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Healing of transplanted composite bone grafts–implants: a pilot animal study

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Abstract: This experimental pilot study was undertaken to evaluate healing of titanium implants transplanted with the surrounding bone into recipient osseous sites in the rabbit mandible. One short implant was inserted in the horizontal portion of the mandible in each of 10 New Zealand rabbits. Subsequently, and during the same session, the implant with 1.5–2.0 mm of bone circumferentially was removed using a trephine bur and immediately transplanted in a through-and-through hole prepared in the contralateral aspect of the mandible. Three months following the transplantation, the animals were sacrificed and the mandibles processed for histological evaluation. The healing pattern was assessed in relation to (1) bone bridging at the interface between the bone core and the surrounding recipient osseous tissue, (2) differences in bone density between the transplanted bone cylinder and the bone at the margins of the recipient site, and (3) bone-to-implant contact (BIC) at the interface. The transplanted graft–implant cores were integrated within the recipient sites in five out of the 10 specimens while the remaining five bone–implant cores showed fibrous encapsulation. Various patterns of resorption were observed within the peri-implant transplanted hard tissues. Percentage BIC ranged between 1% and 72% in the fibrous-encapsulated specimens and between 20% and 62% in the integrated transplants. Within the limits of this pilot study, the results suggest that immediate transplantation of endosseous implants with their surrounding bone into congruous recipient osseous sites cannot predictably yield graft-implant incorporation and osseointegration of the implants. This alternative surgical modality of immediately transplanting a composite bone graft-implant from highly cortical intraoral or extraoral sites to enhance bone quality and/or volume in implant recipient sites such as the maxillary sinus and tuberosity areas needs to be further investigated.

Introduction

In implant surgery, the presence of anatomic restrictions such as the nasal and sinus cavities in combination with insufficient bone volume dictates a more complex therapeutic approach for the placement of endosseous implants. Various treatment modalities have been proposed to augment bone at the implant sites such as guided bone regeneration (Cortellini et al. 1993; Buser et al. 1996; Simion et al. 1998; Corrente et al. 2000), onlay grafting (Williamson 1996; Widmark et al. 1997; Chiapasco et al. 1999), sinus augmentation procedures (Moy et al. 1993; Lundgren et al. 1996; Wheeler et al. 1996; Hürzeler et al. 1997; Valentini & Abensur 1997), distraction osteogenesis (Bell et al. 1999; Stucki-McCormick et al. 1999; Oda et al. 1999), ridge expansion techniques (Scipioni et al. 1994; Vercellotti 2000), and others. Transplantation of a preosseointegrated implant from the mental area to a grafted

maxillary sinus has been described in a clinical case report by Lazzara (1995). The author reported that the process of bone-to-bone healing that occurs in the transplant site might be more reliable than osseointegration in grafted bone. According to the author, another potential advantage of such a procedure is the superior peri-implant bone quality that promotes better implant stability than the cancellous bone of the recipient maxillary site. Similar procedures have been described for the rehabilitation of jawbone defect – where iliac bone including preosseointgrated implants was removed and transplanted into the recipient oral site (Breine & Brånemark 1980) – and for the surgical correction of malpositioned osseointegrated implants using trephined implant-containing bone cores (Hallman & Carlsson 1996) or a segmental osteotomy approach (Svensson et al. 1993; Guerrero et al. 1999; Storum & Carrick 2001). The question as to whether the one-stage transplantation of bone cores including immediately inserted implants can yield graft integration and implant osseointegration has not yet been investigated. This alternative approach of immediate transplantation of a composite bone graft–implant from highly cortical intraoral or extraoral sites might be interesting in oral surgical applications to enhance bone quality or quantity in certain implant recipient sites with poor osseous density or volume such as the maxillary sinus and tuberosity areas.

The purpose of this pilot study was to evaluate the healing of screw-shaped titanium implants inserted in the rabbit mandible, and immediately transplanted with the surrounding bone in osseous sites prepared in the contralateral side of the mandible.

Material and methods

Animals and anaesthesia

Ten adult New Zealand white rabbits of both sexes weighing 3.5–4 kg were used in this study. Immediately prior to surgery, the animals were sedated using an intramuscular (i.m.) injection of ketamine (Ketamin-radiopharm 100 O.K., Radiopharm, Ulm, Germany) 44 mg/kg of body weight, combined with i.m. xylazine (Rompun®, Bayer AG, Leverkusen, Germany) 6–8 mg/kg of body weight. In addition, 0.5 ml of the local anesthetic lidocaine 2% (Xylocaine®, Astra Farmaceutici S.p.A., Milano, Italy) was injected locally at the periphery of the surgical site. The study was approved by the Animal Research Ethics Committee at the University of Padova, Italy. All surgeries were performed under aseptic conditions.

Surgical procedure and experimental design

Prior to surgery, the skin was shaved and cleaned with a mixture of iodine and 70% ethanol. The horizontal portion of the mandible was exposed by a midline incision through the skin, fascia, and periosteum. The implant was inserted in the lateral aspect of the horizontal segment of the mandible anteriorly to the masseter muscle insertion, at approximately 7 mm from the inferior border. By intermittent drilling and cooling with sterile saline, the site was prepared using a 1.5 mm diameter customized cylindrical drill to a depth of 4 mm. A shallow countersinking was carried out to a depth of 1 mm in the outer cortex to accommodate the 3-mm-diameter shoulder of the implant. An attempt was made to have the implant long axis as perpendicular as possible to the outer cortical bone surface. One customized threaded self-tapping titanium fixture (3i, Implant Innovations, Inc., Palm Beach Gardens, FL, USA), 5 mm in length, 3 mm in diameter at the shoulder area and 2 mm at the threaded portion, was manually inserted (Fig. 1). The implant along with 1.5 and 2 mm of bone circumferentially at the shoulder and threaded portions respectively was removed using a trephine of 6 mm of internal diameter (Fig. 2). A through-and-through hole of 5.7 mm diameter was prepared under abundant irrigation with sterile physiologic solution in a symmetrically located site in the contralateral aspect of the mandible using a trephine of 5.7 mm external diameter (Fig. 3A). The implant-containing bone core was then inserted in the prepared osseous site to the level of the external mandibular cortex (Fig. 3B). The fit of the implant-containing bone core into the prepared cavity of the recipient site was subjectively assessed according to the following scale: 1 = tight fit requiring tapping with

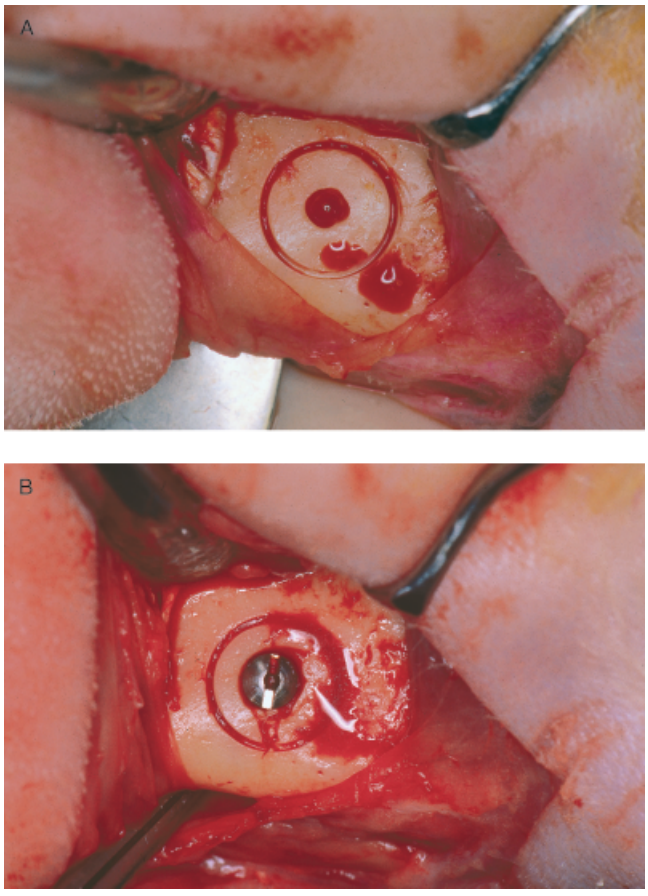

Fig. 1. (A) Prior to implant site preparation, a peripheral slit was outlined with the trephine to help position the implant in a central location. (B) A screw-shaped titanium implant was inserted in the horizontal portion of the rabbit mandible perpendicularly to the bone surface.

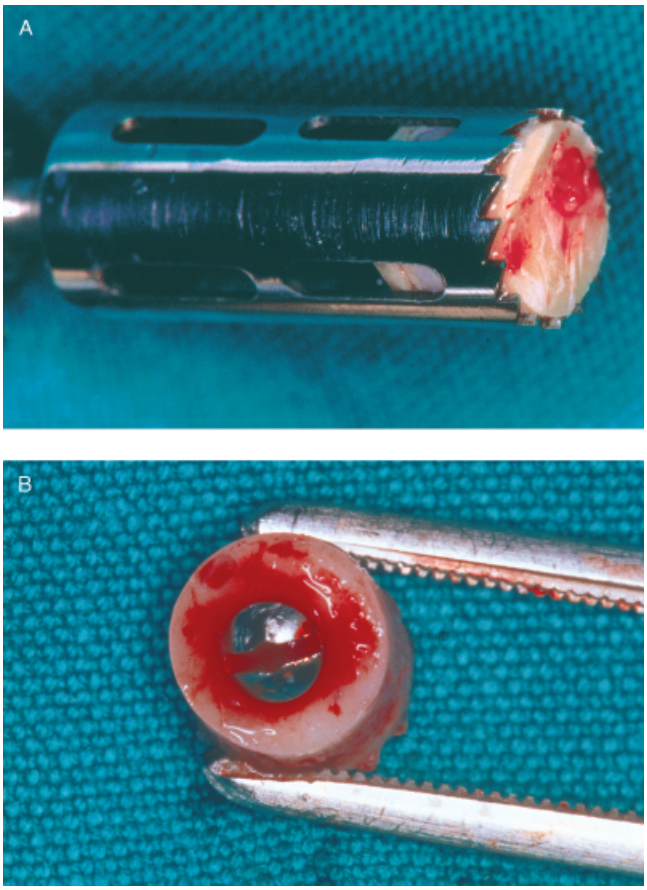

Fig. 2. (A) The implant with 1.5–2.0 mm of surrounding bone was removed with a trephine bur with an internal diameter of 6 mm. (B) The bone–implant core prior to transplantation.

a seating instrument; 2 = adequate fit requiring moderate finger pressure; 3 = easy fit requiring light finger pressure; and 4 = poor fit where the bone–implant core was easily pushed into the recipient site with negligible amount of pressure.

The skin-periosteal flaps were then repositioned and sutured in two separate layers using resorbable sutures. Postoperatively, the animals received antibiotics (Penovet®, Boehringer Ingelheim, Copenhagen, Denmark) at a dose of 0.3 ml per animal and analgesics (Temgesic®, Reckitt and Coleman, Hull, England) at 0.05 mg/kg of body weight for 3 days.

Specimen retrieval and histological processing

After 3 months of healing, the animals were sacrificed with an overdose of carbon dioxide, and the mandibles immediately dissected, washed in saline solution and fixed in 4% buffered paraformaldehyde and 0.1% glutaraldehyde in 0.15 M cacodylate buffer at 4°C and pH 7.4. The specimens were further dehydrated in ascending concentrations of ethanol and preinfiltrated with diluted methylmethacrylate, followed by infiltration with pure methylmethacrylate for 14 days prior to polymerization. After polymerization, the blocks were sectioned through the implant shoulder along a plane perpendicular to the bone surface. One central section of 150 µm was cut using the Exakt machine (Exakt-Apparatebau, Norderstedt, Germany), then ground down to about 30 µm as described by Donath (1988), and stained with modified trichrome stain.

This ground section was histologically and histomorphometrically analyzed using a Leitz Laborlux-S light microscope (Leitz, Wetzlar, Germany) connected to an Intel Pentium III 300 MMX, a video-acquired schedule Matrox, a video-camera, and a KS 100 Software (Zeiss, Hallbergmoos, Germany). The following histologic and histomorphometric parameters were evaluated:

1. Nature of bridging at the interface between the implanted bone core and the osseous tissue surrounding the through-and-through hole of the recipient site as described by Goldstein et al. (1993):
   - *separate* when a gap was present histologically along the complete length of the bone core and the recipient site;
   - *partial* when a partial bridging existed at the bone core–recipient interface;
   - *full* when the bony bridging between the bone core and the recipient was complete.
2. Differences in bone quality between the implanted bone cylinder and the bone at the margins of the recipient site. Bone density in the transplanted bone core (BDT) was calculated as the area of mineralized bone expressed as a percentage of the total connective tissue area within a rectangular surface corresponding to the original dimensions of the harvested bone cylinder (Fig. 3). Bone density at the recipient site (BDR) was determined similarly in the area located 2 mm circumferentially to the transplant.
3. Percentage bone-to-metal contact around all threads throughout the length of the implant body.

The histomorphometric parameters were assessed by the same histologist on two different days, 1 week apart. A mean of the two recordings was then calculated for each central section.

Results

In 50% of the specimens, a fibrous connective tissue gap was present between the entire perimeter of the bone core and the recipient site (Figs 4 and 5). The connective tissue appeared dense, with few cells, and its width ranged between 200 and 800 µm. The osseous margins in contact with the connective tissue did not demonstrate any remodeling areas with osteoblastic or osteoclastic cells. Bone surrounding the interfacial connective tissue formed thin trabeculae arranged circumferentially to the demarcation line with areas of bridging with the host bone (Figs 4 and 5). In three sections, the bone that initially surrounded the implant was almost completely resorbed and a large layer of connective tissue with small amounts of bone separated the transplant from the recipient site (Fig. 4). In one of the

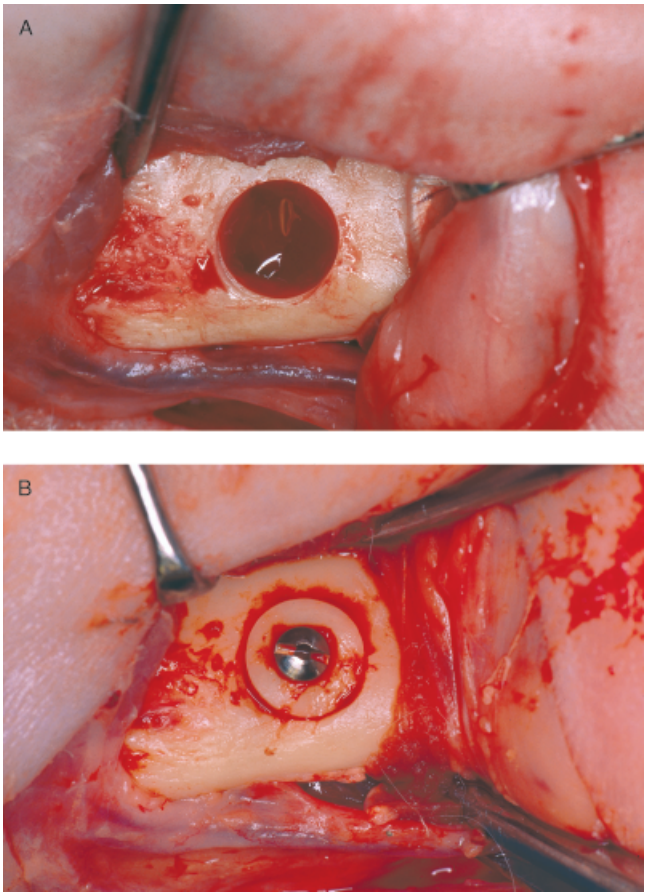

Fig. 3. (A) A through-and-through hole of 5.7 mm diameter was prepared in the contralateral aspect of the mandible. (B) The cylinder implant–bone was press fit inserted in the prepared osseous site to the level of the external mandibular cortex.

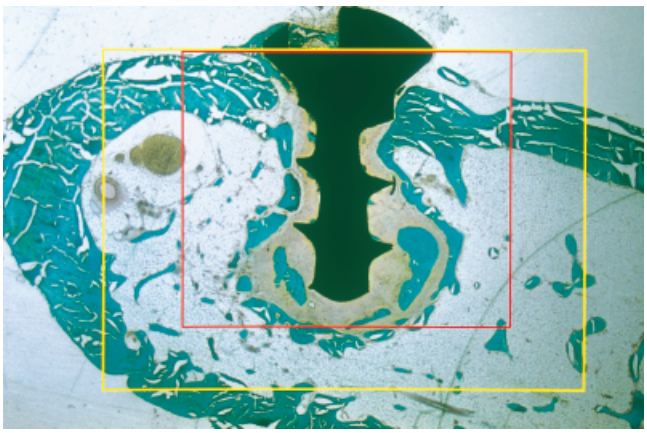

Fig. 4. Failure of graft integration. Most of the transplanted bone has been resorbed and a large fibrous gap can be observed along the entire graft perimeter with negligible interfacial bone-to-implant contact. The rectangular frames refer to the areas where BDT (red frame) and BDR (yellow frame) were measured (modified trichrome stain, original microscope magnification × 3).

remaining two sections (Fig. 5), the circumferential bone that was transplanted with the implant was compact with high bone volume density, reduced marrow spaces, and an architecture different from that present at the recipient site. The fifth section showed an intermediate pattern with circumferential bone surrounded by thin connective tissue (Fig. 6). The gross structural characteristics of the graft in all five specimens appeared to have been maintained with insignificant amounts of newly formed bone observed at the periphery of the graft in only one specimen but never at the implant interface. In these five fibrous-encapsulated specimens, percentage bone-to-implant contact (BIC) ranged between 1% and 72% (Table 1).

In the remaining five specimens, the graft–host interface showed partial bony bridging with bony trabeculae connecting the cancellous and cortical areas of the recipient bony bed to the transplanted core. In one section, bone at the implant surface and within the peri-implant transplanted hard tissues structurally matched the bone present at the margins of the recipient site with variable amounts of connective tissue showing the same histologic characteristics as described above. In four specimens, higher bone volume density with reduced marrow spaces and large bony trabeculae were evident within the graft contours while slender bone trabeculae associated with large cancellous spaces were found at the margins and within the recipient site (Fig. 7). In these partially integrated bone cores, newly formed bone occupied to some extent the graft area; however, isolated areas of nonvital grafted bone with intact morphology could still be observed in scattered portions of the transplanted core. These five specimens demonstrated variable amounts of BIC ranging between 20% and 62% (Table 1), with the implant interface occupied by both grafted and newly formed bone.

Table 1 reports the differences in bone density between BDT and BDR and the BIC values in the two groups of fibrous-encapsulated (Group A) and partially incorporated bone cores (Group B).

Discussion

In the present pilot study, the healing of threaded implants removed with circumferential bone from a mandibular site and immediately transplanted in a symmetrical congruous osseous recipient site of the contralateral hemimandible showed variable patterns of incorporation and BIC.

Healing of the implant-containing bone cores in this study could be biologically compared to that of autogenous inlay, onlay, and interpositional grafts used in reconstructive orthopedic and maxillofacial surgeries. In the present study, two patterns of graft incorporation could be demonstrated: partial graft integration was observed in 50% of the specimens while the

remaining 50% of the cores showed fibrous encapsulation. Failure of graft incorporation could be attributed to factors such as: (1) Inadequate stability of the graft–recipient site system (Lin et al. 1990; Phillips & Rahn 1990). Fibrous encapsulation was shown in five specimens that had a fit index ranging between 1 and 4, with 4/5 cases presenting less than a tight fit. Although the host–graft interface was intimately apposed along a substantial surface area, the lack of stable rigid fixation might have been responsible for the lack of graft incorporation (Lin et al. 1990; Stevenson et al. 1996) even though the grafts were theoretically exposed to minimal motion, shear, or torsional forces during healing. (2) Mechanical and thermal damage during core retrieval and/or recipient site preparation could have resulted in delayed vascularization (Albrektsson 1980) despite the fact that the implant-containing bone cores were placed in a contained, well-vascularized cancellous bone bed. Whether graft derived or host derived, new bone will minimally form without abundant vascularization (Albrektsson 1980) leading to poor host–graft union (Stevenson et al. 1996). (3) Morphology of the bone graft. Revascularization has been reported to occur at different rates in cortical and cancellous bone grafts (Hardesty & Marsh 1990; Lin et al. 1990; Sullivan & Szwajkun 1991; Stevenson et al. 1996). Vascular ingrowth into cortical autografts takes place at a much slower rate than in cancellous grafts, potentially resulting in delayed interfacial bone formation (Alberius et al. 1996; Stevenson et al. 1996). The association of various bone qualities – ranging from very cortical to very cancellous as observed in the five fibrous-encapsulated specimens of Group A – indicates that the architectural features of the grafted bone tissue are not

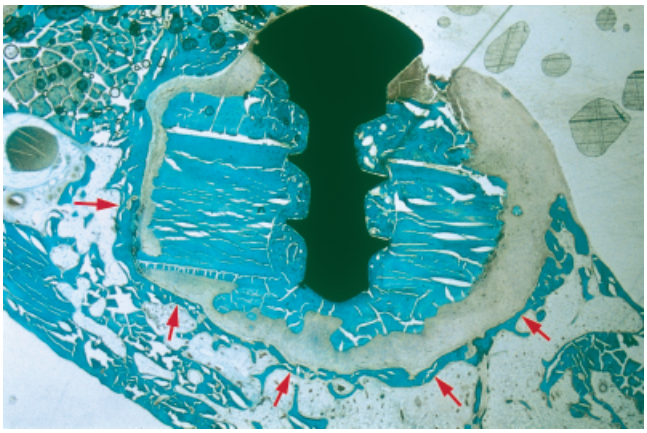

Fig. 5. Fibrous encapsulation of the implant-containing bone core. There is no substitution of the graft with viable in any of its central or peripheral portions. The transplanted core has maintained most of its original volume and appears like an inert sequestrum. Note the bone trabeculae arranged circumferentially at the demarcation line (red arrows) (modified trichrome stain, original microscope magnification × 3).

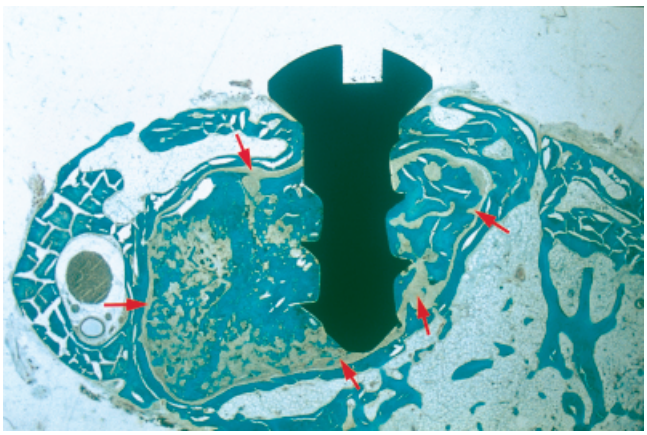

Fig. 6. In this specimen, bony bridging in the cortical area of the host bed corresponding to the implant shoulder can be observed with fibrous encapsulation throughout the remaining periphery of the implanted bone core (red arrows) (modified trichrome stain, original microscope magnification × 3).

Table 1. **Histologic and histomorphometric data in the 10 specimens included in the study.**

	Intraoperative fit of the bone core into the recipient site	Bony bridging at the bone core-recipient site interface	Percentage bone–implant contact (%)	bone density within the transplanted bone core (BDT) (%)	Bone density with in the recipient site (BDR) (%)
Group A					
1	4	Fibrous encapsulation	78	91	32
2	1	Fibrous encapsulation	34	11	21
3	2	Fibrous encapsulation	12	15	11
4	3	Fibrous encapsulation	1	9	8
5	3	Fibrous encapsulation	42	35	26
Min			1	9	8
Max			78	91	32
GROUP B					
1	1	Partial	20	34	28
2	1	Partial	37	41	24
3	2	Partial	36	39	21
4	2	Partial	62	54	29
5	2	Partial	40	52	23
Min			20	34	21
Max			62	54	29

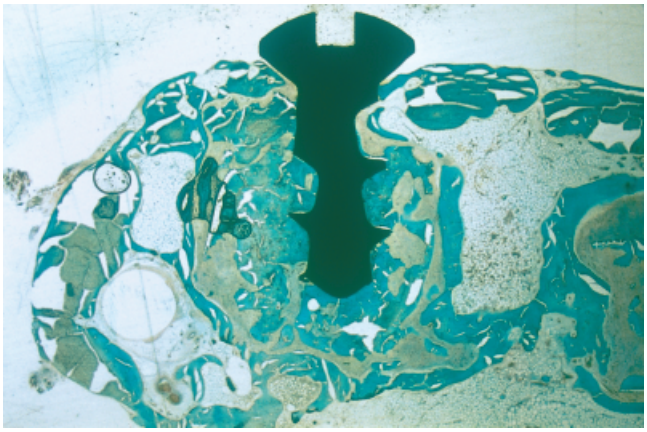

Fig. 7. The transplanted bone core appears integrated with the recipient hard tissues. Note the higher bone density within the graft area vs. the surrounding host bone (modified trichrome stain, original microscope magnification × 3).

the sole factor implicated in inadequate host–graft bony bridging.

One-stage insertion of endosseous implants in combination with autogenous onlay grafting has been shown to yield acceptable clinical outcomes and implant survival rates in a large number of clinical studies (Åstrand et al. 1996; Nyström et al. 1996; Verhoeven et al. 1997; Keller et al. 1999; Lekholm et al. 1999); however, limited histological data are available relative to graft remodeling and kinetics of implant integration in the grafted bone (Schliephake et al. 1991; Shirota et al. 1991; Nyström et al. 1993; Lew et al. 1994; Rasmusson et al. 1998; Schliephake & Aleyt 1998; Lundgren et al. 1999; Rasmusson et al. 1999a). In this pilot study, bone density of the transplanted core was consistently greater than that of the surrounding highly cancellous host bone in Group B where partial bony bridging was established at the graft–recipient site interface. This finding, although not substantiated by a statistical significance due to the small number of animals, is in line with previous observations in animal and human reports. First, the formation of dense bone around an implant with maintenance of the marrow bone structure in the outer vicinity has been reported following experimental implant insertion in dog maxilla (Brånemark et al. 1969), in the marrow cavity of the tibia (Brånemark 1983), and after clinical use in man (Albrektsson 1983; Hansson et al. 1983). Similarly, implants inserted in autogenous iliac crest bone grafts in the one-stage procedure in minipigs have shown the formation of lamina of dense bone around the fixtures while the cancellous bone structure of the iliac graft was preserved (Schliephake et al. 1991). Second, the greater BDT could be attributed to an increase in the amount of bone in the grafted tissue due to new bone formation on the trabeculae of the transplanted bone during healing (Lundgren et al. 1999). In the present report, every attempt was made to locate the graft core donor site and the recipient site in symmetrical locations of the mandible so as to obtain theoretically donor and recipient areas with matching bone density. However, biopsies were not retrieved from the donor site adjacent to the implant location at baseline. Consequently, changes in bone density of the grafted tissue in the recipient bed could not be properly evaluated.

Considerable variations between animals were evident relative to the structural characteristics, resorption, and remodeling patterns of bone in the transplanted graft. In the fibrous-encapsulated specimens of Group A, most of the bone tissue within the original graft boundaries and at the implant interface consisted of the initially transplanted bone with practically no new bone formation or remodeling within or at the periphery of the transplanted core. The lack of host–graft union in this group was likely to be associated with inadequate vascularization and minimal internal repair and substitution by new bone of the substance of the graft. In three specimens, most of the original peri-implant transplanted bone seems to have been resorbed while one specimen maintained most of its original volume. These differences in resorption patterns could be related to the structural characteristics of the grafted tissue. Grafts with different cortical/cancellous fractions have been reported to have different revasculatrization rates and therefore different patterns of resorption (Lin et al. 1990; Sullivan & Szwajkun 1991; Chen et al. 1994). Cortical grafts demonstrated in most studies greater volume maintenance when compared to cancellous grafts. These speculations remain hypothetical as the baseline structural features of the grafted bone tissue were not adequately assessed by biopsies retrieved from the donor site adjacent to the implant location.

In the partially incorporated graft cores, some of the initially transplanted bone had been resorbed and replaced by newly formed bone at 3 months postoperatively. These observations are in line with the findings of various studies on the healing of autogenous onlay grafts with simultaneous implant placement which reported bone remodeling within the graft and at the implant interface up to 24 weeks in the rabbit tibia model (Rasmusson et al. 1998; Rasmusson et al. 1999a), at 5 months in minipigs (Schliephake et al. 1991; Schliephake & Aleyt 1998), and at 4 (Nyström et al. 1993), 6 and 12 months (Lundgren et al. 1999) in humans. The percentage BIC in this group (20–62%) falls within the range reported in various histological studies evaluating the implant interface in simultaneous implant placement in free autogenous bone grafts (Schliephake et al. 1991; Shirota et al. 1991; Lew et al. 1994; Schliephake & Aleyt 1998; Lundgren et al. 1999; Rasmusson et al. 1999b). However, it is difficult to associate these BIC values with a specific degree of implant stability. Although the percentage BIC has been correlated, at least partially, with implant stability through resonance frequency (Rasmusson et al. 1997, 1999b) and torque removal studies (Johansson & Albrektsson 1987), other parameters such as the biomechanical properties of the surrounding bone, i.e. type of bone, degree of maturation, and geometry, have been advocated as important contributors to the support of screw-shaped implants.

In conclusion, the results of this pilot study suggest that graft incorporation and implant osseointegration are not consistent findings following immediate transplantation of a titanium implant with its surrounding bone into a congruous osseous site. The lack of integration of the bone transplants can be attributed to factors such

as mechanical and thermal damage to the osseous tissue during core retrieval and/or recipient site preparation, inadequate fixation of the transplant into the recipient site, and structural characteristics of the graft. Clinical applications of such a procedure to transplant implants with their surrounding bone cores from intraoral sites with a sufficient amount of bone and/or highly dense bone quality to sites lacking bone volume or adequate bone density are to be considered experimental and require further investigation in animal models. Several questions also remain to be answered such as: (1) Is there a minimal amount of bone needed circumferentially around the implant to ensure a successful osseointegration and graft incorporation following immediate transplantation? (2) Is bone quality of the transplanted bone core and that at the recipient site crucial for the successful outcome of the procedure? (3) How long is the healing period necessary following transplantation and prior to implant prosthetic loading? (4) and finally, will implants transplanted with bone cores of high bone density maintain that same peri-implant bone quality when transplanted in sites with cancellous bone quality?

Résumé

Cette étude pilote expérimentale a été entreprise pour évaluer la guérison d'implants en titane transplantés avec l'os avoisinant dans des sites osseux receveurs de la mandibule du lapin. Un implant court a été inséré dans la portion horizontale de la mandibule chez dix lapins de Nouvelle-Zélande. Ensuite, durant la même session chirurgicale, l'implant entouré d'os de 1,5 à 2 mm a été enlevé à l'aide d'un trépan et immédiatement réimplanté dans une cavité de part en part préparée en contralatéral de la mandibule. Trois mois après la transplantation les animaux ont été tués et les mandibules préparées pour l'évaluation histologique. Le type de guérison a été évaluée vis-à vis de : 1) l'interaction entre l'os entourant l'implant et l'os au niveau du site receveur, 2) les différences de la densité osseuse entre le cylindre osseux transplanté et l'os aux bords du site receveur, 3) le contact os-implant (BIC) au niveau de l'interface. Le greffon était intégré dans le site receveur chez cinq des dix spécimens tandis que les cinq autres avaient subi une encapsulation fibreuse. Des types variés de résorption ont été observés à l'intérieur des tissus paroïmplantaires durs transplantés. Le pourcentage BIC était de 1 à 72 % chez les spécimens encapsulés par du tissu fibreux et entre 20 et 62% dans les implants intégrés. Dans les limites de cette étude pilote, les résultats suggèrent que la transplantation immédiate d'implants endo-osseux entouré par de l'os dans des sites osseux receveurs ne peut pas avoir une incorporation prévisible et une ostéoïntégration prévisible des implants. Cette modalité chirurgicale alternative de la transplantation immédiate d'un greffon os-implant depuis des sites intra ou extra oraux très corticaux pour augmenter la qualité osseuse et/ou son volume dans les sites receveurs de l'implant tels que le sinus maxillaire ou les tubérosités doit être davantage analysée.

Zusammenfassung

Diese experimentelle Pilotstudie wurde durchgeführt, um die Heilung von Implantaten, welche mit dem umgebenden Knochen in Empfängerstellen des Knochen von Kaninchenunterkiefern transplantiert wurden, zu untersuchen. Ein kurzes Implantat wurde in den horizontalen Anteil des Unterkiefers von 10 Neuseeland-Kaninchen eingesetzt. Während derselben Sitzung wurde das Implantat mit insgesamt 1.5–2 mm umgebenden Knochen mit einer Hohlfräse entfernt und sofort in ein durchgehendes Loch, welches auf der kontralateralen Seite des Unterkiefers präpariert wurde, eingesetzt. Drei Monate nach der Transplantation wurden die Tiere geopfert und die Unterkiefer wurden für die histologische Untersuchung aufgearbeitet. Das Heilungsmuster wurde ermittelt in Relation zu: (1) Knochenbrückenbildung bei der Berührungsfläche zwischen dem Knochenkern und dem umgebenden Empfängerknochengewebe; (2) Unterschiede in der Knochendichte zwischen dem transplantierten Knochenzylinder und dem Knochen an den Rändern der Empfängerstelle; (3) Knochen-Implantat-Kontakt (BIC) an der Berührungsfläche. Die transplantierten Knochen-Implantat-Kerne zeigten Integration in den Empfängerstellen bei 5 von 10 Präparaten, während die verbleibenden 5 Knochen-Implantat-Kerne eine fibröse Einkapselung zeigten. In den periimplantären transplantierten Hartgeweben konnten verschiedene Resorptionsmuster beobachtet werden. Der prozentuale BIC variierte zwischen 1% und 72% bei den Präparaten mit fibröser Einkapselung und zwischen 20% und 62% bei den integrierten Transplantaten. Innerhalb der Grenzen dieser Pilot-Studie lassen die Resultate vermuten, dass die sofortige Transplantation von enossalen Implantaten mit den umgebenden Knochengeweben in kongruente Empfängerstellen im Knochen nicht voraussagbar zur Integration des Transplantats und zur Osseointegration des Implantats führt. Diese alternative chirugische Vorgehensweise der sofortigen Transplantation eines zusammengesetzten Knochen-Implantat-Transplantats von intra- oder extraoralen Stellen mit viel kortikalem Knochen zur Verbesserung der Knochenqualität und/oder des Volumens bei den Implantatempfängerstellen wie etwa im Sinus maxillaris oder in der Tuberregion muss weiter erforscht werden.

Resumen

Este estudio piloto experimental se llevó a cabo para evaluar la cicatrización de implantes de titanio transplantados con el hueso circundante en lugares receptores óseos en la mandíbula del conejo. Se insertó un implante corto en la porción horizontal de la mandíbula de cada uno de 10 conejos de Nueva Zelanda. Seguidamente, y durante la misma sesión, se retiró el implante con 1.5–2.0 mm de hueso circundante con una fresa de trépano e inmediatamente transplantado en un orificio preparado a través del aspecto contralateral de la mandíbula. Tres meses tras el transplante, los animales se sacrificaron y las mandíbulas fueron procesadas para evaluación histológica. Se valoró el patrón de cicatrización en relación con: (1) formación de puentes óseos en la interfase entre el núcleo de hueso y el tejido óseo receptor circundante; (2) diferencias en la densidad ósea entre el cilindro de hueso transplantado y el hueso en los márgenes del lugar receptor; y (3) contacto hueso-implante (BIC) en la interfase. Los núcleos de injerto-implante transplantados se integraron en los lugares receptores en 5 de los 19 especímenes mientras que los restantes 5 núcleos de injerto-implante mostraron encapsulación fibrosa. Se observaron varios patrones de reabsorción dentro de los tejidos duros periimplantarios transplantados. El porcentaje de BIC varió entre el 1% y el 72% en los especimenes con encapsulación fibrosa y entre el 20% y el 62% en los transplantes integrados. Dentro de los limites de este estudio piloto, los resultados sugieren que el transplante inmediato de implantes endooseos con su hueso circundante en lugares congruentes de recepción no puede conducir predeciblemente a la incorporación injerto-implante y a la osteointegración de los implantes. Esta modalidad quirúrgica de transplante inmediato de un compuesto de injerto-implante de lugares altamente corticales intraorales o extraorales para realzar la calidad ósea y/o el volumen en lugares de recepción de implantes tales como el seno maxilar y las áreas de la tuberosidad necesitan ulteriores investigaciones.

要旨

この予備的実験研究では、家兎の下顎骨床に周囲骨と共に移植したチタン・インプラントの治癒を評価した。ニュージーランド・ラビット１０羽において、各々１本の短いインプラントを下顎の水平部分に埋入した。その後同じ術中に１．５～２．０ｍｍの周囲骨と共にインプラントをトレファン・バーによって切除し、即時に下顎反対側に形成したスルー・アンド・スルー型の穴に移植した。移植後３ヶ月後に動物を屠殺し、下顎骨を処理して組織学的評価を行った。治癒パターンは１）移植骨とその周囲の受給側骨組織との界面での骨架橋、２）円柱形の移植骨と、受給側辺縁骨の骨密度の違い及び３）界面での骨とインプラントの接触面積（ＢＩＣ）について評価した。１０コの標本のうち５コでは、移植骨－インプラントの複合体は受給部位において統合していたが、残りの５コでは骨－インプラントの複合体に線維組織が入りこんでいた。移植したインプラント周囲の硬組織内には、様々な吸収のパターンが認められた。線維組織に包みこまれた標本ではＢＩＣの比率は１％から７２％までの幅があり、統合した複合体では２０％から６２％までの幅があった。これらの結果は、この予備的研究の限界内において、骨内インプラントと周囲骨を、大きさが等しい受給側骨床に即時移植しても、移植骨－インプラントの結合とインプラントの骨性結合の予知性は高くないことを示唆している。上顎洞や上顎結節部などのインプラント埋入部位の骨質及び／あるいは骨量を増強するために、皮質骨の割合が高い口腔内または口腔外の部位から骨－インプラントの複合体を採取して、即時移植するという新しい術式には、さらなる研究が必要である。

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