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Histological assessment of augmented jaw bone utilizing a new collagen barrier membrane compared to a standard barrier membrane to protect a granular bone substitute material

A randomized clinical trial

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Abstract: Successful bone augmentation requires predictable space maintenance and adequate exclusion of those cells that lack osteogenetic potential from the defect area. Natural bone mineral is considered to be osteoconductive and is used as space maker in combination with membrane barrier techniques. The aim of this study was to compare qualitative histological results achieved by using deproteinized bovine bone mineral (DBBM) as a space maintainer and a new collagen barrier (Ossix™, test group) vs. the same bone substitute and the standard e-PTFE membrane (Gore-Tex®, control group). Twenty-eight patients were randomly assigned to the test or the control group. Seven months after augmentation procedures, biopsies were obtained at reentry and were analysed histomorphometrically. In all, 14 specimens of group I (test group, Ossix™) and 13 specimens of group II (controls, PTFE-membranes) showed close qualitative similarity of their histologies. Histomorphometrically, total mineralized bone area was 42% ± 18% in group I vs. 39% ± 15% in group II. The unmineralized tissue area was 44% ± 15% vs. 46% ± 12% and the area of DBBM remnants 14% ± 9% and 15% ± 12%, respectively. The differences were statistically nonsignificant (Mann–Whitney test). The occurrence of barrier exposure did not interfere with the histological outcome either in the test or in the control group. The new collagen barrier combined with the DBBM provided qualitative bone regeneration comparable to the standard e-PTFE material combined with the same mineral.

The application of the principle of guided bone regeneration (GBR) has proven to be successful in a number of controlled animal studies and clinical trials (Buser et al. 1996; Berglundh & Lindhe 1997; Fiorellini et al. 1998). The healing pattern has been shown to involve all steps of *de novo* bone formation including blood clot formation, invasion by osteoprogenitor cells, their differentiation into osteoblasts and the apposition of an extracellular matrix, consisting mainly of connective tissue which finally mineralizes to form woven bone and later is remodelled into lamellar bone (Hämmerle et al. 1998). The bone defects filled with blood only and effectively separated from the gingival soft tissue by a barrier have the capacity to generate new bone (Lang et al. 1994). However, in a human model Hämmerle et al. (1996) demonstrated that the blood clot tends to shrink during healing . Therefore, bone grafts or bone substitutes are used to reduce the defect volume, thereby stabilizing the blood clot and preventing the shrinking tendency. Furthermore, these materials maintain space by supporting membranes, thus preventing their collapse into a large defects (Buser et al. 1998; Hämmerle et al. 1998; Kohal et al. 1999).

Bone substitutes may be derived from natural materials of osseous or nonbony origin or from synthetically produced ceramics (Ouhayoun 1997). All these materials are different in their surface characteristics and show specific integration as well as degradation patterns within the augmented tissue (Guillemin et al. 1989; Berglundh & Lindhe 1997; Buser et al. 1998; Gauthier et al. 1999; Hall et al. 1999). Osteoconductivity index measurements reveal similar values for Deproteinized Bovine Bone Mineral (DBBM/Bio-Oss®–Geistlich Biomaterials, Baden-Baden, Germany) and autologous bone grafts (Berglundh & Lindhe 1997; Carmagnola et al. 2000). Remodelling and substitution of DBBM material in particular within the newly regenerated bone has been investigated in the animal studies by McAllister et al. (1999) and Araújo et al. (2001). No data are available showing how DBBM material performs in humans if applied as the only substitute without autologous bone additives.

The clinical outcome was reported to be enhanced, if substitute material was applied in combination with a membrane barrier (Kohal et al. 1998; Hockers et al. 1999). Expanded polytetrafluoroethylene (e-PTFE; e.g. Gore-Tex®–Membrane GTAM oval-6, Implant Innovations, Karlsruhe, Germany) is a nonresorbable bio-inert membrane material of choice in bone regeneration (Buser et al. 1996; Berglundh & Lindhe 1997; Fiorellini et al. 1998; Simion et al. 1999). However, the unpredictability of the results in cases associated with an inflammatory process caused by dehiscences of the soft tissues has frequently been reported (Lang et al. 1994; Nowzari & Slots 1995). Bacteria were shown to invade and, passing through the microporous structure of the e-PTFE material, to attack the generating tissue underneath the barrier (Wecke et al. 1995; Chen et al. 1997). The incidence of premature membrane exposure for e-PTFE material has been shown to be up to 50% (Strietzel 2000). The utilization of biodegradable barrier membranes resulted in an uneventful healing of the soft tissue, making the membrane retrieval unnecessary (Simion et al. 1997). Such degradable barriers in the form of collagen membranes [BioGide® (Geistlich Biomaterials, Baden-Baden, Germany) – porcine collagen type I and III barrier] have been tested in animal studies (Hockers et al. 1999) and found to be effective in bone regeneration in humans (Zitzmann et al. 1997). Although the wound healing appeared improved, the risk of an early degradation of the collagen remained, thus affecting the regenerating tissue and jeopardizing the success of augmentation (Zitzmann et al. 1997; Aaboe et al. 1998).

The purpose of the present study was to compare the effect of a new biodegradable barrier Ossix™ (ColBar R & D Ltd, Ramat Hasharon, Israel) to that of the Gore-Tex material on the quality of regenerated bone in lateral bone augmentation utilized with DBBM as bone substitute. The healing and remodelling processes were assessed histomorphometrically. The influence of the membrane exposure on the quality of the newly regenerated bone was analysed.

Material and methods

The study protocol was approved by the Ethics Committee of the Charité, Humboldt University Berlin (#949/98). The participants were patients referred to the clinic or from the pool of recall patients from the Department of Periodontology. Patients showing at least one edentulous area with an insufficient amount of bone laterally either in the maxilla or in the mandible and requiring an implant supported prosthetic rehabilitation were included. Each patient received printed information concerning the procedure and signed a written consent. In all, 28 partially edentulous patients entered the study and were randomly assigned for the test (group I) or the control group (group II) of 14 patients each. The mean age was 45 years, ranging between 22 and 65 years (Table 1).

The test group received a new bovine collagen type I barrier for bone regeneration – Ossix, while the control group was treated with e-PTFE material (Gore Tex). The two surgeons and the patient were advised of the randomization outcome during surgery, right before barrier application.

Exclusion criteria were systemic diseases; diabetes mellitus, pregnancy, lactation period, untreated periodontitis, smoking, noncompliance and poor oral hygiene.

The lateral bone augmentation was carried out prior to implant installation. The surgical protocol followed the guidelines established by Langer & Langer (1990) and Buser et al. (1995). According to their recommendations, midcrestal incisions in the mandible and paracrestal palatal incisions in the maxilla were performed prior to the elevation of a full thickness flap. Releasing incisions were positioned in the apical angle of the adjacent teeth. The defects were filled laterally with DBBM after small perforations of the cortical bone to ensure bleeding from the cancellous bone (BioOss, cancellous granules 0.25–1.0 mm in size). The DBBM particles were enriched with patient's own venous blood prior to application.

The new collagen barrier membrane provided enough rigidity to be bend around the augmented zone of the alveolar crest without an additional stabilization, whereas the control membranes were secured on the crestal bone by titanium tacks (Friatec, Mannheim, Germany) to prevent micromovements. By horizontally releasing the periosteum, the complete coverage of the elevated flaps was achieved with tension free sutures (Silk 3.0, Resorba, Nürnberg Germany; Dexon 5.0, Braun, Spangenberg, Germany). The postoperative

Table 1. **Comprehensive data of group I and group II patients**

Group	Age (years)		Indication[1] (*n*)		Area (*n*)		Rate of Exposures (total *n* at week...)	
	Mean	Range	Maxilla	Mandible	Anterior	Posterior		
							Week 2	Week 4
Test (I)	44.9 ± 13.5	22–65	SG – 3 ES – 1 –	SG – 3 ES – 2 DE – 5	5	9	9	2
							Week 1–3	Week >3
Control (II)	41.2 ± 13.1	20–66	SG – 3 – DE – 1	SG – 4 ES – 4 DE – 2	3	11	7	10

[1]SG = Single Gap; ES = Edentulous Space; DE = Distal Extension.

regimen included Amoxicillin 750 mg 3 × a day for 7 days (Cephoral 1000 mg 2 × a day in cases of allergy), Ibuprofen 400 4 × a day for 5 days and 0.12% chlorhexidine mouthrinses 2 × a day for 14 days. The sutures were removed 2 weeks after surgery. Patients were reexamined at week 1, 2 and 4 and at months 3 and 6 after the augmentation treatment. Patients exhibiting a dehiscence of the soft tissue were instructed to use chlorhexidine gel 3 × a day at the exposed areas and were reexamined regularly. If the inflammatory process went on showing exudative activity, the premature retrieval of the exposed barrier was scheduled. The reentry procedure combined with the implant installation was carried out 7 months after the augmentation. The flap design was repeated and a hollow cylinder bur (Straumann, Freiburg, Germany) was used to prepare the implantation site by obtaining biopsies from the augmented area. Solid titanium plasma-sprayed implants (ITI, Straumann) were installed according to the ITI protocol. A total number of 50 implants was installed, 13 of them as single tooth implants and the others aiming at supporting fixed partial dentures.

Histology

The samples obtained were immediately fixed in 4% buffered formalin for 2 weeks. The biopsies were decalcified in EDTA, dehydrated in serial steps of ethanol and embedded in paraffin. If more than one biopsy per patient was available, the remaining biopsies were embedded undecalcified using Technovit 9100new (Kulzer, Bensheim, Germany) and semithin sections (5 µm) were prepared using a hard tissue microtome (Polycut, Leica, Germany). These sections were stained with Toluidine-Blue, Masson–Goldner and Kossa–Goldner stains.

Sections from the paraffin blocks were obtained by a sledge microtome (Leitz, Bensheim, Germany). The decalcified sections were routinely stained in Hematoxylin-Eosin and Mallory trichrome (Fig. 1) and were histomorphometrically analysed.

Histomorphometric analysis and statistics

Histomorphometric analyses were performed with a Leitz DM-RXE® microscope (Zeiss) equipped with an image system KS 400® (Zeiss). The various tissue components were expressed in percentage of the total area of the biopsy. The total biopsy area was split into Bone Area, which included mineralized tissue (BnAr); Tissue Area – the proportion of the fibrous tissue, the fatty cell compound included as well as the vascular compound (TiAr); and the area occupied by remnants of DBBM particles (DBBMAr).

The distribution of the mean values was tested by the graphic analysis (Q-Q-Plot) and the Kolmogorov–Smirnov Test. The statistical analyses were performed after the distribution of values was known. Due to the small sample size the Wilcoxon and the Mann–Whitney tests for paired comparison were used to estimate the differences between the mean values in the test and the control groups. The correlation values between different parameters were estimated by the cross table analysis calculating the association coefficients for the nominal scaled parameters (ψ, Cramer-V, Contingency Coefficient, Uncertainty Coefficient, Chi square test). The statistical calculations were carried out with the SPSS 9.0 software (SPSS 9.0 for Windows, SPSS Inc., Chicago, IL, USA).

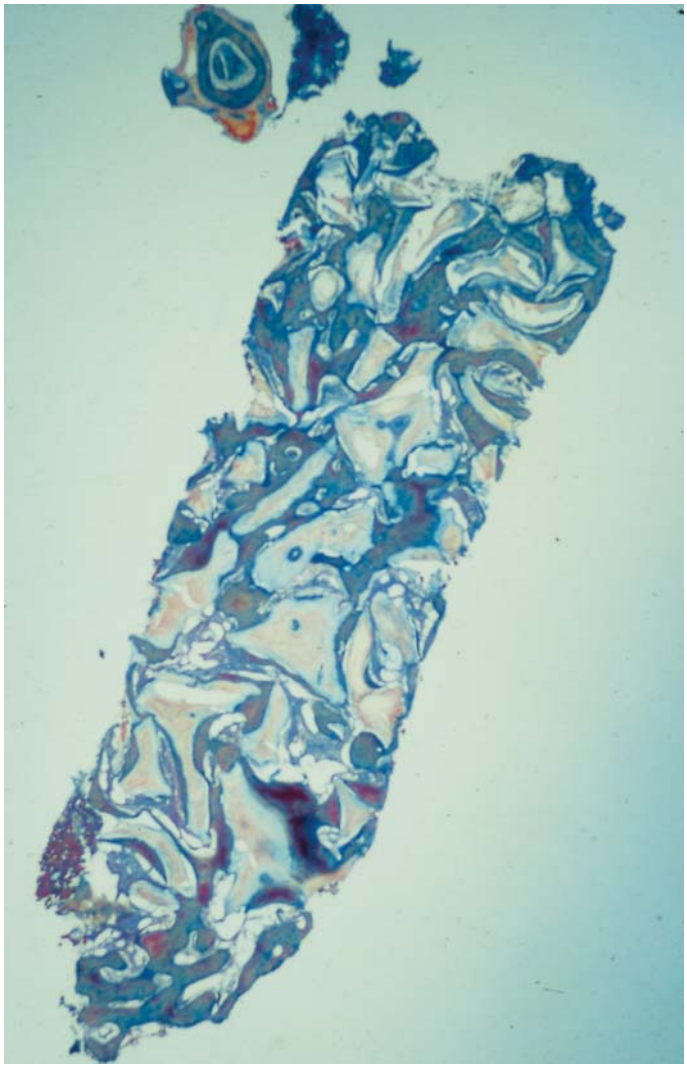

Fig. 1. A decalcified Mallory trichrome stained section from a test group specimen gives an overview of the biopsy at the 5-fold magnification.

Results

All 28 patients completed the study. The healing in the test and in the control group proceeded in different patterns during the 7 months post augmentation.

In the test group (groupI) five out of 14 sites healed uneventfully. In nine patients dehiscences occurred within the first 14 postoperative days, prior to or during su-

ture removal. Within the following 30 days, i.e. within 4 weeks after the suture removal, the healing by secondary epithelization was completed in all nine exposed sites. In one patient the entire exposed area was completely covered by new gingiva but some DBBM granules were partially exfoliated. However, this case was considered completely closed, as there was no exposed membrane surface detectable after 4 weeks. Whereas the majority of the dehiscences (7 sites) showed a completed soft tissue healing within 2 weeks after suture removal, two barriers remained exposed at the 4-week postsurgery examination (Table 1). However, at the 6-week appointment, these two demonstrated a completely closed new gingiva. Neither the soft tissues nor the barriers showed any clinically signs of inflammation or degradation, nor were signs of swelling, redness or exudation visible during the whole period of exposure. The incidence of the soft tissue dehiscences was 64% after the initial healing phase. Nevertheless, all 14 sites showed an improved volume and shape of the alveolar crest at the reentry 7 months later and 14 biopsies were obtained for histomorphometry.

No significant association was detected between the 'dehiscence' and the implant region (anterior or posterior region, $P = 0.726$); the 'dehiscence' and the indication group (single gap, edentulous space, distal extension, $P = 0.699$); the 'dehiscence' and the gender ($P = 0.33$); or the dehiscence and age ($P = 0.383$). The size of dehiscence did not correlate either with the site of implantation ($P = 0.179$) or with patient's age ($P = 0.372$).

In the control group (II) four out of 14 sites healed uneventfully, the other 10 sites experienced the barrier exposure either during the initial healing phase or later within the 7-month trial. The frequency of the premature barrier exposure resulted in 71% for the controls (Table 1). If a dehiscence occurred, attempts were made to keep the barrier free of an inflammatory reaction by application of antimicrobial chemicals (chlorhexidine). As soon as any signs of suppuration became evident, the barriers were removed, which caused an additional 10 surgical interventions. Though the infection and the inflammatory reaction reduced the volume of the augmented area in the exposed sites, 13 sites showed improved dimensions at the reentry and 13 biopsies were obtained. One site was a total failure due to infection and had to be reaugmented at reentry surgery.

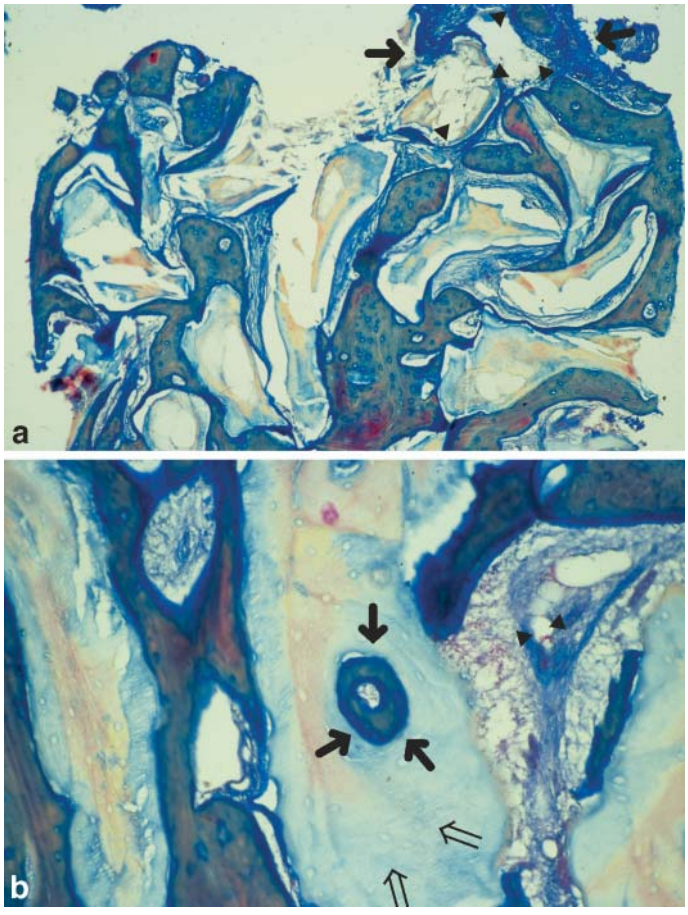

Fig. 2. The test group specimens showed almost complete integration of DBBM remnants into newly formed already remodelled bone with secondary osteons and some osteblasts along the particles. (a) The coronal part of the section is characterized by some connective tissue (long arrows), which partially covers single DBBM remnants (black triangles), ×16. (b) The mineralization activity within the DBBM particle – hollow arrows – (osteon formation in the centre – short black arrows) is accompanied by high vascularization of the fibrous tissue (black triangles) ×50. (a and b are fragments of Fig. 1).

Histology

The histological analysis revealed a close similarity in the composition of the specimens in the test and in the control group as demonstrated in Figs 2a and 3a. One patient in each group showed lack of mineralization after 7 months, despite the fact that the membrane healing proceeded in both without dehiscences.

The newly formed bone showed primary osteons with narrow vascular canals and secondary osteons with characteristic cement lines. The remnants of the DBBM particles were completely integrated into thick trabeculae of lamellar bone with some remnants of primary woven bone. The trabeculae consisted of different generations of lamellar bone, divided by cementum lines, indicating the ongoing remodelling process. The orientation of the trabeculae was circumferential around the DBBM material, demonstrating the parallel fibre bone structure (Figs 2b and 3b).

The DBBM remnants varied in shape according to their location; nondegraded granulae were located in the most coronal parts of the sections, close to the barrier surface. Small round degraded DBBM particles, embedded in fibrous tissue, were related to the apical zones of the biopsies. Small capillaries were frequently observed among these degraded particles.

The lining cells distributed along the margins of the DBBM particles, the zones of mineralization activity within the remnants, the multinuclear and the osteoclast-like cells in the resorption pitts on the DBBM surfaces suggested an ongoing pro-

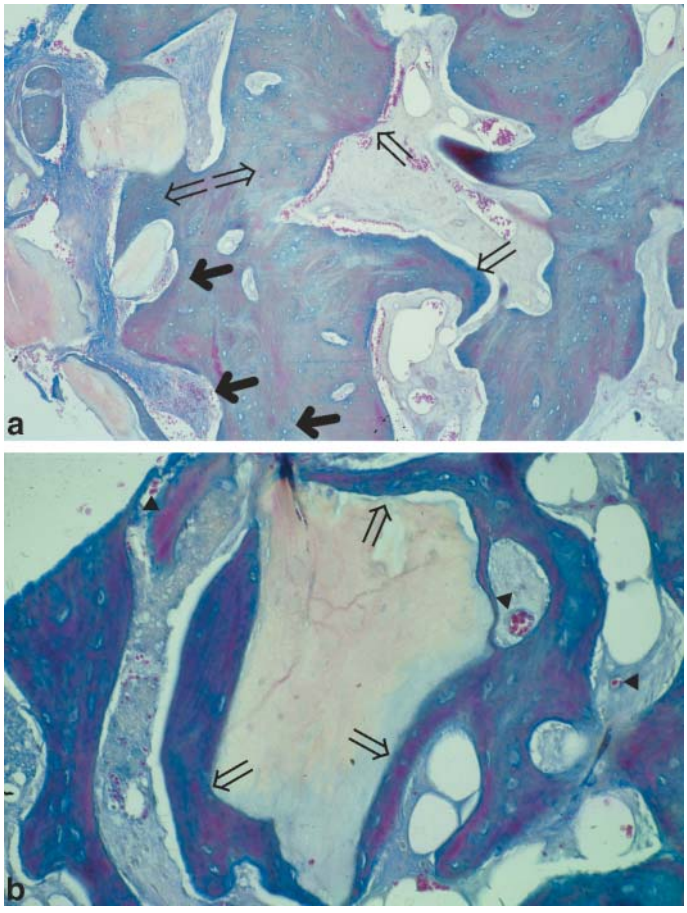

Fig. 3. Decalcified, Mallory-stained sections from the control group reveal similar composition of the tissues as the tests. (a) The coronal part of the section shows some DBBM material partially integrated into the supracrestal connective tissue layer (hollow arrows). The arrows indicate the transition from supracrestal tissue to the osseous crest (short black arrows) and some DBBM particles (hollow arrows) totally integrated into the newly formed bone. (×16). (b) The mineralization activity inside the lamellar bone structures is indicated by reddish coloured zones, whereas no activity is detectable inside the DBBM particle. However, it is embedded in the new bone and the vascularization of fibrous tissue compound is comparable to that in the test group – (Fig. 2a + b) black triangles (×50).

cess of the graft substitution by the new bone. The unmineralized tissue consisted of collagen fibres, fatty cells, vessels and DBBM remnants in both groups.

Morphometric results

The results of the histomorphometrical analysis shown in Fig. 4 revealed no statistically significant differences in the composition of the biopsies from the test and the control group (Mann–Whitney test for paired comparison). The compartment of the mineralized bone area in the test group was 42% (SD 18%) vs. 39% (SD 15%) in the control group. Unmineralized tissue area was 44% (SD 15%) vs. 46% (SD 12%) and the compartment of the remaining DBBM material was 14% (SD 9%) vs. 15% (SD 12%) (Fig. 4).

No significant correlations were found between the occurrence of a membrane dehiscence and the amount of new bone in the biopsies ($P = 0.409$, Chi-Square Test).

Discussion

The lateral augmentation of the alveolar ridge was successful in all patients in both groups except for one expected failure in the control group. The dehiscences which occurred in the test group showed a complete healing by new gingiva within 4 weeks after suture removal. Studies on bacterial adherence to barrier materials utilized in GTR failed to show significant differences in the bacterial colonization of different barriers (Wang et al. 1994; Chen et al. 1997; Sela et al. 1999). It is conceivable that the dehisced areas were exposed to the oral bacteria and their collagenolytic enzymes. However, the new cross-linked collagen barrier utilized in the present study might have a pronounced capacity to withstand those collagenases. In conclusion to their research work on the use of resorbable barriers in the GBR procedure many authors desired a longer lasting barrier effect, which would improve the outcome (Lundgren et al. 1994; Simion et al. 1997). The stability of the new collagen barrier over a period of 6 months was demonstrated by our group in a clinical case series (Friedmann et al. 2001).

The dehiscences which occurred in the control group were followed by premature retrieval of the e-PTFE membranes as none of these dehiscences showed any healing tendency. In one patient the infection caused severe inflammation and the generated tissues had to be removed totally at the barrier retrieval surgery. This is in agreement with the results from previous studies on exposed e-PTFE material (Lang et al. 1994; Nowzari & Slots 1995). The composition and the quality of the new bone were not affected by the phenomenon of exposure either in the test or in the control group. In the specimens obtained, no signs of any inflammatory reaction were detected histologically after the 7 months of healing. Neither the unmineralized compartment nor the area of the grafting material remnants revealed presence of the giant cells. The patients with the infected barriers were reexamined weekly and barriers were retrieved as soon as the first signs of suppuration became visible. This strict protocol may explain the good histological outcome.

The amount of the new mineralized bone in the present study was 39% (test) and 42% (control), respectively. Various differently designed animal studies assessed the composition of the new augmented bone under the use of biomaterials. In a recently published study the proportion of the mineralized bone around the DBBM material was 43.5% in a beagle dog model (Araújo et al. 2001). Other investigators reported that the proportion of the new bone was 20.3% (Hockers et al. 1999), 30% (Hämmerle et al. 1998) and 62%

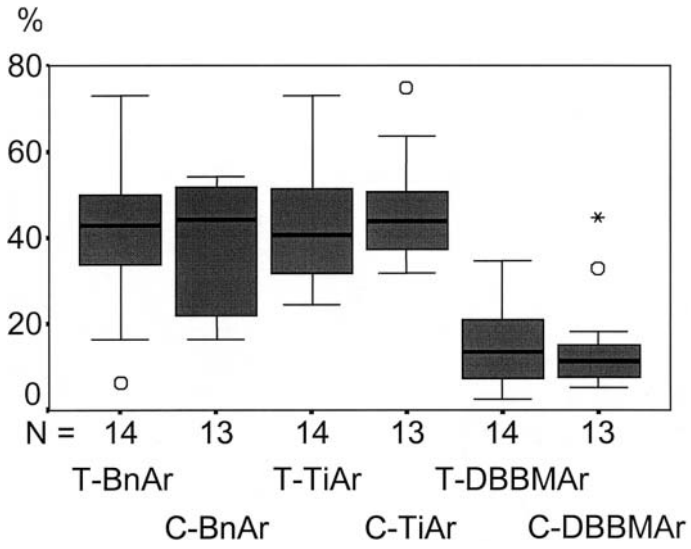

Fig. 4. The distribution of the compounds of Bone area (BnAr), Tissue area (TiAr) and DBBM remnants (DBBMAr) in the test (T) and in the control groups (C); the symbols indicate the statistical outliers

(McAllister et al. 1999) in the animal experiments utilizing DBBM and a membrane barrier. Bone substitutes of different origin tested in mechanically created defects revealed bone formation rates of 53.9% for the autologous grafts and of 49% for the hydroxyl apatite filled defects in a minipig model (Buser et al. 1998).

In our study the graft material (DBBM) remained in 15% in the test and 14% of the area in the control group. Hämmerle et al. (1998) found 13% DBBM remnants in defects that healed without a membrane and 21% in defects covered by a membrane. The bone substitute area was 19% after 7.5 months in DBBM grafted sinuses and was reduced to 6% 7.5 months later in a monkey study (McAllister et al. 1999). In a dog experiment the graft area was reduced from 17.1% after 3–10.8% after 7 months of healing (Berglundh & Lindhe 1997). Araújo et al. (2001) found 14.8% of an unloaded area occupied by remnants of DBBM 1 year after the grafting procedure in another dog study. The pattern of distribution of the DBBM material used alone for grafting of the alveolar defects in humans has yet not been investigated. Though the findings from the animal experiments are hardly comparable to the clinic situation, the data of the presented study showed close similarity in the composition of the new regenerated bone to those reported previously. The lining cells and the multinuclear cells which were found in the resorption lacunae probably indicated an ongoing degradation and a substitution of DBBM guided by the osteoclasts.

In our results we could not find a statistically significant difference in the composition of new bone between the test and the control group. The occurrence of membrane dehiscences in the test group was not detrimental to the bone quality at the reentry after 7 months of completed healing. The quality of the regenerated bone in the controls did not interfere with membrane exposure. However, the exposed control barriers had to be removed at an additional surgery, while the test barriers did not show any signs of an inflammation if dehiscences occurred. The latter presented rather an uneventful delayed pattern of gingival healing.

Conclusions

The new collagen barrier Ossix was suitable for the technique of guided bone regeneration and, utilized in combination with the natural bone mineral, provided highly predictable healing pattern and augmentation success. The results were comparable to those achieved using the combination DBBM/e-PTFE. In cases of barrier exposure the test barrier presented beneficial characteristics, remaining stable and nondegradable during a period of exposure. In conclusion: the Ossix barrier seemed an appropriate alternative to the Gore-Tex material. According to histomorphometric data, DBBM is suitable as bone substitute material alone, without addition of autologous bone particles.

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Résumé

L'épaississement osseux réussi demande un maintien de l'espace prévu et une exclusion adéquate des cellules qui n'ont pas de potentiel ostéogénique de la zone de la lésion. Le minéral osseux naturel est considéré comme ostéoconductif et est utilisé comme marqueur d'espace en association avec les techniques de membrane barrière. Le but de cette étude a été de comparer les résultats histologiques quantitatifs obtenus en utilisant du minéral osseux bovin déprotéiné (DBBM) en tant que mainteneur d'espace et une nouvelle membrane collagène (Ossix*TM*, groupe test) Vs le même substitut osseux et une membrane standard en téflon (Gore-Tex®, groupe contrôle). Vingt-huit patients ont été répartis au hasard entre groupes test et contrôle. Sept mois après ces processus d'épaississement osseux des biopsies ont été prélevées lors de la chirurgie de réentrée et analysées histomorphométriquement. Quatorze échantillons du groupe test et treize du groupe contrôle ont montré des similitudes qualitatives très proches au niveau des biopsies. Histomorphométriquement, la zone osseuse minéralisée totale était de 42±18% dans le groupe test Vs 39±15% dans le groupe contrôle. La zone de tissu non-minéralisé était respectivement de 44±15% Vs 46%±12% et celle avec des restes de DBBM était de 14±9% et 15±12%. Ces différences n'étaient pas statistiquement significatives (test de Mann-Whitney). Dans les deux groupes l'exposition de la membrane barrière n'interférait pas avec le résultat histologique dans les deux groupes. La nouvelle barrière collagène combinée au DBBM s'accompagne d'une regénération osseuse qualitative comparable à celle obtenue par la membrane en teflon associée à ce même DBBM.

Zusammenfassung

Für die erfolgreiche Knochenaugmentation ist der Erhalt eines Hohlraumes und ein adäquater Ausschluss der Zellen, welche kein osteogenetisches Potential besitzen, aus dem Defektareal erforderlich. Natürliches Knochenmineral ist osteokonduktiv und wird als Stützmaterial in Kombination mit der Membrantechik verwendet. Das Ziel dieser Studie war, qualitative histologische Resulta-

te, welche mit deproteiniertem bovinem Knochenmineral (DBBM) als Platzhalter und einer neuen Kollagenmembran (OssixÖ, Testgruppe) erreicht werden, mit demselben Knochenersatzmaterial und einer Standard e-PTFE-Membran (GoreTex®, Kontrollgruppe) zu vergleichen. Achtundzwanzig Patienten wurden zufällig der Test- oder Kontrollgruppe zugeteilt. Sieben Monate nach der Augmentation wurden bei der Wiedereröffnung Biopsien entnommen und histomorphometrisch analysiert. Vierzehn Präparate der Gruppe I (Testgruppe, OssixÖ) und 13 Präparate der Gruppe II (Kontrolle, PTFE-Membran) zeigten sehr grosse Aehnlichkeit in der Histologie. Histomorphometrisch betrug das totale Areal mit mineralisiertem Knochen 42%+/-18% bei Gruppe I gegenüber 39%+/-15% in Gruppe II. Das Areal mit unmineralisiertem Gewebe betrug 44%+/-15% gegenüber 46%+/-12% und das Areal mit DBBM-Ueberresten betrug 14%+/-9% bzw. 15%+/-12%. Die Unterschiede waren statistisch nicht signifikant (Mann-Whitney-Test). Das Auftreten von Membranexpositionen beeinträchtigte weder bei der Test- noch bei der Kontrollgruppe das histologische Resultat. Die neue Kollagenmembran in Kombination mit DBBM lieferte eine qualitative Knochenregeneration, welche mit der Regeneration mittels einer Standard e-PTFE-Membran in Kombination mit demselben Mineral vergleichbar ist.

Resumen

El éxito en el aumento de hueso requiere un mantenimiento predecible del espacio y una adecuada exclusión del área del defecto de aquellas células que carecen de potencial osteogénico. Se considera que el mineral óseo natural es osteoconductivo y se usa como mantenedor de espacio en combinación con técnicas de barrera de membrana. La intención de este estudio fue comparar los resultados histológicos cualitativos logrados usando mineral de hueso bovino desproteinizado (DBBM) y una nueva barrera de colágeno (Ossix™, grupo de prueba) frente al mismo sustituto óseo y la membrana de e-PTFE (Gore-Tex®, grupo de control). Se asignaron veintiocho pacientes aleatoriamente a los grupos de prueba o de control. Siete meses tras el aumento se obtuvieron biopsias a la reentrada analizándose histomorfometricamente. Catorce especimenes del grupo I (grupo de prueba, Ossix™) y 13 especimenes del grupo II (control, membranas-PTFE) mostraron similitudes cualitativas de sus histologías. Histomorfometricamente, el área ósea totalmente mineralizada fue del 42%±18% en el grupo I frente al 39%±15% en el grupo II. El área de tejido no mineralizado fue del 44%±15% frente al 46%±12% y el área de remanentes de DBBM fue del 14%±9% y 15%±12%, respectivamente. Las diferencias fueron estadísticamente no significativas (test de Mann-Whitney). La aparición de una exposición de la barrera no interfirió con los resultados histológicos tanto en el grupo de prueba como en el de control. La nueva barrera de colágeno combinada con el DBBM suministró una regeneración ósea cualitativa comparable al material estándar de e-PTFE combinado con el mismo mineral.

要旨

骨増多術の成功には、空隙を維持する事と骨形成能を欠く細胞を欠損部から適切に排除する事が必要である。天然の骨ミネラルは骨伝導性を有すると考えられており、スペース・メーカーとしてメンブレンバリヤー・テクニックと併用されている。本研究では、脱蛋白牛骨ミネラル（DBBM）をスペース・メンテナーとして使い、新しいコラーゲン・バリヤー(Ossix™、試験群)を併用した場合と、同じ骨材料と標準の e-PTFE メンブレン(GoreTex®、対照群)を併用した場合の結果を定性的、組織学的に比較した。

２８名の患者を無作為に試験群か対照群に割り振った。増多術７ヶ月後の二次手術時に組織生検を行い、組織形態計測によって分析した。

グループ１（試験群 Ossix™）の１４の標本、グループ２（対照群 PTFE メンブレン）の１３の標本は、組織学的に高い定性的な類似性を示した。組織形態計測では、石灰化した骨総面積はグループ１が４２％±１８％、グループ２は３９％±１５％であった。非石灰化組織の面積は各々４４％±１５％と、４６％±１２％であり、DBBM 残渣面積は各々１４％±９％と１５％±１２％であった。両群の差は統計学的に有意ではなかった（Mann-Whitney テスト）。試験群でも対照群でも、バリヤーの露出によって、組織学的結果は損なわれなかった。DBBM と新しいコラーゲン・バリヤーの併用は、同骨ミネラルと標準の e-PTFE 材料の併用に匹敵する定性的な骨再生を達成した。

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