the gain of the instrumentation amplifier and the cutoff frequency of the low-pass filter can be remotely adjusted. The microcontroller uses HCI Command packets to connect to the opposing Bluetooth module and HCI data packets to transmit signal data to the dental implant osseointegration stimulator. The microcontroller used is Texas Instrument's MSP430. Finally, the dental implant osseointegration stimulator consumes a lot of power and requires a high-voltage power supply[27]. A step-by-step charging method was used to charge the high-voltage capacitor, and a small-sized DC power supply was implemented[28]. A control system capable of driving the stimulation coil with a stimulation protocol was configured[29].

IV. Practal Analysis and Implement

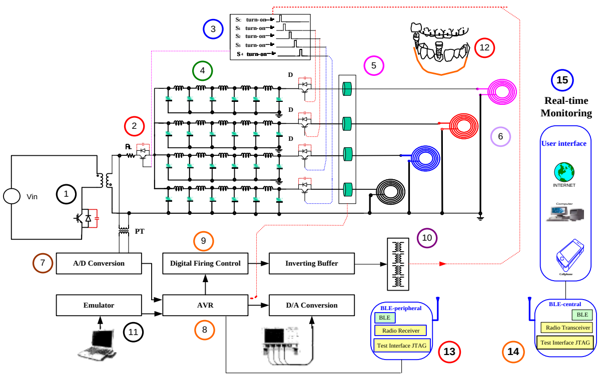

Figure 1 shows that this device consists of a stimulation pulse driver (Analog part), a microcontroller

Figure 1 shows that this device consists of a stimulation pulse driver (Analog part), a microcontroller part, and a Bluetooth module, and to implement the stimulation pulse, the portable version is used in the form of a mask cap on both jaws, and the dental implant osseointegration stimulator, among the regulators of OPG and OPGL, cytokines such as PGE2 and TNF and hormones such as PTH, 1α, 25-(OH)2D3, and glucocorticoid promote the production of OPGL and thus promote the bone absorption function.

In response to mechanical stimulation, the inflammatory cytokine PGE2 is produced at the site of bone resorption compression, affects the alveolar bone through the periodontal ligament space, and is found in the gingival crevicular fluid, and reacts in a chain reaction to easily induce bone remodeling by regulating OPGL and OPG.

Symbol ① is a flyback type input terminal of the power supply, symbol ② acts as a switch with an IGBT, and symbol ③ is a switch that drives the power element IGBT and can sense delay and superimposed signals. Symbol ④ represents a pulse forming circuit, and symbol ⑤ can measure the current value with a Rogoski coil. Symbol ⑥ represents a stimulation coil, symbol ⑦ represents an A/D input terminal entering the microprocessor, symbol ⑧ represents a microprocessor, data transmission between the microcontroller and the Bluetooth module is UART communication, the transmission speed is 115,200bps, the transmission speed of the Bluetooth asynchronous channel is 723.2kbps, the gain of the instrumentation amplifier and the cutoff frequency of the low-pass filter can be remotely adjusted.

Symbol ⑨ represents a digital drive signal, symbol ⑩ represents a pulse transformer, and symbol ⑪ allows commands to be re-input from the outside. Symbol ⑫ represents a dental implant, and the expression of OPG, a cytokine that inhibits the proliferation and activation of osteoclasts, has a direct effect on the activity of osteoclasts and helps to promote active bone remodeling activity. Symbol ⑬ represents Bluetooth-1, symbol ⑭ represents Bluetooth-2, and the dental implant osseointegration stimulator consumes a lot of power and requires a high-voltage power supply. A step-by-step charging method was used to charge a high-voltage capacitor, and a small-sized DC power supply was implemented, and a control system capable of driving a stimulation coil using a stimulation protocol was configured.

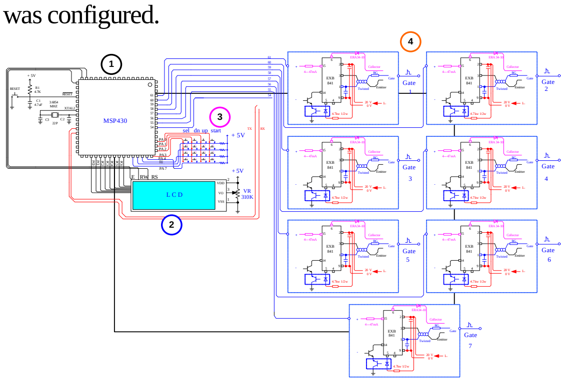

Figure 2 is an operation diagram of a dental implant osseointegration stimulator

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Figure 2 is an operation diagram of a dental implant osseointegration stimulator, and symbol ① represents an MSP430 microprocessor. When magnetism is supplied to the blood flow to osteoblasts that create bone, osteoclasts that destroy bone, and bone cells, it affects the iron in red blood cells. Clumped red blood cells are released, the blood's mechanism of action is activated, ion effects are promoted, blood circulation is normalized, and oxygen efficiency is increased, contributing to the activation of osteoblasts. Symbol ② is an LCD display, symbol ③ is a push button. For this purpose, when discharging the high voltage charged in a large-capacity capacitor to a coil for generating a magnetic field, a method is mainly used to allow a very large current in the form of a sinusoid to flow by using a discharge circuit in which the inductance of the capacitor and the coil form a resonant circuit. Symbol ④ is a driving circuit with a built-in IGBT overcurrent protection circuit, which causes a resonant discharge to occur during one sinusoidal cycle, and generates a very large current through one cycle of resonance in which the power accumulated in the capacitor is transferred to the coil and then returned to the capacitor.

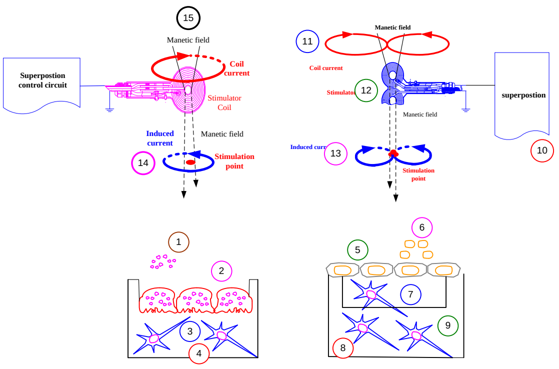

Figure 3 is a dental implant osseointegration stimulator

Figure 3 is a dental implant osseointegration stimulator that is used for various treatments, such as the maxilla, mandible, and front, and when analyzing the expression of IL, a cytokine that induces bone resorption in implant patients, the mask-type dental implant osseointegration stimulator shows higher osteoclast activity than normal teeth. Symbol ① indicates pre-osteoclast, symbol ② indicates osteoclast, symbol ③ indicates osteoocyte, symbol ④ indicates phosphorus, symbol ⑤ indicates osteoblast, symbol ⑥ indicates pre osteoblast, symbol ⑦ indicates calcium, symbol ⑧ indicates phosphorus, and symbol ⑨ indicates osteocyte.

Symbol ⑩ represents a superposition circuit, symbol ⑪ represents a magnetic field, symbol ⑫ represents stimulation, symbol ⑬ represents induction current in a 2-loop coil, symbol ⑭ represents induction current in a 1-loop coil, and symbol ⑮ represents a magnetic field in a 1-loop coil.

Figure 4 shows that the dental implant osseointegration stimulator promotes healing, relieves pain, and increases phagocyte or enzyme activity through the movement of ions through the cell membrane, or facilitates depolarization of the cell membrane, changes in membrane potential, secretion of growth factors, calcium ion transport, and chondrocyte synthesis.

Symbol ① represents a stimulation coil for stimulating teeth and periodontal ligaments, symbol ② is a stimulation point, symbol ③ affects capillaries, symbol ④ is osteoblast, symbol ⑤ is perriodontal ligament, symbol ⑥ is blood vessels, symbol ⑦ is IL-1, IL-6, symbol ⑧ is fibroblast, symbol ⑨ is osteocyte, symbol ⑩ is superposition circuit, symbol ⑪ is formed to stimulate by forming a magnetic field.

Stimulation reduces the expression of cytokines, such as those in the components of symbol ⑫ stimulation coil, symbol ⑬ two-loop induced coil, symbol ⑭ one-loop coil current, symbol ⑮ one-loop magnetic field, symbol 16 one-loop stimulation point, symbol 17 one-loop coil induced current, symbol 18 one-loop magnetic field, symbol 19 two-loop magnetic field, symbol 20 osteoblast, symbol 21 metalloproteinases, symbol 22 OPG, symbol 23 cathepsins, symbol 24 teeth model, and symbol 25 osteocyte.

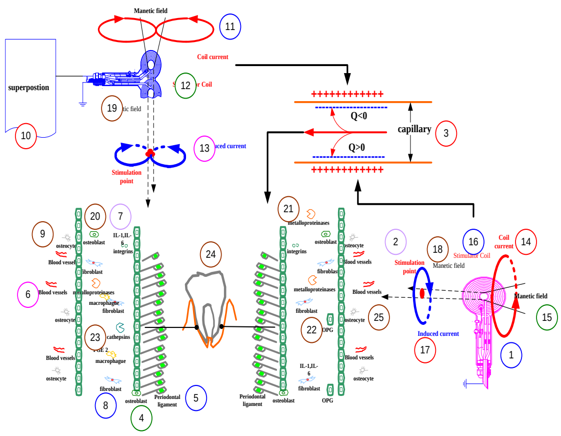

Figure 4 shows that the dental implant osseointegration stimulator promotes healing

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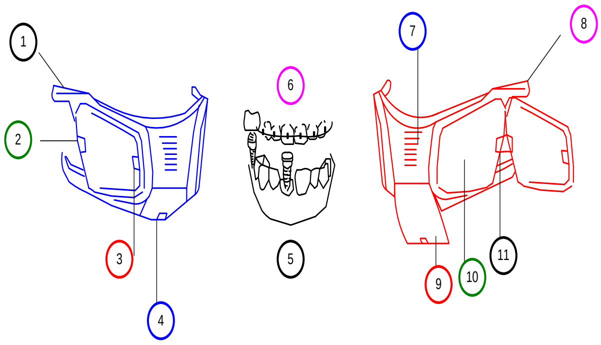

Figure 5 is a portable dental implant osseointegration stimulation device

Figure 5 is a portable dental implant osseointegration stimulation device. In dental implants and orthodontics, periodontal ligament cells are cells that exist in the tooth root and alveolar bone, and they express osteoblast differentiation markers alkaline phosphatase (ALP) and osteocalcin and form calcified nodules.

They produce osteoclast differentiation inducer IL-6 by IL-1 β, a bone resorption-inducing cytokine, and have similar characteristics to osteoblasts. Symbol ① is a mask-type dental implant osseointegration stimulator that is mounted on the ear, and the portable dental implant osseointegration stimulator is a device that loses periodontal ligament tissue during the extraction process in patients who have had dental implants.Symbol ② is a connecting part, symbol ③ is a locking device when closed, symbol ④ is a front locking device, symbol ⑤ is a tooth implant model, symbol ⑥ is an upper jaw orthodontic model, symbol ⑦ is an air intake, symbol ⑧ is an ear hook device in reverse, symbol ⑨ is a front open state, symbol ⑩ is a part where the left control and power device go, and symbol ⑪ is a connecting link in the open state.

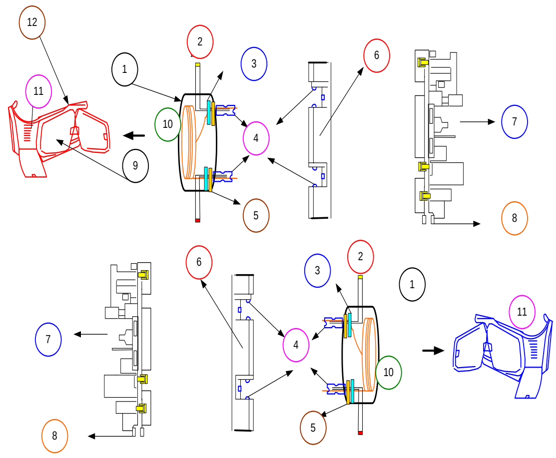

Figure 6 is a portable mask-type dental implant osseointegration stimulator

Figure 6 is a portable mask-type dental implant osseointegration stimulator, and the mask-type dental implant osseointegration stimulator directly causes contraction and vasodilation of arterioles and capillaries by stimulating the sympathetic nerves in its effect on blood vessels. Symbol ① is the primary cover of the stimulation coil, symbol ② is the motion sensor, symbol ③ is the temperature sensor, symbol ④ is the metal connection, symbol ⑤ is the cooling sensor, and the mask-type dental implant osseointegration stimulation device has the advantage of penetrating deep into the deep part, and it is possible to make the magnetic field flow not only to the blood flowing in the epidermal cells but also to the blood flowing deep into the bone, which also affects bone treatment.. Symbol ⑥ is the stimulation support, symbol ⑦ is the control and power control board, symbol ⑧ is the power connection, symbol ⑨ is the part where the mask-type control unit is inserted, symbol ⑩ is the stimulation coil, symbol ⑪ is the mask air intake, and symbol ⑫ is the mask-type dental implant osseointegration stimulation device.

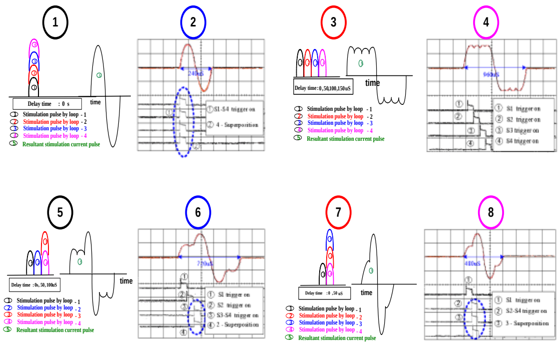

Figure 7 is a dental implant osseointegration stimulation device

Figure 7 is a dental implant osseointegration stimulation device that applies a method of adding a stimulation coil for various treatments, and is a stimulation device that adopts a stimulation pulse that can be applied to narrow, deep, thin, and wide areas. Symbol ① represents the current pulse of the stimulation coil that triggers s1, s2, s3, and s4 simultaneously, with a delay time of 0 sec and a pulse width of 240 µS. Symbol ② triggers s1, delays s2 by 50 µS, and then triggers s3 and s4 after a delay time of 100 µS. Symbol ③ triggers s1 and s2 simultaneously, then triggers s3 at 50 µS and s4 at 100 µS, and then represents the current pulse of the stimulation coil, which appears in a 3-stage form and has a pulse width of 720 µS.

Symbol ④ triggers s1 at 0 sec without a delay time, and then triggers s2, s3, and s4 all at once after a delay time of 50 µS. This method provides magnetic

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stimulation to patients undergoing implant placement, thereby affecting the blood flow deep within the body and deep into the bone, thereby lowering the expression of cytokines that induce bone resorption (IL-1 α, IL-1 β, IL-6, OPG, PGE2). In order to achieve early settlement after implant placement, a device for stimulating implant osseointegration using various magnetic pulse stimulation was adopted, and if the capacity was insufficient, a method of adding a stimulation coil was adopted as shown in the figure.

Figure 8 is a dental implant osseointegration stimulation device applied during osteoclast and osteoblast activity. Osteointegration is important for the early settlement of the implant, and the implant and bone tissue are combined in the form of osseointegration, and osseointegration between the implant and the alveolar bone has a great influence on the success rate of the implant. Symbol ① is the microprocessor of MSP 430 TI, symbol ② is

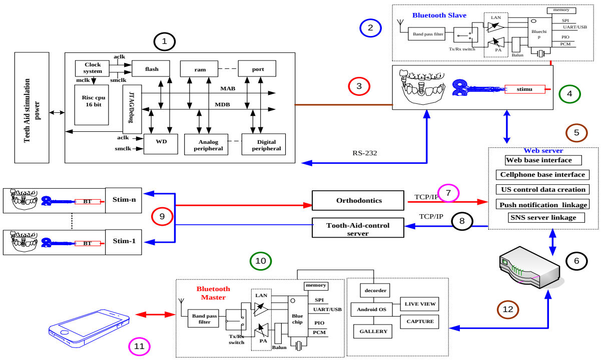

Figure 8 is a dental implant osseointegration stimulation device applied during osteoclast and osteoblast activity

Bluetooth, symbol ③ is a tooth model, symbol ④ is applying a stimulation pulse, symbol ⑤ is a Web server, symbol ⑥ is a network server, symbol ⑦ is a TCP/IP dedicated to orthodontics, symbol ⑧ is the TCP/IP of the tooth implant osseointegration device, symbol ⑨ is a stimulation coil that supplies a stimulation pulse to the final tooth, symbol ⑩ is Master Bluetooth, and symbol ⑪ is monitored by a cell phone.

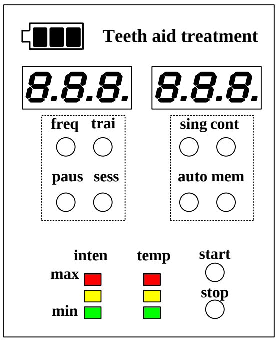

Figure 9 shows that in the dental implant osseointegration stimulation device

Figure 9 shows that in the dental implant osseointegration stimulation device, there are osteoclasts that dissolve, decompose, and absorb bone components, and osteoblasts that attach bone components such as calcium, magnesium, and phosphorus to create new bone minerals. Bone growth or bone repair occurs through these two cells, and they maintain the appropriate concentration of minerals necessary for the body, such as calcium and phosphorus. This is a function displayed on the LCD panel attached to the actual dental implant osseointegration stimulator product, and by function, it can be divided into the menu window displayed on the LCD window, battery capacity display, Teeth Aid stimulator, frequency, train, pause, session, single, continue, memory, intense, temperature, start, stop, etc. function view.

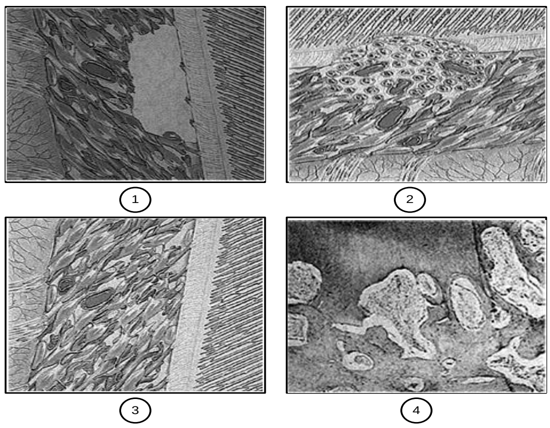

Figure 10 shows Inflammatory root resorption appears

Figure 10 shows symbol ① Inflammatory root resorption appears histologically one week after trauma, and the factors affecting the onset or degree of inflammatory root resorption are first, root resorption begins due to periodontal ligament

damage, Symbol ② shows second, root resorption exposes dentinal tubules, third, products of necrotic periodontal tissue and bacterial presence in the exposed dentinal tubules, and fourth, the age and maturity of the patient. Symbol ③ shows that the destroyed periodontal ligament is mostly connected, making it difficult to recognize the line of destruction, and new Sharpey's fibers extend from the cementum surface to the alveolar bone surface.
Symbol ④ shows that the periodontal ligament and cementum are extensively damaged as a result of replacement root resorption..
When the periodontal ligament and cementum become necrotic and resorbed, a denuded area is formed, and the bone-forming cells release alveolar bone into this area, directly connecting the dentin and the alveolar bone, causing dentoalveolar ankylosis.

V. Experiment Results

Figure 11 shows the expression related to proliferation and differentiation of osteoblasts by treating human osteoblast-like MG-63 cells with 1 Tesla and 2 Tesla magnetic stimulation devices in the experiment. After 6 days of treatment of human osteoblast-like MG-63 cells, osteoblasts proliferated in the 2 Tesla experimental group, which promotes bone healing. The frequency of 2 Tesla is effective, and thermal and electrical effects are

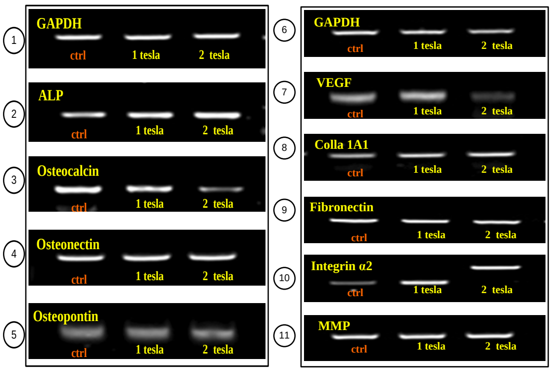

Figure 11 shows the expression related to proliferation

effective for cell proliferation. The factors related to osteoblast differentiation expressed when treating human osteoblast-like MG-63 cells with magnetic stimulation are verified. Osteoblasts synthesize bone matrix components such as Type I collagen, ALP, osteocalcin, osteonectin, and osteoopontin, secrete enzymes, and are regulated by the expression of bone-related genes. Symbol ① is GAPDH: glyceraldehyde 3-phosphate dehydrogenase, symbol ② is alkaline phosphatase (ALP), symbol ③ is osteocalcin, symbol ④ is osteonectin, and symbol ⑤ is osteopontin. The results of reverse transcription-polymerase chain reaction analysis. Expression of, and during the osteoblastic differentiation of MG-63 cells.

As an enzyme that increases in expression during proliferation and differentiation of mineralized tissue, it is confirmed that osteoblast differentiation and ALP activity increase, and osteocalcin, a bone protein component involved in bone calcification, increase in expression, which means that the magnetic stimulation device promotes bone formation factors. VEGF, a vascular endothelial growth factor involved in angiogenesis, induces bone-destroying cells and promotes bone remodeling, and the increase in VEGF expression during magnetic stimulation device treatment is related to angiogenesis and bone healing.

Integrin is a glycoprotein composed of two subunits of heterodimers, which is involved in cell adhesion and plays a central role in cell-to-cell adhesion, and it can bind to the extracellular matrix and cytoskeleton actin fibers, and plays a role in regulating cell growth and differentiation.

In the group treated with 2 tesla, the expression level of integrin alpha 2 was observed to be lower than in the other groups, and when treated with 1 tesla, there was no difference in the expression of integrin alpha 2 compared to the control group, suggesting that when treated with 1 tesla, it is closely related to cell attachment and migration compared to the group treated with 2 tesla. Reverse transcription-PCR analysis was performed to confirm the differentiation and expression of osteoblasts. On the 7th day after magnetic stimulation, the control group, 1.3 tesla, 1 tesla, and 2 tesla experimental groups were analyzed.

Compared to the control group, the 1 tesla and 2 tesla experimental groups showed increased gene expression of alkaline phosphatase (ALP), osteocalcin, vascular endothelial growth factor (VEGF), and collagen 1A1. In the case of integrin alpha 2, the expression level in the 2 tesla experimental group was low, and the expression level in the control group and 1 tesla experimental group was similar. On the other hand, there was no difference in the gene expression of osteonectin, osteopontin, fibronectin, and matrix metalloproteinase (MMP)2. Symbol ⑥ is GAPDH: glyceraldehyde 3-phosphate dehydrogenase, symbol ⑦ is vascular endothelial growth factor (VEGF), symbol ⑧ is colla 1A1, symbol ⑨ is integrin α2, symbol ⑩ is integrin α2, symbol ⑪ is matrix

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metalloproteinase (MMP). The results of reverse transcription-polymerase chain reaction analysis. Figure 12. Periodontal ligament cells are cells that exist between the root and the alveolar bone. They express osteoblast differentiation markers alkaline phosphatase (ALP) and osteocalcin, as well as form calcified nodules and produce osteoclast differentiation inducer IL-6 in response to bone resorption-inducing cytokine IL-1 β. Periodontal ligament cells are similar to osteoblasts, and periodontal ligament cells mediate bone formation and resorption, and are involved in tooth movement due to orthodontic force and alveolar bone remodeling and destruction that occurs during periodontitis. Patients who receive dental implants may lose the function of regulating bone formation and resorption by periodontal ligament tissue due to loss of periodontal ligament tissue during the extraction process.

Among the regulators of OPG and OPGL, cytokines such as PGE2 and TNF and hormones such as PTH, α,25-(OH)2D3, and glucocorticoid promote the production of OPGL and thus promote bone resorption function. PGE2, an inflammatory cytokine, is produced in the compression site where bone resorption occurs by stimulation and affects the alveolar bone through the periodontal ligament space and is found in the gingival crevicular fluid. Symbol①, Expression of interleukin-1 α(IL-1 α) in dental implant patients.(I: implant teeth, A: adjacent implant, C: common teeth)(I': Magnetic Stimulation -implant teeth, A': Magnetic Stimulation -adjacent implant, C': Magnetic Stimulation -common teeth) Symbol②, Expression of interleukin-1 β(IL-1 β) in dental implant patients. (I: dental implant teeth, A: adjacent implant, C: common teeth) (I': Magnetic Stimulation -implant teeth, A': Magnetic Stimulation -adjacent implant, C': Magnetic Stimulation -common teeth) Symbol③, Expression of interleukin-6 (IL-6) in dental implant patients. (I: implant teeth, A: adjacent implant, C: common teeth) (I': Magnetic Stimulation -implant teeth, A': Magnetic Stimulation -adjacent implant, C': Magnetic Stimulation -common teeth) Symbol ④, Expression of prostaglandin E2 (PGE2) in dental implant patients. (I: implant teeth, A: adjacent implant, C: common teeth) (I': Magnetic Stimulation -implant teeth, A': Magnetic Stimulation -adjacent implant, C': Magnetic Stimulation -common teeth) Symbol ⑤, Expression of osteoprotegerin (OPG) in dental implant patients.(I: implant teeth, A: adjacent implant, C: common teeth) (I': Magnetic Stimulation -implant teeth, A': Magnetic Stimulation -adjacent implant, C': Magnetic Stimulation -common teeth)

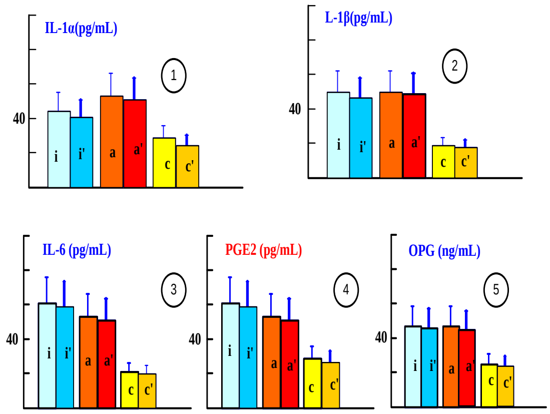

Figure 12. Periodontal ligament cells are cells that exist between the root and the alveolar bone

VI. Discussions

The effect of pulsed magnetic fields on blood vessels is that they stimulate sympathetic nerves, causing direct contraction and dilation of arterioles and capillaries, and sympathetic signals transmitted to the brain through the spinal cord can in turn affect the activity of skin sympathetic nerve vascular contraction and dilation fibers, thereby increasing blood volume in capillaries and blood vessels.

The advantage of magnetic fields is that they penetrate deep into the body, allowing the magnetic field to flow not only to the blood flowing through epidermal cells but also deep into the bones, which also affects bone treatment.

When magnetism is supplied to osteoblasts that create bone, osteoclasts that destroy bone, and thus to the blood flowing through bone cells, it affects the iron in red blood cells, dissolving clumped red blood cells, activating the blood mechanism, promoting ion effects, normalizing blood circulation, and increasing oxygen efficiency, which contributes to the activation of osteoblasts.

VII. Conclusion

Among the regulators of OPG and OPGL, cytokines such as PGE2 and TNF and hormones such as PTH, 1α, 25-(OH)2D3, and glucocorticoid promote the production of OPGL. It promotes bone resorption function, and PGE2, an inflammatory cytokine, is produced in the area of bone resorption compression by mechanical stimulation, affects the alveolar bone through the periodontal ligament space, and is found in the gingival crevicular fluid. It reacts in a chain reaction and easily induces bone remodeling by regulating OPGL and OPG. The osteoclast activity of the bone surrounding the implant is more active than that of the normal tooth. In the implant placement site and the expression of bone remodeling, the expression of IL-1α, IL-1β, IL-6, OPG, and PGE2 in the implant and adjacent teeth is higher than that in the normal tooth or opposing tooth, and actively helps the activity of osteoclasts.

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