Bone Regeneration Around Implants Using Spherical and Granular Forms of Bioactive Glass Particles

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Purpose: *It has been reported that previous Biogran® (3i Implant Innovations, Inc., Palm Beach Gardens, FL) can be converted in vitro* into hydroxyapatite (Biogran II®) to accelerate new bone formation. The purpose of this study was to evaluate the bone regeneration around implants placed in critical-sized defects in rabbit tibia using granular and spherical forms of Biogran II® in regards to implant contact, bone-to-graft contact, bone graft area, and total bone volume.

Materials and Methods: *Twelve adult New Zealand rabbits were used, offering 24 surgical sites (1 in each tibia), where 6-mm round defects were created allowing the homocentric insertion of a screw type experimental implant with Osseotite® (3i Implant Innovations, Inc.) surface. Half of the defects (group A) were filled up with spherical and half (group B) with granular forms of Biogran II®. Ossix® (3i Implant Innovations, Inc.) membranes covered the surgical sites.*

Results: *The histological evaluation after 8 weeks showed new bone formation in both groups, without any statistically significant differences in regards to bone-to-implant contact, bone-to-graft contact, bone graft area, and bone volume. Both dissolution of the outer shell and inner silica gel of the particles were observed mostly in spherical particles. In addition, new bone formation within the protected pouch interconnected with the surrounding new bone was observed exclusively in spherical particles of Biogran II®.*

Conclusion: *Faster dissolution of both outer and inner portions of spherical particles of Biogran II® led to better integration with the surrounding new bone during an 8-week period of healing. (Implant Dent 2006;15:386–394)*

Key Words: bioactive glass, bone regeneration, acid-etched surface

The success of dental osseointegrated implants presupposes the existence of a sufficient volume of healthy bone at the recipient site during implant placement.[1] However, in case of inadequate bone volume, certain techniques[2] have been employed to retrieve the lost hard tissues using autogenous bone taken from intraoral donor sites[3] or other bone substitutes.[4] Bioactive glass granules of narrow size range (300−355 mm) have been successfully used as an artificial bone substitute during bone regeneration procedures in periodontal defects,[5] sinus floor elevation,[6–8] postextraction sites,[9] as well as bony defects.[10–13] Their osteoconductive and osteo-stimulative properties are due to a series of reactions and transformations observed at their external and internal areas following implantation and contact with tissue fluids.[11] It was demonstrated that the interfacial ion exchange between the glass particles and surrounding tissue fluids results in the formation of a silicon-rich gel that extends throughout the center of the particles covered by a CaP-rich layer that is formed on the outer surface. Small cracks in the CaP-rich layer allow phagocytic cells to penetrate the silicon-rich gel, resorb the gel, and excavate the internal area of the particles. The lacunae formed by the resorption lead to an internal protected environment where a bone-like substrate gradually matures to new bone. Moreover, it has been shown that the remodeling of the glass particles is higher in sites where the remodeling activity of the surrounding bone progresses faster.[14] Huygh *et al*[15] confirmed previous histological results using a microchemical analysis to describe an increase in the relative amount of silicon in the center of the particle 1 month after implantation and a great reduction after 2 months. The silicon at the borders of the granules was reduced to nearly 0% in 1 month, without any change during the following evaluation periods. The line scan showed an irregular image in the inner part of the particles caused by invasion of fibrous tissue in the 2 and 3-month sections, while the dot map-

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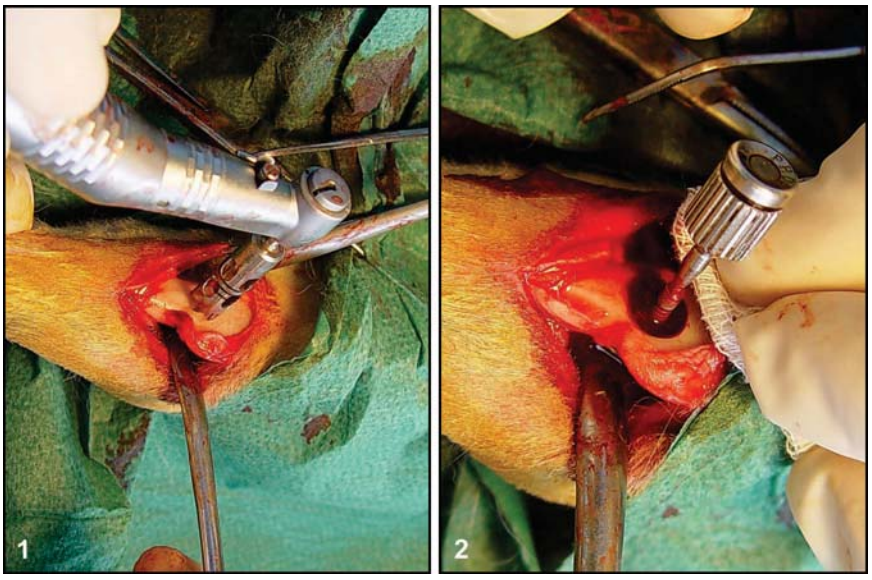

Fig. 1. A 6-mm trephine bur was used to create a cortical defect at the median metaphysis of the tibia.
Fig. 2. The implants were placed homocentrically to the round osteotomy and were stabilized at the opposite cortex, leaving a uniform space of 2 mm around their cervical portion.

ping revealed bone formation in the protective pouch in 6, 12, and 24 months.

In an effort to accelerate the *in vivo* reaction of the current Biogran® (3i Implant Innovations, Inc., Palm Beach Gardens, FL) bioactive glass, Radin *et al*[16] reported the conversion of the granules to excavated calcium phosphate when immersed in simulated physiological solution at 37°C with and without serum proteins. The extent of the conversion was measured on the basis of cumulative silicon release. Further analysis was made in a project supported by 3i Implant Innovations Inc.,[17] where the current granular and spherical forms of current Biogran® were converted *in vitro* to hydroxyapatite (Biogran II®) by immersing them in K_2HPO_4 solutions. Increasing K_2HPO_4 concentration, pH, and temperature resulted in increased conversion rate, while the organic additions in K_2HPO_4 solutions had little effect on the extent of reaction. The spherical form of prereacted Biogran II® exhibited differences in regards to the crystal growth process and micro-cracks observed in the outer surface of the hydroxyapatite shells. It is claimed that from the 11 reaction stages that are needed to describe the bond formation between the current Biogran® and living tissue, the first 5 stages are accomplished *in vitro*, resulting in faster new bone formation around the new material since its biological process of tissue integration starts immediately from the 6th up to 11th reaction stage.[17]

The purpose of this study was the histological and histo-metric evaluation of the bone regeneration around implants placed in critical-sized defects in rabbit tibia using granular and spherical forms of prereacted Biogran II®.

Materials and Methods

A total of 12 adult white New Zealand rabbits weighing 3–4 kg were quarantined for observation in separate cages. They were fed *ad libitum* a laboratory diet prior to their use according to the institutional regulations and control of the Dental School of Thessaloniki, following the ethical regulations according to the protocol outlined by the General Secretariat of Research and Technology in Greece. Prior to surgery, the animals were sedated with an intramuscular injection using 1–2 mg/kg for kg of weight diazepam (Stedon 10 mg; Adelco, Chromatourgia Athinon, Athens, Greece), and then were anesthetized by intramuscular injections of a combination of a dose of 35 mg/kg ketamine (Imalgene® 1000; Merial, Lyon, France) and a dose of 5 mg/kg xylazine (Rompun®; Bayer AG, Leverkusen, Germany) for kg of weight. Local anesthesia was also administered by subcutaneous infiltration of 1.7 mL of mepivacaine hydrochloride (Mepivastesin 228; 3M ESPE AG, Seefeld, Germany). Each tibial metaphysis close to the medial condyle offered room for one experimental site. Pilot experiments indicated that creating 2 surgical sites might lead to fracture of the tibia. The surgical area was prepared by shaving and washing with 10% povidone iodine solution (Betadine®; Mundifarma S.A., Switzerland). An appropriate incision was made, and both skin and periosteum were elevated, exposing the cortical plate of the inner side of the tibia. A 6-mm round osteotomy was made with a trephine bur (Fig. 1), and a drill 1.8 mm in diameter was inserted through the osteotomy to penetrate the opposite cortical plate of the tibia. The medulla was not removed from the marrow cavity, and a screw type implant 2.0 mm in diameter and 10 mm in length with double-acid etched surface (Osseotite®; 3i Implant Innovations, Inc.) was placed homocentrically to the osteotomy and stabilized at the opposite cortex, leaving a uniform space of 2 mm around its cervical portion (Fig. 2). Either spherical (for group A) or granular (for group B) forms of Biogran II® were loosely packed, filling the defect up to the cervix of the implant. Ossix® membranes (3i Implant Innovations, Inc.) were used to cover the surgical sites. The periosteum, and muscle fascia were then repositioned and sutured separately with absorbable Vicryl sutures (Ethicon, Inc., Johnson & Johnson, Somerville, NJ), and the skin with silk sutures. Postoperatively, a single dose of 1–3 mg/kg for kg of weight ketoprofen (Romefen® 100 mg/ml; Merial) was administered intramuscularly as an analgesic, while antibiotic care was given subcutaneously using 5 mg/kg enrofloxacin (Baytril® 5%; Bayer AG) for kg of weight daily for 3 days. A total of 24 surgical sites were made using this experimental design. Of them, 12 were grafted with spherical (group A) and 12 with granular (group B) forms of Biogran II®.

The animals were kept under appropriate postsurgical medication and

care in separate cages, and were sacrificed after 8 weeks with an intravenous overdose of 10 mL of potassium chloride 10% (DEMO S.A., Athens, Greece) after they had been anesthetized as described previously. The samples were then subjected to histological preparation and evaluation.

Histological Preparation

The implants with the surrounding bone were transversally separated from the tibia with a manual bone saw, rinsed with saline, and were prefixed by immersion in a solution of 30% formalin for an hour followed by fixation in 10% formalin for 48 hours. The retrieved biopsies were prepared for nondecalcified ground sections. A series of ascending grades of alcohol were used to dehydrate the samples, ending with 3 separate immersions in absolute 100% alcohol. Samples were then infiltrated with resin (Technovit® 7200; Heraeus Kulzer GmbH, Wehrheim, Germany) and polymerized for 12 hours in blue light. An Accutom II® high-speed microtome (Struers, Copenhagen, Denmark) and a DAP-V® grinding device (Struers) were used to prepare thin (60–80 mm) sections stained with a solution of toluidine blue and pyronine-G. The histological sections were evaluated using a transmission light microscope (Axiostar Plus; Zeiss, Göttingen, Germany) with an integrated color digital video camera (DC88AP; Sony, Tokyo, Japan) and a frame grabber. The selected images were then digitized for the histo-metric analysis using the image analysis software (ActioVisio; Zeiss). Bone-to-implant contact, bone-to-graft contact, bone graft area, and the total volume of the regenerated bone (bone volume) were measured and expressed as a percentage of the total cortical defect area. The percentage of both spherical and granular Biogran II® particles exhibiting excavation of their inner part was also calculated.

The Mann-Whitney nonparametric test was used for statistical comparisons of the previous measurements between the 2 groups.

Results

All samples exhibited various degrees of bone regeneration in the defect area. In 3 samples of group A and in 4 of group B, fibrous tissue was observed around the head and coronal threads of the implants where no bone apposition on the implant surface was present (Fig. 3). However, no fibrous tissue or signs of inflammatory reaction existed in the rest of the defect area. The outer cortex of the bony defects was not restored in the samples of both groups (Fig. 4). Bone trabeculae were distributed uniformly within the defect region, and comprised both woven and mature lamellar bone with osteons (Fig. 5). New bone was developed from the endosteal cortical host bone surrounding the defect toward the implant surface, penetrating deeply into the space between the implant threads. The degree of the direct bone-to-implant contact varied, and, in the majority of the samples, the density of the new bone was higher, close to the implant surface (Fig. 5).

The particles of both forms of Biogran II® were interlocked with each other by the new bone trabeculae, and many of them were seen in close proximity, but not in direct contact with implant surface (Figs. 4 and 5B). The characteristic fissuring was routinely seen in both types of the Biogran II® particles, but no dissolution of the outer shell of the granular form could be seen. In some of them, the internal silica gel was dissolved, but still no new bone formation was present (Fig. 6). Contrarily, many (about 25%) of the spherical particles had their outer shell dissolved in various degrees (Fig. 5), and new bone formation was observed in the internal lacunae (Fig. 7). In some of them, woven bone was formed in the center

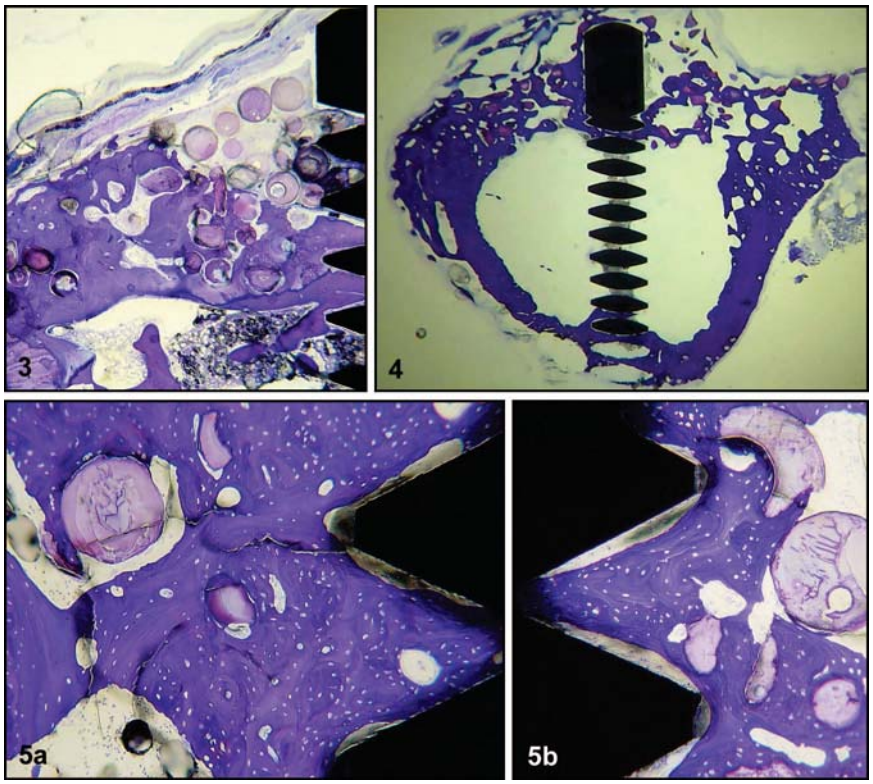

Fig. 3. In some samples, fibrous tissue mixed with Biogran II® particles was observed around the head and coronal threads of the implants. No bone apposition on the implant surface could be seen in this area (toluidine blue and pyronin-G, original magnification ×25).

Fig. 4. A typical sample of group B where the experimental design can be seen. The outer cortex of the bony defects around the implant was not restored in the samples of both groups. However, new bone filled the defect in close proximity with the implant surface (toluidine blue and pyronin-G, original magnification ×12.5).

Fig. 5. A and B. Samples of group A (spherical form of Biogran II®). Woven and mature lamellar bone with numerous osteons could be seen within the defect area. Some of the spherical particles were intact, exposing only the typical fissuring characteristics. However, many of them had their outer shell dissolved, and remnants of this shell could be observed integrated with the new bone (toluidine blue and pyronin-G, original magnification ×100).

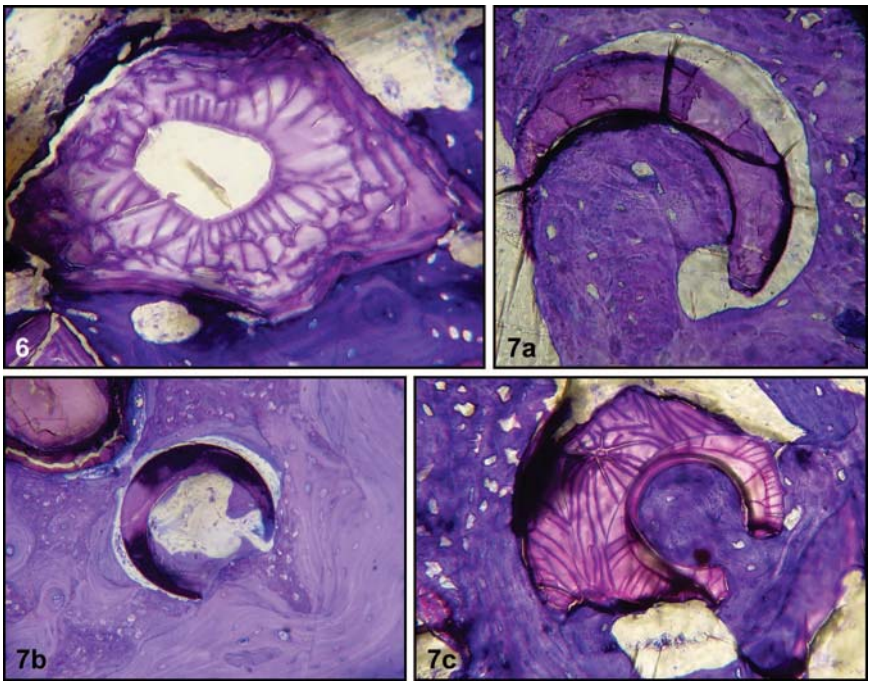

Fig. 6. Granular particle of Biogran II®. The characteristic fissuring was present, but no dissolution of the outer shell could be seen. In some of them, the internal silica gel was dissolved, but still no new bone formation was present (toluidine blue and pyronin-G, original magnification ×200).

Fig. 7. A–C. The spherical particles had their outer shell dissolved in various degrees, and woven bone filled the internal lacunae completely (A and C) or partially (B). This woven bone was interconnected with the surrounding bone, enhancing the integration between new bone and graft (A–C) (toluidine blue and pyronin-G, original magnification ×200).

Table 1. Mean Values of the Bone-to-Implant Contact, Bone-to-Graft Contact, Bone Graft Area, and Bone Volume Between the 2 Forms of Biogran II®

	Biogran II® Forms	
	Spherical (group A)	Granular (group B)
Bone-to-implant contact (%)	57.96 ± 15.19	51.27 ± 18.46
Bone-to-graft contact (%)	56.36 ± 7.99	52.07 ± 8.10
Bone graft area (%)	12.51 ± 3.6	14.29 ± 2.24
Bone volume (%)	63.80 ± 15.56	64.43 ± 5.30

Table 2. Statistical Comparisons Between the Spherical and Granular Forms of Biogran II® in Regards to Bone-to-Implant Contact, Bone-to-Graft Contact, Bone Graft Area, and Bone Volume According to the Mann-Whitney Test

	Biogran II® Forms	
	Spherical (group A)	Granular (group B)
Bone-to-implant contact (%)	$P = 0.423 > 0.05$	NS
Bone-to-graft contact (%)	$P = 0.337 > 0.05$	NS
Bone graft area (%)	$P = 0.522 > 0.05$	NS
Bone volume (%)	$P = 0.522 > 0.05$	NS

NS is nonstatistical difference.

of the particle (Fig. 7C), while in others, the outer shell was diminished, and the new bone was interconnected with the surrounding new bone that filled the defect (Figs. 7A and B).

Histometric Evaluation

The mean value of the bone-to-implant contact was 57.96% ± 15.19% and 51.27% ± 18.46%, while the mean value of the bone-to-graft contact was 56.36% ± 7.99% and 52.07% ± 8.10% for group A (spherical form) and group B (granular form), respectively. The area covered by the Biogran II® particles (bone graft area) was 12.51% ± 3.6% and 14.29% ± 2.24%, while the total new bone area (bone volume) was 63.80% ± 15.56% and 64.43% ± 5.30% for group A and group B, respectively (Table 1).

The statistical evaluation showed that there were no statistically significant differences between groups A and B in regards to bone-to-implant contact, bone-to-implant contact ($P = 0.423 > 0.05$), bone-to-graft contact ($P = 0.337 > 0.05$), bone graft area ($P = 0.522 > 0.05$), and bone volume ($P = 0.522 > 0.05$) (Table 2). The only difference that was found between the 2 groups was related to the existence of new bone regeneration within the internal chamber of the particles. Twenty-five percent of the spherical form particles included in the defect region depicted various degrees of bone regeneration within their internal chamber. Moreover, the dissolution of the outer shell was obvious, leaving remnants of the shell embedded in new bone trabeculae. On the contrary, none of the granular particles exhibited new bone formation within their internal chambers.

Discussion

The experimental model of rabbit tibia metaphyses used in this study has also been used in previous studies and has served as a bony site for experimental implant placement,[18,19] creation of cortical defects alone,[20] or in combination with implants.[21] In this study, the implants were stabilized at the opposite cortical plate of the tibia, allowing their cervical areas to be surrounded by a uniform 2-mm defect space. According to our experience, only 1 experimental site per tibia should be performed to avoid a consequent fracture of the long bone. Liljensten *et al*[21] previously used the aforementioned experimental model for the evaluation of the bone forming capabilities of other materials. However, in an effort to avoid fractures, they created smaller sized defects (5 mm) to place 2 mm in diameter implants. They found slightly lower

bone-to-implant contact (45% *vs*. 57% of this study) using cortical graft, while the DBM bone grafts tested in their study produced significantly lower bone-to-implant contact. The values of the bone volume were not comparable with this study since their measurements were confined only within implant threads and not within the whole defect area.

This study demonstrated that both forms of Biogran II® were good scaffolds for new bone formation in peri-implant defects. The Biogran II® particles were in close proximity, but not in direct contact, with the implant surface, allowing bone to develop between grafts and implant. Direct comparisons with other studies cannot be made since their authors used commercially available Biogran® in bony defects alone or before implant placement and not in conjunction with immediate placement around implants. In addition, Biogran II® is currently a new product available only for experimental use. However, in comparison with other studies that used the previous Biogran® and included histo-metric measurements, higher bone volume was found for both forms of Biogran II®. Tadjoedin[7] and Cordioli[8] *et al* published 14.60% and 30.6% bone volume, respectively, in bone cores taken from grafted sinus after placement of the former Biogran®. In a rabbit tibia experimental model, Ruhaimi[12] found a lower percentage of new bone within the Biogran® particles (28%) than in the present study, where by subtracting the bone graft area from the total bone volume, the new bone value was still higher for both forms of Biogran II® (spherical: 51.29% and granular: 50.14%). Attempting a different experimental model, Stavropoulos *et al*[22,23] used Teflon (DuPont Co., Wilmington, DE) capsules in rat mandible and found limited new bone formation (12.6%) one year after surgery. A striking finding of their study was that Biogran® arrested new bone formation, whereas in the nongrafted capsules, higher bone volume was observed. Their results are not in agreement with the present study, possibly due to various factors such as the specific characteristics of their model and the use of the previous Biogran®.

It is of special interest that during the control period of the present study, only the spherical form of Biogran II® particles exhibited new bone formation within their protective shells. Although the characteristic fissuring was seen almost in all particles, dissolution of the outer shell was observed mostly in spherical particles. An explanation can be sought in the different thermal expansion coefficients between the spherical and granular forms.[17] Granular particles contain edges that can easily release the strain energy when hydroxyapatite crystals were formed, while in spherical particles, the same strain energy may lead to cracks. Moreover, SEM analysis revealed thinner shell structure in spherical particles due to different reaction conditions during conversion procedures.[17] Further research needs to be conducted on the dissolution characteristics of the 2 forms over time.

Conclusions

Both spherical and granular forms of Biogran II® promoted new bone formation in critical-sized defects around implants in an 8-week evaluation period. Using the rabbit tibia experimental model, the total bone volume as well as the new bone development within the Biogran II® particles were higher compared to other studies where the previous Biogran® was used. Micro-cracks and fissuring characteristics were seen in both forms, but the dissolution of the outer shell and the consequent ingrowth of new bone within the protected chamber were observed only in spherical particles. This new woven bone was usually interconnected with the surrounding trabecular bone that filled the defect so as to enhance the integration between new bone and bone graft.

Disclosure

The authors claim to have no financial interest in any company or any of the products mentioned in this article.

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Abstract Translations

GERMAN / DEUTSCH

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Knochengewebswiederherstellung im das Implantat umlagernden Gewebe durch Verwendung kugelförmiger und granularer Formen von bioaktiven Glaspartikeln

ZUSAMMENFASSUNG: Zielsetzung: Es wurde darüber berichtet, dass das Vorgänger-Biogran® im Laborversuch zu Hydroxylapatit umgewandelt werden und als Biogran II® die Bildung neuen Knochengewebes beschleunigen kann. In der vorliegenden Studie sollte die Regeneration des Knochengewebes im das Implantat umlagernden Gewebe bei kritischen Größendefekten untersucht und bewertet werden. Die Versuche hierzu wurden an den Schienbeinen von Hasen durchgeführt, an denen die Wirkweise der granularen und kugelförmigen Formen des Biogran II® in Bezug auf Implantatkontakt, Knochen-Transplantatkontakt, Knochentransplantatbereich und komplettes Knochengewebsvolumen beurteilt werden sollte. ***Methoden und Materialien:*** Zwölf ausgewachsene Neuseeland-Hasen wurden zum Versuch herangezogen. An jedem Schienbein der Versuchstiere wurde eine Operationsstelle geschaffen, also insgesamt 24, an denen runde Defekte von 6 mm Größe vorbereitet wurden, die das konzentrische Einfügen eines mit einer Osseotite®-Oberfläche versehenen Schraubimplantats im experimentellen Stadium ermöglichten. Die Hälfte der Defekte (Gruppe A) wurde mit granularem Biogran II® und die andere Hälfte mit kugelförmigen Formen des Biogran II® aufgefüllt. Ossix®-Membrane fanden zur Abdeckung der Operationsbereiche Anwendung. ***Ergebnisse:*** Die nach 8 Wochen durchgeführte histologische Untersuchung ergab eine Knochenneubildung für beide Gruppen ohne statistisch bedeutsame Unterschiede in Bezug auf Implantatkontakt, Knochen-Transplantatkontakt, Knochentransplantatbereich und komplettes Knochengewebsvolumen. Die Auflösung von sowohl äußerer Hülle wie auch innerem Siliziumoxidgel wurde zumeist bei den kugelförmigen Partikeln beobachtet. Außerdem konnte eine Knochengewebsneubildung innerhalb der mit dem umgebenden neuen Knochengewebe verbundenen geschützten Tasche ausschließlich für die kugelförmigen Partikel des II® festgestellt werden. ***Schlussfolgerung:*** Betrachtet über einen Heilungszeitraum von 8 Wochen, ermöglichte die schnellere Auflösung von sowohl äußerem wie auch innerem Bereich der kugelförmigen Partikel des Biogran II® eine bessere Integration mit dem neuen Knochengewebe.

SCHLÜSSELWÖRTER: Bioaktives Glas, Wiederherstellung des Knochengewebes, Säuregeätzte Oberfläche

SPANISH / ESPAÑOL

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Regeneración del hueso alrededor de implantes usando formas esféricas y granulares de partículas de vidrio bioactivas.

ABSTRACTO: Propósito: Se ha informado, que previos Biogran® se puede convertir in vitro en hidroxiapatita (Biogran II®), para poder acelerar la formación de nuevo hueso. El propósito de este estudio fue evaluar la regeneración de hueso alrededor de los implantes colocados en defectos de tamaño crítico en la tibia de conejos usando formas esféricas y granulares de Biogran II® con respecto al contacto con el implante (BIC), contacto de hueso al injerto (BGC), área del injerto de hueso (BGA) y volumen total del hueso (BV). ***Métodos y Materiales:*** Se usaron doce conejos adultos de Nueva Zelanda, ofreciendo 24 sitios quirúrgicos (uno en cada tibia) donde se crearon defectos de 6 mm permitiendo la colocación homocéntrica de un implante experimental tipo tornillo con una superficie de Osseotite®. La mitad de los defectos (grupo A) se llenaron con formas granulares y la mitad (grupo B) con formas esféricas de Biogran II®. Membranas Ossix® cubrieron los sitios quirúrgicos. ***Resultados:*** La evaluación histológica luego de 8 semanas demostró la formación de nuevo hueso en ambos grupos sin diferencias estadísticamente significativas con respecto a BIC, BGC, BGA y BV. Se observaron ambas, la disolución de la capa externa y el gel interno de sílice principalmente en las partículas esféricas. Además, la formación de nuevo hueso dentro de la cavidad protegida interconectada con el nuevo hueso se observó exclusivamente en las partículas esféricas de Biogran II®. ***Conclusión:*** Una disolución más rápida de las partes internas y externas de las partículas esféricas de Biogran II® llevó a una mejor integración con el nuevo hueso que lo rodeaba durante un período de curación de 8 semanas.

PALABRAS CLAVES: Vidrio bioactivo, regeneración del hueso, superficie grabada con ácido

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Regeneração do osso em torno de implantes usando formas esféricas e granulares de partículas de vidro bioativo.

RESUMO: Objetivo: Foi relatado que o Biogran® anterior pode ser convertido in vitro em hidroxiapatita (Biogran II®), a fim de acelerar nova formação do osso. O objetivo deste estudo foi avaliar a regeneração do osso em torno de implantes colocados em defeitos de tamanho crítico em tíbia de coelho usando formas granulares e esféricas de Biogran II® com relação a contato do implante (BIC), contato osso a enxerto (BGC), área de enxerto do osso (BGA) e volume total do osso (BV). ***Métodos e Materiais:*** Doze coelhos adultos da Nova Zelândia foram usados, oferecendo 24 locais cirúrgicos (um em cada tíbia) onde defeitos redondos de 6mm foram criados, permitindo a inserção homocêntrica de um implante experimental tipo parafuso com superfície de Osseotite®. Metade dos defeitos (Grupo A) foi preenchida com formas granulares e metade (Grupo B) com formas esféricas de Biogran II®. Membranas de Ossix® cobriram os locais cirúrgicos. ***Resultados:*** A avaliação histológica após 8 semanas mostrou nova formação de osso em ambos os grupos sem quaisquer diferenças estatisticamente significativas com relação a BIC, BGC, BGA e BV. Tanto a dissolução da concha

externa quanto a do gel de Silica interno foram observadas principalmente em partículas esféricas. Além disso, nova formação de osso dentro da bolsa protegida interconectada com o osso novo circundante foi observada exclusivamente em partículas esféricas de Biogran II®. ***Conclusão:*** A dissolução mais rápida tanto das porções externa quanto interna de partículas esféricas de Biogran II® levou à melhor integração com o osso novo circundante durante um período de 8 semanas de cura.

PALAVRAS-CHAVE: Vidro bioativo, regeneração do osso, superfície despolida por ácido

JAPANESE / 日本語

粒状または球状のbioactive glass particleを使った インプラント周辺骨再生

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概要：

目的：新骨形成を促進するために、Biogran®がヒドロキシアパタイト（Biogran II®）に試験管的に転換できることはこれまで報告されてきた。本研究の目的は、ウサギ顎骨の重篤なsize defectに粒状または細球状のBiogran II®を使って装着されたインプラント周囲の骨再生を、implant contact (BIC)、bone to graft contact (BGC)、bone graft area(BGA)、total bone value (BV)によって評価することにあった。

素材と方法：12匹の成ニュージーランドラットが使用された。24カ所の手術サイト（各顎骨にひとつ）に6mmの丸形欠損が作られて、そこにOsseotite®表面のスクリュータイプインプラントがhomocentricalに埋入された。欠損部の半分（A群）に粒状、他の半分（B群）に球状のBiogran II®が使われた。手術サイトはOssix® membraneでカバーされた。

結果：8週間後の組織学的評価では、BIC、BGC、BGA、BVについて両群に統計的有意差のない新骨形成が認められた。両群ともに、粒の外部シェルと内部のシリカゲルの溶解は主に球状の粒において認められた。さらに、周辺の新骨と結合した保護ポーチ内部の新骨形成は、球状のBiogran II®だけに観察された。

結論：球状のBiogran II®における外部シェルと内部シリカゲルのより早い溶解は、8週間の治癒期間中に周辺新骨とのより良好なintegrationを助ける。

キーワード：Bioactive glass、骨再生、アシッドエッチ表面

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CHINESE / 中国語

利用球形與粒狀生物玻璃顆粒,促進植體周圍骨質再生

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摘要：

目的：根據報告顯示，先前的Biogran® 可在試管內轉化成氫氧磷灰石（Biogran II®）以加速新骨質的生成。本研究的目的旨在評估使用粒狀與球形Biogran II®植入兔脛骨關鍵尺寸缺損，其植體周圍骨質的再生,其中包括植體接觸面（BIC）、骨移植接觸面（BGC）、骨移植接觸區域（BGA）以及總骨量（BV）等評估。

資料與方法：使用12隻紐西蘭種成兔，提供24個外科手術部位（每個脛骨1個）並製造6mm的圓形缺損，以容許以同心圓方式插入含Osseotite® 表面的螺形實驗植體。其中，一半的缺損（A組）以粒狀Biogran II®填滿,另一半（B組）則以球狀Biogran II®填滿，再以Ossix® 薄膜覆蓋手術部位。

結果：8週後的組織學評估顯示，兩組在新骨質生成上，其BIC、BGC，BGA 與BV沒有任何統計學上的明顯差異。大多數球形顆粒可觀察到顆粒外層與內部矽膠凝體的溶解。此外，僅在Biogran II®球形顆粒觀察到與周圍新骨質互相連接的保護囊內，有新骨質生成。

結論：Biogran II®球形顆粒的顆粒外層與內部矽膠凝體更快溶解，促使它與周圍新骨質在8週的康復期內，有更良好的整合。

關鍵字：生物玻璃、骨質再生、磨砂表面

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