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Solcoseryl, a tissue respiration stimulating agent, significantly enhances the effect of capacitively coupled electric field on the promotion of bone formation around dental implants

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Abstract: In the present study we examined the combined effect of application of a capacitively coupled electric field (CCEF) and the tissue respiration stimulating agent, Solcoseryl, on the promotion of bone formation around dental implants histologically and mechanically. After a dental implant was inserted into each femur of Japanese white rabbits, Solcoseryl (2 ml/kg) was administered intravenously in the ear vein and a CCEF was applied for 4 h per day for 14 days. The degree of bone formation on microscopic observation, bone contact ratio, bone surface area ratio, and the level of removal torque of the implant in the Solcoseryl- and CCEF-treated group were significantly higher than the respective value in the control group, which had not been treated with Solcoseryl nor CCEF. Thus, the combination of CCEF stimulation and Solcoseryl effectively promoted the formation of new bone. It is suggested that the clinical use of a combination of CCEF stimulation and Solcoseryl for dental implants promotes osseointegration.

Dental implants are employed for prosthetic purposes in the field of dentistry. Moreover, the number of patients who undergo dental implant therapy has been increasing in recent years. Nearly all implants that are used clinically are manufactured from titanium, and there have been many shapes and surface modifications in recent years. The period between insertion of the implant and osseointegration of the implant into the surrounding bone is especially important for successful dental implantation (Brunski et al. 1979). In implant therapy, the initial healing period occupies the longest length of time during the entire healing period up to seating of the superstructure. The entire healing period of an implant in the mandible or maxilla has been reported to be 6 weeks to 6 months (Lekholm 1983; Buser et al. 2000). The development of techniques that shorten the initial healing period may enhance the quality of life of patients.

Therefore, the development of a procedure that enhances postoperative ingrowth of bone into dental implants and shortens the period of healing, thereby leading to early restoration of the patient's occlusion, is required for successful oral implantology (Ochi et al. 1996; Matsumoto et al. 2000). Bassett & Becker (1962) first introduced such a technique and reported that osteogenesis was enhanced by the generation of electric potentials. Application of electromagnetic and electric fields has been shown to promote bone formation (Ryaby 1998). To date, we have demonstrated that pulsing electromagnetic field (PEMF) and capacitively coupled electric field (CCEF) have osteogenic actions *in vitro* (Hirose 1993; Ochi 1993; Yajima et al. 2000) and *in vivo* (Ochi et al. 1996; Matsu-

moto et al. 2000; Shigino et al. 2000). Thus, we demonstrated that PEMF and CCEF stimulation may be useful for promoting bone formation around rough-surfaced dental implants. These findings indicate that magnetic or electric stimulation could be useful in implantology. As the next step, we attempted to find techniques that promote bone formation more rapidly.

Recently, several investigators have reported that Solcoseryl promotes tissue respiration and stimulates bone formation in the mandible of dogs and rats (Fukuda 1983, 1989; Fukuda et al. 1996). More recently, we demonstrated that Solcoseryl promoted bone formation around dental implants (Ochi et al. 2000). Therefore, we were interested in the effect of a combination of CCEF stimulation and Solcoseryl. The present study examined the effect of combined application of a capacitively coupled electric field and the tissue respiration stimulating agent, Solcoseryl, on the promotion of bone formation around dental implants.

Material and methods

Experimental animals

Twelve adult, male, Japanese white rabbits (Hokudo, Sapporo, Japan) weighing approximately 2.5 kg were used in this study. The rabbits were kept individually in cages for 1 week. The rabbits were then adapted to bilateral leg braces. The animal protocol was approved by the Animal Committee of the Health Sciences University of Hokkaido.

Preparation of implants

POI 2-piece-type implants (Finafix, Kyosera Co., Kyoto, Japan) made of titanium alloy (Ti 6Al-4V) were used. The diameter of the implant was 3.2 mm and the length of the endosseous portion was 10 mm. An oxidized layer of 1350–1400 Å in thickness was deposited on the implant surface by anodic oxidation. The screw portion of the implant was blasted. This treatment increases the contact area between the implant and the bone, thereby strengthening the affinity of the implant for the bone (Ochi et al. 2000).

Fig. 1. Photograph of the CCEF generator used for treating rabbit femurs.

Implant placement surgery

Implant placement surgery was performed according to the method of Ochi et al. (1996). The distal ends of both femurs were shaved, and local anesthesia on the femurs was applied. After the skin incision, the fascia and then the periosteum were retracted to expose the medial aspect of the distal end of the right and left femurs. The implant in the right femur of each rabbit was used for histological observation of the tissue surrounding the implant, and the implant in the left femur was used for measurement of the implant removal torque. Using an electric engine (Implanter II, Kyosera Co.) at a low revolution (800 r.p.m.), a hole 3.6 mm in diameter and 10.0 mm depth was drilled inside the marrow at the end of each bone with a clover drill (#2–32-S, #3–32-S, Kyosera Co.), while pouring sterile physiologic saline onto the area. The implant was placed in the hole by tapping. The fascia was then stitched with the skin. The implants were placed in the femurs of all rabbits in the same position and direction as much as possible.

Experimental design: effect of Solcoseryl and capacitively coupled electric field (CCEF)

Solcoseryl was purchased from Taiho Pharmaceutical Co. (Tokyo, Japan). This agent is a material extracted from the laky blood of calves. A CCEF that delivered 60 kHz, 10 Vp-p sine wave signals was induced over the area where the implants were placed using OSTERON II to both femurs of a rabbit (Fig. 1, Mizuho Ika Co., Tokyo, Japan). Treatment (three rabbits in each group) was applied for 14 days starting on the day after the implant placement surgery. In the Group A femurs (control), no treatment was applied. In the Group B femurs, CCEF was applied daily for 4 h per day (CCEF-4). In the Group C femurs, CCEF was applied daily for 8 h per day (CCEF-8). In the Group D femurs, Solcoseryl (2 ml/kg/day) was administered via the ear vein, and then CCEF was applied for 4 h per day; these treatments were given daily starting on the day after implant placement surgery (Solcoseryl-and-CCEF-4).

Histological examination and calculation of bone to implant contact ratio and bone surface area ratio on nondecalcified specimens

Femur samples were embedded in polyester resin (Rigolac, Ohken, Tokyo, Japan), and sliced into sections of various thicknesses as described below, perpendicular to the direction of the implant as much as possible using an Exakt cutting grinding system (BS 3000, MG 4000, Exakt Co., Hamburg, Germany). Each section was further polished to a thickness of 50 microns for microscopic and fluoroscopic observations.

Basic fuchsin-methylene blue double staining

The staining solution consisted of 2% fuchsin and 0.1% methylene blue in sodium hydroxide-alcohol, and the sections were stained as described previously (Huber et al. 1968; Shimamura et al. 1971). In the basic fuchsin-methylene blue double staining, original bone stained pink and new bone reddish-violet. The junction between original bone and new bone was clearly visible. After staining, the specimens were observed at low and high magnification under a microscope (Olympus, Tokyo, Japan). The resulting low-magnification images were scanned into a computer and subject to image analysis using NIH Image 1.57 software (National Institutes of Health, Bethesda, MD, USA) (Haider et al. 1993; Shirota et al. 1993; Takeshita et al. 1993). Small pieces were prepared out of each implant from the right femur by cutting at five points and were used to measure the bone contact ratio and bone surface area ratio. All of the segments used for evaluation of the length of new bone were located 2–6 mm below the bone surface. In each image, the border of the drilled hole was traced. The area of the drilled hole itself, the area of the implant, and the area of the bone in the drilled hole were measured. The bone contact ratio was defined as the percentage of the length of new bone that was in contact with the implant, out of the total length along the surface of the implant (length of new bone in contact with implant/length of implant × 100). The bone surface area ratio was defined as the percentage of the area of new bone in the drilled hole out of the

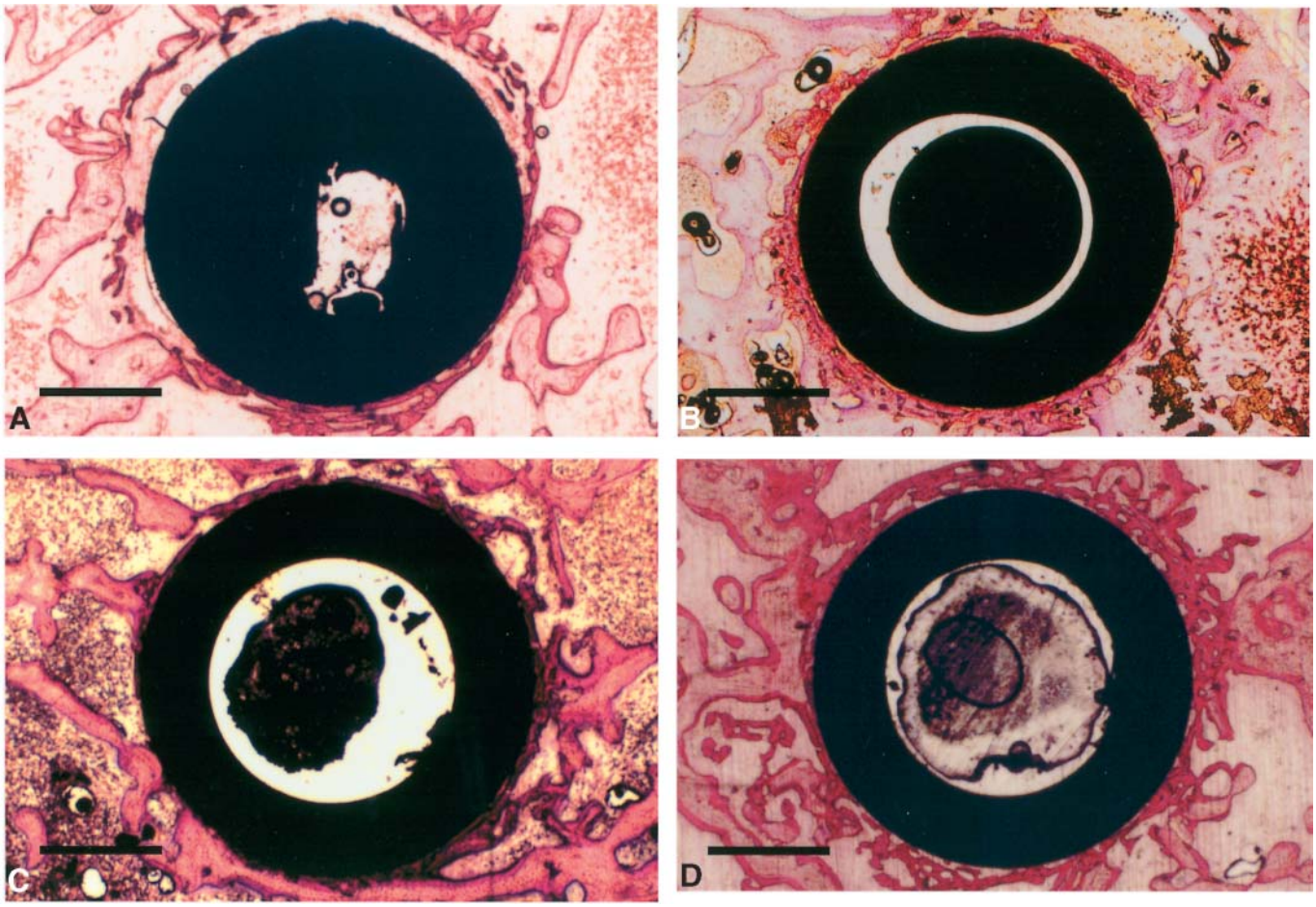

Fig. 2. Histological observation of the tissue surrounding the dental implant upon basic fuchsin-methylene blue double staining (low magnification). Dental implants were placed in the femurs of rabbits, and the rabbits were sacrificed 14 days later. Representative microscopic views (×17, bar = 1 mm) of femur sections are shown. CCEF, capacitively coupled electric field. (A) Control: No treatment. (B) CCEF was applied daily for 4 h per day. (C) CCEF was applied daily for 8 h per day. (D) Solcoseryl was administered via the ear vein and then CCEF was applied for 4 h per day; these treatments were given daily.

total area in the drilled hole (area of new bone in the drilled hole/total area of drilled hole × 100).

Fluorescent labeling agents

Following implant placement, each of the following fluorescent labeling agents was administered intramuscularly in each of the left and right femoral regions of all rabbits at different time points after implant placement:

- 30 mg/kg oxytetracycline (Showa Yakuhin Kako Co., Tokyo, Japan) was administered immediately after implant placement;
- 8 mg/kg calcein (Kanto Chemical Co., Tokyo, Japan) was administered 5 days after implant placement;
- 30 mg/kg Alizarin-Komplexon (Merck, Darmstadt, Germany) was administered 12 days after implant placement.

An Olympus BH2-RFCA fluorescent microscope (Tokyo, Japan) was used for the fluoroscopic observations by the BV excitation method (Takahashi et al. 1979). To observe bone formation by triple fluorescent labeling, the bone was stained *in vivo* at three different time points with three different fluorescent colors of oxytetracycline (yellow) (immediately after implant placement), calcein (green) (5 days after placement), and Alizarin-Komplexon (red) (12 days after placement).

Measurement of implant removal torque

The implant removal torque reflects the affinity of an implant for the bone in which it is implanted. Before the rabbit was sacrificed, the rabbit was placed under general anesthesia by injecting 10 mg/kg pentobarbital (Nembutal, Abbot Co., North Chicago, IL, USA) and the top of the implant inserted in the femur was exposed. A ready-made driver (Kyosera Co.) was attached to the top of the implant, and the torque was measured using a torque wrench (Torque gauge 2400 ATG-N, 15 BTG-N, Tounichi Industry, Tokyo, Japan) equipped with a Co-Cr alloy connector. The torque was measured in the direction perpendicular to the implant as much as possible (Ochi et al. 2000).

Statistical analysis

The resultant data were expressed as the mean ± standard deviation and were subjected to analysis of variance (ANOVA). Comparison of group means was performed using Fisher's protected least significant difference (PLSD). Differences between group means were considered to be statistically significant at a level of $P < 0.05$, $P < 0.01$.

Results

Histological observation of sections with basic fuchsin-methylene blue double staining (Figs 2 and 3)

In the low-magnification pictures, the original bone stained pink with basic fuchsin-methylene blue staining seen scattered all over the image. New bone, which was stained reddish violet by the basic fuchsin-methylene blue, was mainly found around the implant. A greater amount of new bone formation was observed inside the drilled hole in comparison with that outside the hole in the three treated groups (Fig. 2B, C, D), but not in the control group (Fig. 2A). The rabbits that were treated with both Solcoseryl and CCEF-4 showed the largest amount of new bone formation around the implant (Fig. 2D).

In the high-magnification pictures, the sections of the femurs of the control group showed a small amount of newly formed bone in the drilled hole (Fig. 3A). The sections of the Solcoseryl and CCEF-4 femurs (Fig. 3D) showed a greater amount of newly formed bone in the drilled hole compared with those of the CCEF-4 femurs (Fig. 3B). In the Solcoseryl and CCEF-4 femurs (Fig. 3D), much of the new bone had formed along the implant surface, and the newly formed trabecular bone in the drilled hole was relatively thick and complex in shape. However, the amount of newly formed bone in the CCEF-8 femurs and the Solcoseryl and CCEF-4 femurs were nearly the same on histological observation of the high-magnification pictures (Fig. 3C, D).

Histological observation of fluorescent-labeled femur sections (Fig. 4)

The fluorescent-labeled sections of the control femurs (Fig. 4A) revealed that most of the newly formed bone in the drilled hole was stained with calcein (green) and Alizarin-Komplexon (red). On the other hand, in both the CCEF-4 (Fig. 4B) and CCEF-8 femurs (Fig. 4C), most of the newly formed bone in the drilled hole was stained with oxytetracycline (yellow) and calcein (green). In the Solcoseryl and CCEF-4 femurs (Fig. 4D), large amounts of the new bone in the drilled hole were labeled with oxytetracycline (yellow), calcein (green) and Alizarin-Komplexon (red). Thus, the combined treatment of Solcoseryl and CCEF-4 (Fig. 4D) promoted bone formation in all stages.

Bone contact ratio (Fig. 5A), bone surface area ratio (Fig. 5B), and implant removal torque level (Fig. 5C)

The mean bone contact ratio in the Solcoseryl and CCEF-4 group was 81%, and this was approximately 1.3 times higher than that in the CCEF-4 group ($P<0.05$)

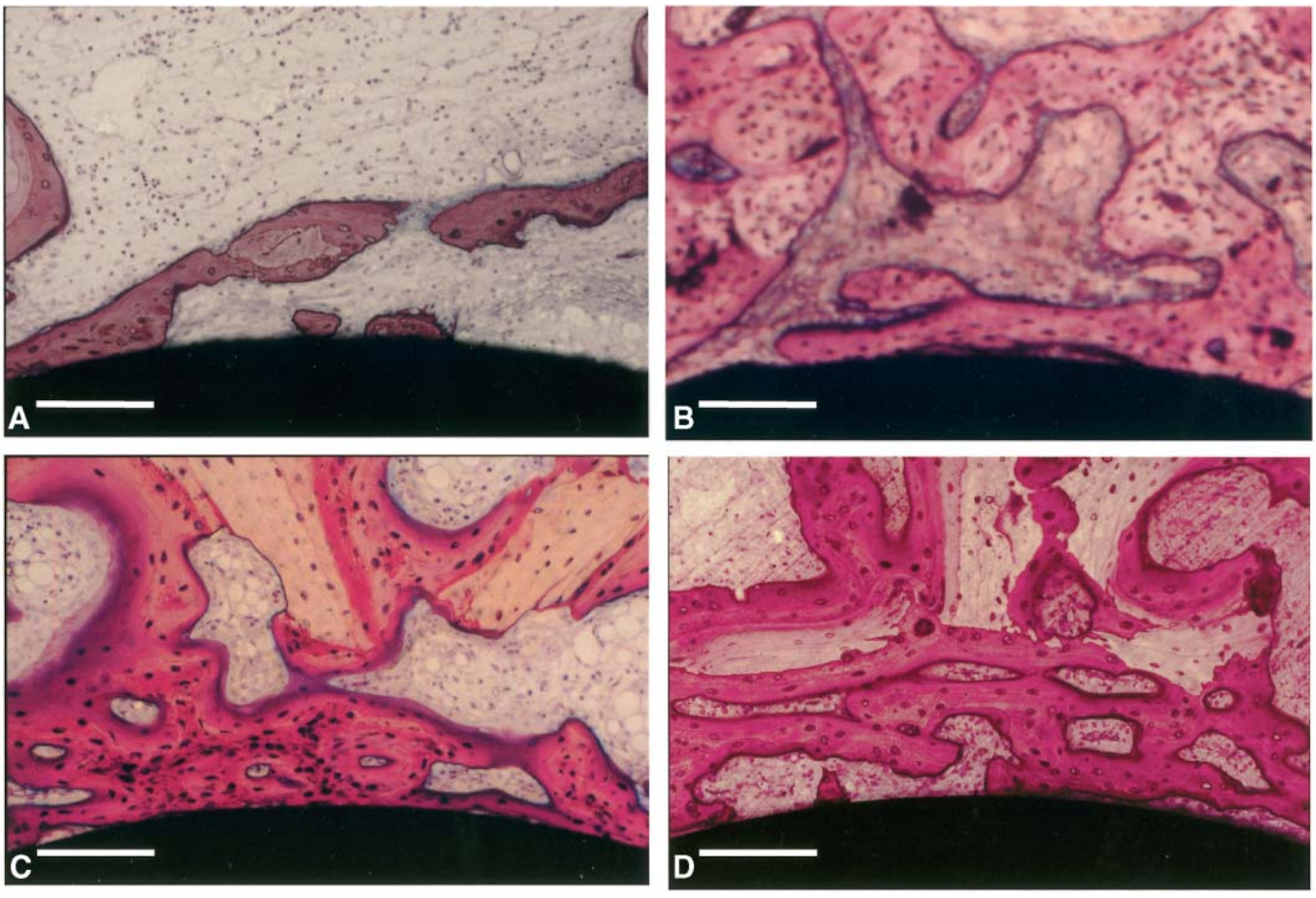

Fig. 3. Histological observation of the tissue surrounding the dental implant upon basic fuchsin-methylene blue double staining (high magnification). Dental implants were placed in the femurs of rabbits, and the rabbits were sacrificed 14 days later. Representative microscopic views (×170, bar = 0.1 mm) of femur sections are shown. CCEF, capacitively coupled electric field. (A) Control: No treatment. (B) CCEF was applied daily for 4 h per day. (C) CCEF was applied daily for 8 h per day. (D) Solcoseryl was administered via the ear vein and then CCEF was applied for 4 h per day; these treatments were given daily.

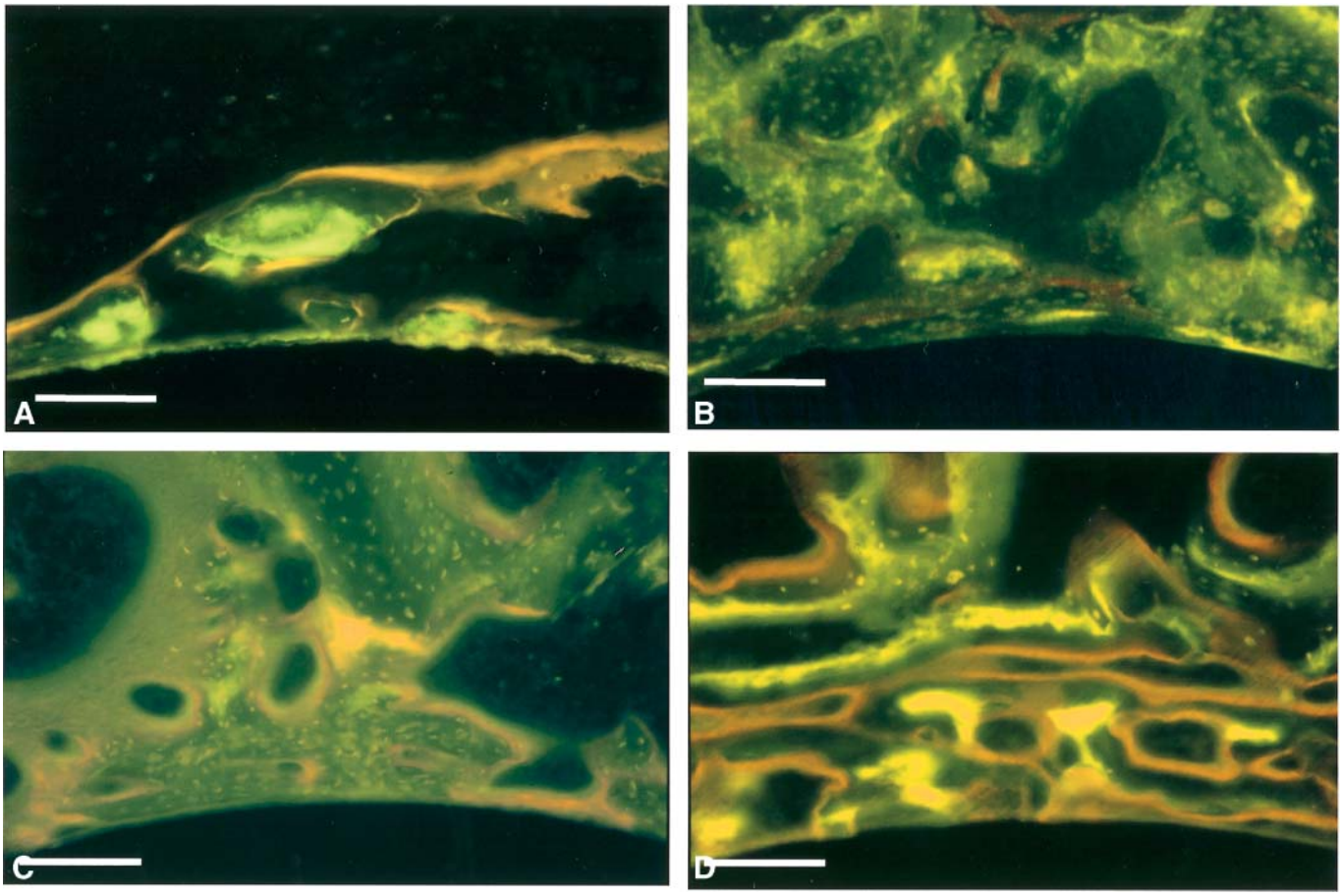

Fig. 4. Histological observation of fluorescent-labeled femur sections under a fluorescent microscope. Representative microscopic views (×170, bar = 0.1 mm) of femur sections. CCEF, capacitively coupled electric field. Yellow, oxytetracycline, administered immediately after implant placement; green, calcein, administered 5 days after implant placement; red, Alizarin-Komplexon, administered 12 days after implant placement. (A) Control: No treatment. (B) CCEF was applied daily for 4 h per day. (C) CCEF was applied daily for 8 h per day. (D) Solcoseryl was administered via the ear vein and then CCEF was applied for 4 h per day; these treatments were given daily.

(Fig. 5A). The mean bone contact ratio in the CCEF-8 group was approximately 1.2 times higher than that in the CCEF-4 group ($P < 0.05$). There was no significant difference in the bone contact ratio between the Solcoseryl and CCEF-4 and CCEF-8 groups.

The mean bone surface area ratio in the Solcoseryl and CCEF-4 group was 78%, and this was approximately 1.5 times higher than that in the CCEF-4 group ($P < 0.05$) (Fig. 5B). Also, the mean bone surface area ratio in the CCEF-8 group was approximately 1.2 times higher than that in the CCEF-4 group ($P < 0.05$). There was no significant difference in the bone surface area ratio between the Solcoseryl-and-CCEF-4 and CCEF-8 groups. Thus, the bone contact ratio and the bone surface area ratio of the Solcoseryl-and-CCEF-4 group were significantly higher than the respective value in the CCEF-4 group.

The mean implant removal torque of the control group was 21 N/cm, and that of the CCEF-4, CCEF-8 and Solcoseryl-and-CCEF-4 groups was 36, 41, and 38 N/cm, respectively (Fig. 5C). Thus, the implant removal torque of the three treated groups was significantly higher than that of the control group ($P < 0.01$, $P < 0.01$, $P < 0.01$). The implant removal torque among the CCEF-4, CCEF-8 and Solcoseryl-and-CCEF-4 groups did not significantly differ.

Discussion

Bassett's group (Bassett & Becker 1962) reported that osteogenesis could be enhanced by the generation of electric potentials. The application of electromagnetic or electric field is a useful method for promoting bone formation, and one study demonstrated the clinical usefulness of application of CCEF for the treatment of orthopedic injuries (Ryaby 1998). Expeditious postoperative ingrowth of bone is essential for clinically successful fixation of oral implants (Adell et al. 1989). CCEF treatment accelerates bone fracture healing (Brighton 1981; Chang et al. 1991) and also may prevent and cure osteoporosis (Brighton et al. 1988). The demonstrated osteogenic actions of CCEF *in vivo* were, in part, confirmed by *in vitro* studies (Fitzsimmons et al. 1986, 1989, 1992; Zhuang et al. 1997). We recently demonstrated that CCEF stimulates bone healing around endosseous implants in rabbit femurs (Ochi et al. 1996). This indicates that CCEF may be a useful procedure for achieving successful endosseous implantation. CCEF stimulation of undifferentiated mesenchymal tissue that emerges through drilling during implant placement surgery, would promote bone formation and accelerate osseo-

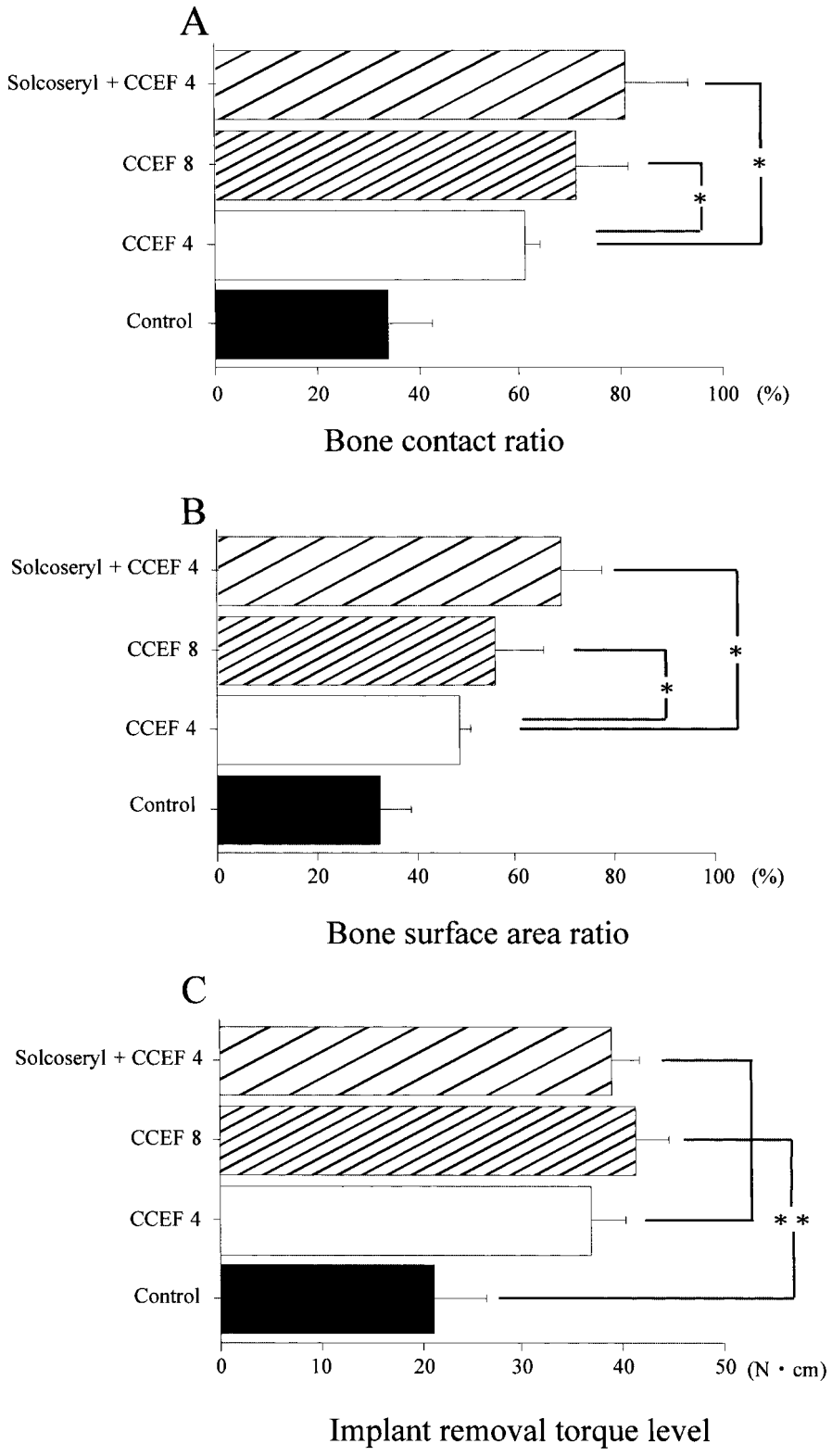

Fig. 5. Comparison of (A) the bone contact ratio (B) bone surface area ratio and (C) the level of implant removal torque. CCEF, capacitively coupled electric field. Control: No treatment. CCEF 4: CCEF was applied daily for 4 h per day. CCEF 8: CCEF was applied daily for 8 h per day. Solcoseryl + CCEF 4: Solcoseryl was administered via the ear vein and then CCEF was applied for 4 h per day; these treatments were given daily. The results are expressed as mean ± standard deviation. Each bar represents the results of three dental implants. $^{*}P<0.05$, $^{**}P<0.01$.

integration. With CCEF stimulation, it is possible to localize the electric stimulation to limited areas around the implant. Furthermore, the CCEF equipment is portable in a belt. Since the majority of patients who require dental implants are in normal health, CCEF treatment is very useful. In dentistry, Solcoseryl dental adhesive paste is used to promote the healing of stomatitis, dry socket, denture ulcer, and soft tissue caused by granulation after guided bone regeneration (Stoller & Schar 1972; Vamos & Kovesi 1980; Metah 1987; Buser et al. 1994). Only a few studies have examined whether Solcoseryl promotes bone formation. Roll (1963), Gabka (1967) and Steinhoff (1967) clinically applied Solcoseryl to fractures, and compared the healing period of fractures that had or had not been treated with Solcoseryl. Based on the clinical features of the patients, X-ray diagnosis and their experience, they concluded that Solcoseryl administration promotes healing. In addition, in basic studies, Fukuda (1983, 1989) and Fukuda et al. (1996) administered Solcoseryl to artificial fractures of dog mandible. They reported that the fractures of the Solcoseryl-treated group healed more rapidly than those of the control group, and that Solcoseryl effectively heals fractures in terms of histological diagnosis related to the healing process. Interestingly, we recently reported that Solcoseryl promoted bone formation around dental implants (Ochi et al. 2000). Therefore, we hypothesized that the combination of CCEF stimulation and Solcoseryl may further promote the formation of new bone.

In the present study, we observed the degree of bone formation, the bone contact ratio, bone surface area ratio and removal torque of the implant in rabbit femurs that had or had not been treated with Solcoseryl and/or CCEF. In the rabbit femur implant model, we previously reported that the structure of the new bone at 4 weeks after implantation was similar to that of the existing bone (Matsumoto et al. 2000). The newly formed trabecular bone at 4 weeks after implantation had increased width and had the same structure as the existing bone, in comparison with the newly formed trabecular bone at 2 weeks after the operation in experiments using the same implants. Consequently, it is suggested that bone growth around the implant in the rabbit femur continues up to 4 weeks

after placement. Therefore, in the present study, bone formation during the 2-week period after implantation was studied. First, we observed bone formation by basic fuchsin-methylene blue double staining and fluorescent labeling agents. Histological observation with basic fuchsin-methylene blue double staining showed that most of the new bone at 14 days after implantation had formed along the implant surface, and that the newly formed trabecular bone in the drilled hole was relatively thick and complex in shape. In addition, the bone was stained *in vivo* at three different time points (the first, middle and late periods) with three different fluorescent colors. We previously reported that femurs of the control group (no-treatment group) were labeled at the middle and late periods; femurs of the CCEF-4 group were labeled at the first and middle periods; and the femurs of rabbits treated with Solcoseryl alone were labeled at all three periods (Ochi et al. 2000). The present study showed that the femurs of rabbits treated with Solcoseryl and CCEF were labeled at the first, middle and late periods after implantation, which suggested that new bone was actively forming during the entire experimental period. Next, we demonstrated that the bone contact ratio, bone surface area ratio and the level of removal torque of the implant in the Solcoseryl and CCEF-4 group were significantly higher than the respective level in the CCEF-4 group.

To date, several groups have performed *in vitro* studies in an attempt to elucidate the mechanisms underlying CCEF- or Solcoseryl-stimulated osteogenesis. CCEF exposure to an embryonic organ culture significantly increased the degree of embryonic bone matrix formation (Fitzsimmons et al. 1986). CCEF stimulates the proliferation of human osteoblastic cells; this is most likely mediated by an increase in the secretion of insulin-like growth factor (IGF)-II (Fitzsimmons et al. 1989, 1992). CCEF enhances the transforming growth factor (TGF)-mRNA level in MC_3T_3-E1 osteoblastic cells (Zhuang et al. 1997). On the other hand, as to Solcoseryl, Fukuda (1996) prepared mobile and immobile bone deficiency in the rat mandible and examined the effect of Solcoseryl on the repair process. The authors reported that Solcoseryl promotes healing by inducing early formation of new bone, increasing the amount of new bone, and activating the outer periosteum reaction (Ochi et al. 2000). These actions suggest the usefulness of this agent. These results indicate that the activated cells in the venous blood stimulate the differentiation of undifferentiated mesenchymal tissue and promote bone formation. Moreover, Solcoseryl increases the blood circulation, in addition to stimulating new bone formation and increasing the amount of new bone (Ochi et al. 2000). From these reports and our results, although we can not fully explain the mechanism by which the combined application of CCEF stimulation and Solcoseryl strongly activates new bone formation, it is suggested that the combination of CCEF stimulation and Solcoseryl activates new bone formation and increases the amount of bone directly or indirectly by improving environmental factors.

Solcoseryl is used clinically in humans. The pharmacological actions of Solcoseryl include promotion of mitochondrial respiration, increase in ATP production, stimulation of tissue function, improvement of saccharometabolism under hypoxic conditions, activation of the reticuloendothelial system, and activation of antiulcer action; all of these actions promote the regeneration of tissue (Ueda et al. 1981; Watanabe 1983). These actions of Solcoseryl are thought to be clinically beneficial for patients with gastroduodenal ulcer, skin ulcer, or sequelae of cerebrovascular dysfunction (Phornphutkul et al. 1977). In the present study, Solcoseryl was injected daily into the ear vein, which is relatively easy, starting on the day after the operation up to the day of sacrifice. The administered dose was the maximum dose that is effective in promoting bone formation, namely, 2 ml/kg/day, according to the studies of Fukuda (1983, 1989) and Fukuda et al. (1996). In conclusion, our study shows for the first time that a combination of CCEF stimulation and Solcoseryl promoted the formation of new bone effectively. In our results, the effect of the combination of CCEF-4 stimulation and Solcoseryl administration was similar to that of CCEF-8 stimulation. Namely, Solcoseryl accelerated osteogenesis. It seems that CCEF stimulation for a long period of time is accompanied by physical and mental fatigue in patients. Thus, CCEF stimulation for a short period of time would be useful for patients. It is suggested that the clinical use of a combination of CCEF stimulation and Solcoseryl for dental implants may promote osseointegration. In a clinical application of the joint treatments of CCEF and Solcoseryl, CCEF stimulation would be given for 4–8 h a day. Ideally, the patient would wear a hand-made oral plate with electrodes for CCEF stimulation. It is possible to apply a CCEF to the mandible with skin electrodes from outside the oral cavity. Solcoseryl would be injected into a vein. The dose of 2 ml/kg of Solcoseryl administered to the rabbits is equivalent to an excessively large amount for humans. Much future work is needed to determine the amount and times of Solcoseryl injection. Upon administering joint treatment of CCEF and Solcoseryl after placement of a dental implant, we estimate that osseointegration would occur in 2–4 weeks. Thereafter, we would perform prosthetic restoration, in which early occlusal loading is possible. Thus, Solcoseryl is expected to shorten the period of healing following dental implant placement.

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Résumé

Dans l'étude présente l'effet combiné de l'application d'un champ électrique couplé capacitaire (CCEF) et de l'agent stimulant de la respiration tissulaire, le Solcoseryl, sur la promotion de la formation osseuse autour des implants dentaires a été examiné histologiquement et mécaniquement. Après l'insertion d'un implant dentaire dans chaque fémur de lapins blancs japonais, le Solcoseryl (2 l/kg) a été administré en intraveineuse dans la veine de l'oreille et un CCEF a été appliqué pendant quatre heures par jour pendant quatorze jours. Le degré de formation osseuse lors de l'observation microscopique, la proportion de contact osseux, la proportion d'aire de surface osseuse et le niveau de force de torsion à l'enlèvement ont été significativement plus importants que les valeurs respectives du groupe contrôle qui n'avait été traité ni par Solcoseryl ni par CCEF. L'association d'une simulation de CCEF et de Solcoseryl augmente donc efficacement la formation du nouvel os. L'utilisation clinique combinée d'une stimulation de CCEF et de Solcoseryl pour les implants dentaires augmenterait leur ostéoïntégration.

Zusammenfassung

In dieser Studie untersuchten wir den histologischen und mechanischen Einfluss der kombinierten Anwendung eines enorm starken elektrischen Feldes (CCEF) und eines den Gewebsumbau anregenden Wirkstoffes, dem Solcoseryl, auf die Förderung der Knochenbildung um Zahnimplantate. Nachdem in jeden Femur von weissen Japanhasen ein Zahnimplantat eingesetzt worden war, erhielten die Tiere Solcoseryl (2 ml/kg) intravenös in die Ohrvene und während 14 Tagen 4h pro Tag ein CCEF. Bei der mikroskopischen Untersuchung waren die Menge der Knochenneubildung, das Verhältnis des Knochenkontaktes und das Verhältnis der Knochenoberfläche, aber auch der Ausdrehwiderstand von Implantaten der Solcoseryl/CCEF-Gruppe signifikant grösser als die entsprechenden Werte der Kontrollgruppe, die weder mit Solcoseryl, noch mit CCEF behandelt worden war. Somit fördert eine Kombination von CCEF-Stimulation und Solcoseryl effektiv die Neubildung von Knochen. Man vermutete, dass der klinische Einsatz einer Kombination von CCEF-Stimulation und Solcoseryl bei den Zahnimplantaten die Osseointegration fördert.

Resumen

En el presente estudio hemos examinado el efecto combinado de la aplicación de un campo eléctrico acoplado capacitivamente (CCEF) y los agentes estimuladores de la respiración tisular, Solcoseryl, en la promoción de la formación ósea alrededor de implantes dentales histológica y mecánicamente. Tras la inserción de un implante dental en cada fémur de conejos blancos japoneses, se administró Solcoseryl (2 ml/kg) intravenoso en la vena de la oreja y se aplicó una CCEF 4 horas al día durante 14 días. El grado de formación ósea en la observación microscópica, el índice de contacto óseo, el índice de área de superficie ósea, y el nivel de torque de remoción del implante en los grupos tratados con Solcoseryl y CCEF fue significativamente mas alto que los valores respectivos del grupo de control que no se trató con Solocoseryl o CCEF. Por lo tanto, la combinación de estimulación CCEF y Solcoseryl promovió efectivamente la formación de nuevo hueso. Se sugiere que el uso clínico de una combinación de estimulación CCEF y Solcoseryl para implantes dentales promueve la osteointegración.

要旨

本研究は容量結合型電場（CCEF）刺激法と組織呼吸刺激剤 Solcoseryl の併用が、歯科インプラント周囲の骨形成促進に及ぼす影響を組織学的および力学的に検討した。日本白色家兎の大腿骨に歯科インプラントを埋入した後、Solcoseryl（２ｍｌ/ｋｇ）を耳静脈内に注入し、ＣＣＥＦを毎日４時間、１４日間適用した。顕微鏡所見による骨形成の程度、骨接触率、骨面積比率およびインプラント除去トルクは、Solcoseryl とＣＣＥＦ刺激の併用群が、Solcoseryl あるいはＣＣＥＦ刺激の処置を受けていない対照群よりも有意に高い値を示した。従ってＣＣＥＦ刺激と Solcoseryl の併用は、効果的に新生骨の形成を促進した。歯科インプラント治療におけるＣＣＥＦ刺激と Solcoseryl 併用療法の臨床応用はオッセオインテグレイション獲得を促進することが示唆された。

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