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HETEROLOGOUS TRANSPLANTATION WITH KIEL BONE

An Experimental and Clinical Study

By

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Kieler-Knochen Span, or Kiel Bone, is a material for transplants that was evolved at the University Surgical Department at Kiel. It has been used since autumn, 1962, in clinical work at the Department of Orthopaedics, the University of Umeå, and an account is given in this article of our experience of it to date.

Owing to the difficulty of obtaining an ideal control group, clinical and radiologic evaluations based on a limited number of transplant cases are unreliable, and for this reason the study was extended to include a series of experiments on the dog; this also provided an opportunity to evaluate the studies on which the preparation of Kiel Bone is based. Finally, a comparison of Kiel Bone with autologous and homologous banked bone was made on a small number of human subjects, using the same method as in the dog.

LITERATURE

Comprehensive historical surveys and reviews of the literature on bone transplantation have been published in papers by *Chase & Herndon* (1955) and *Bauermeister* (1958). In the original sense of the term "transplantation", namely the transfer of living tissue to continue its life in a new environment, only autologous transplantation is strictly possible, for homologous and heterologous grafts set up a reaction in the host tissue, in consequence of which they die and are either sloughed or absorbed. In the case of certain tissues, such as bone, this reaction takes place so slowly that there is time for absorption and replacement

by cells of the host tissue, and the transplant can fulfil certain simple mechanical functions. It is thus no disadvantage if the homo- and heteroplants are dead when they are inserted; on the contrary, some degree of denaturation—for instance by freeze-drying—has even been considered to be to the good.

The above-mentioned authors and a number of others, including *Maatz, Lentz & Graf* (1954), *Enneking* (1962), *Bonfiglio* (1958), *Nilsonne* (1963) and *Burwell* (1964), consider that the chance of incorporation is best for autoplants, followed by homoplants and then heteroplants. In a dissertation published in 1954 and a revision of it in 1959 Bauermeister (at the Kiel Surgical Department) has reported the experiments that led to the introduction of Kiel Bone. He used a "spongiosa test" published by *Maatz et al.* (1954) in which small plugs of cancellous bone to be tested or compared are transplanted side by side in the spongiosa of the dog. Evidence of incorporation will usually be present after 2 weeks. In over 300 experiments Bauermeister used this technique for comparing auto-, homo-, and heterologous transplants and those of bone treated in some 20 different ways. The experiments included heterotopic transplantation in the back muscle of the dog and tests of mechanical strength. On the properties of the tested material Bauermeister reached the following conclusions: the rate of healing is greatly dependent on the surface area per unit volume bone; fine-meshed cancellous bone is in this respect better than coarse cancellous or compact bone; the age of the donor is important; bone from newborn takes one third to one half the time required for that from adults. Too thorough removal of proteins in the bone by, for instance, heating in an open flame or boiling with solvents greatly reduces the strength of the material.

On the basis of this experience Kiel Bone is prepared in the following manner. Bone from calves or pigs a few weeks old is cleaned coarsely and sawn into standardized pieces of compact or cancellous bone suitable for surgical use. These are treated for 48 hours with 20 per cent hydrogen peroxide at 37°. After washing in water for one day and drying, the fat is removed and the pieces are sterilized in ether or acetone vapour for 15–24 hours.

Bauermeister claims that this material approaches, and is in some respects even superior to, autologous bone as regards the osteogenic activity in cancellous plugs, and that in any case it is superior to homoplants. It compares with fresh bone in strength and has no antigenic properties. Summarizing his assessment of the various types as

transplant materials he accords fresh autologous bone first place, followed in turn by Kiel Bone, banked homologous, fresh homologous and fresh heterologous bone.

The treatment with hydrogen peroxide would seem to reduce the antigenic properties of the proteins by oxidizing the side chains in the amino acids. This results in a change in the secondary and the, in this context, important tertiary structure (*Paul*, 1964).

In chemical analysis of cancellous Kiel Bone we have found a fat content of 3.5 per cent on extraction by Soxhlet's method (2 hours in petroleum ether and 2 hours in ethanol). Though Bauermeister does not specify the protein content of Kiel Bone it is obvious that he considers it to be extremely low.

On subjecting Kiel Bone to x-ray crystallographic examinations after decalcification *Gattow & Mühzenberg* (1963) found close similarities to pure collagen, and they consider that the material is not deprived of protein to any large extent. *Fuchs et al.* (1963) reached the same conclusion by chemical analysis. However, they also verified Bauermeister's results regarding the callus-forming properties of Kiel Bone, which they found quite comparable with those of autoplants.

From the several reports of clinical results published in recent years it is evident that Kiel Bone is in general use at many of the larger surgical and orthopaedic departments in Germany. From 7 of these, 705 cases have been compiled (Kiel [*Bauermeister* 1961, *Lubinus* 1963], Berlin [*Maatz* 1963, *Koch & Dahmen* 1962] and Heidelberg [*Hopf*]). Most of the indications for bone transplantation are represented here.

The material has been variously assessed. Hopf recorded failures in no less than 44 per cent of 142 cases, 20 per cent of them through infection. As a rule, however, the figures are considerably more favourable, with a mean proportion of failures of 18 per cent. Among the good results are those reported by Popkirov, who obtained primary healing in 20 and secondary healing in 4 cases of chronic osteomyelitis (22 cases) and tuberculous osteitis (2 cases); Lubinus obtained good results in all 19 cases of intercorporal fusion operations in the lumbar spine.

In a recent paper on the indications and contra-indications of the use of Kiel Bone, *Williams* (1964) reports the application of this material for compact grafts in 7 cases of non-union of the tibia and 1 of the femur. He infers from his results that Kiel Bone is a very useful substance in the armamentarium of the orthopaedic and traumatic surgeon.

SPONGIOSA TEST ON THE DOG

Using the method evolved by *Maatz et al.* (1954) we have compared fresh autologous bone, homologous banked bone and Kiel cancellous bone in experiments on the dog.

Five animals weighing 23–26 kg were used. After anaesthetizing with Nembutal the crests of both ilia and both tubera ischii were exposed and at each site 3 holes were cut with a thin-walled cylindrical drill of 4 mm internal diameter. Each hole was filled with a plug of cancellous bone removed with the same drill, and the autologous, homologous and Kiel bone were always placed in the same order. The muscles and skin were closed and after an interval of 2–6 weeks the part of the bone containing the 3 plugs was removed and sawn straight through the plugs, perpendicular to their axes. One half was fixed in absolute alcohol for the preparation of ground sections for microradiography, and the other was fixed in formaldehyde for the usual histologic examination after decalcification. Altogether 60 plugs were placed. In all cases the homologous bone was taken from the preceding dog in the series and preserved at —20° for 4–15 days. There was no evidence of infection of the wound or other complications.

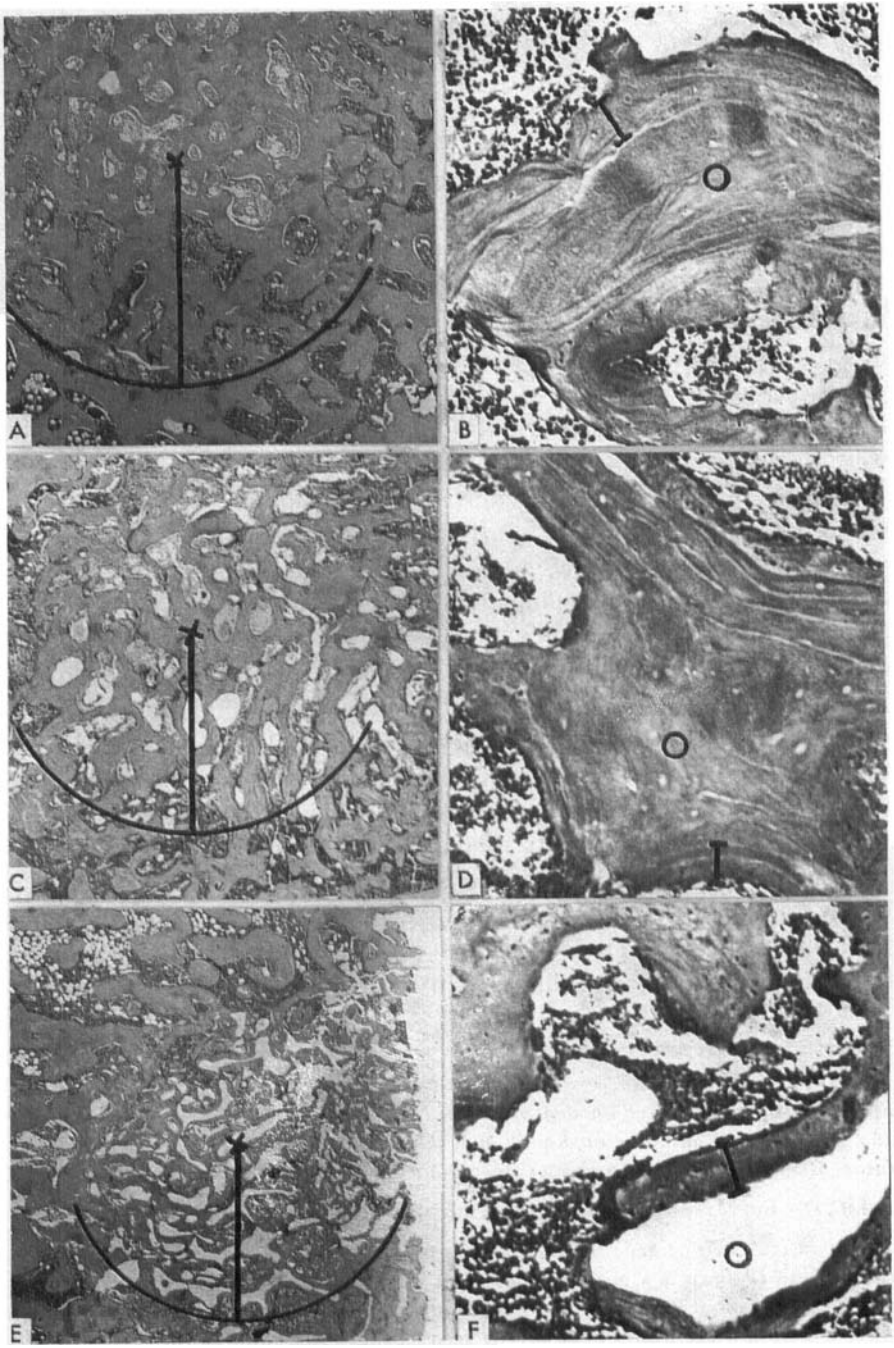
For the routine histological examination the section were stained by the eosin—haematoxylin, van Gieson and McManus PAS methods. The following criteria of healing were examined.

1. Callous formation between the plug and the host spongiosa.
2. The progress of the formation of new bone from the periphery of the plug towards the centre.
3. The intensity of the creeping substitution.
4. The degree of inflammation and any sloughing reaction.
5. Any fibrous encapsulation—a sign of poor healing.

Figure 1. Spongiosa test on the dog after 18. days. Haemotoxylin-eosin stain. *A,C,E.*—Survey pictures (*ca.* × 10). *B,D,F, ca.* × 100.

Cross-section of the test plugs (*cf.* Figure 2). The cross marks the centres. The line represents the radius of the cross-section and the arc a part of its periphery, that is, the border between the transplant and the host tissue.

A, B Autoplants. *C, D* Homoplants. *E, F* Kiel Bone.
B and *D* show the non-vital autto- and homoplant trabeculae (○), in the periphery of which creeping substitution is occurring, with osteoblasts and a zone of new vital bone (|—|). In *F* the Kiel trabeculae were lost during preparation, leaving a cavity (○)around which bone formed (|—|). The small circle indicates the centre of the non-vital trabeculae. |—| denotes the width of the zone of new vital bone.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All 12 plugs in the specimens removed after *two weeks* were found and identified. In one slide the Kiel plug was in contact with the compact bone, where periosteal bone formation complicated the evaluation. All the transplants had healed, and there was intense callus formation, which had also reached the centre of the plugs. All the trabeculae of the transplants were devoid of stainable cell nuclei but were surrounded by zones of vital new bone—creeping substitution—with active osteoblast zones and distinct osteocytes; osteoclasts were numerous. In the Kiel plugs the dead trabeculae were more or less dissolved (an effect of decalcification) and were sometimes entirely absent. Osteogenesis was, however, as good as in the auto- and homoplants; nor was there any fundamental difference between the three types as regards healing or inflammatory granulation tissue. There were no signs of sloughing or encapsulation.

In 2 of the 4 specimens removed after *18 days* the various plugs could not be identified with confidence, but in the other 2 all the plugs were easily recognized (Figure 1). Here, too, bone formation had reached the centre of the plugs, with creeping substitution of the dead trabeculae of the transplants. In the Kiel plugs these had been partly dissolved during the decalcification, just as in the two-week specimens. In one dog osteogenesis was slightly more intense in the autologous plug than in the other 2, and in another animal the same applied to the Kiel graft. By and large, however, there was little to choose between the 3 materials as regards the properties under consideration, and none of the transplants displayed any evidence of sloughing.

One of the *three-week specimens* could not be evaluated with certainty. In one of the others all 3 plugs exhibited sparser bone formation towards the centre. The zones of new bone around the trabeculae of the transplant were possibly slightly narrower in one of the homo-

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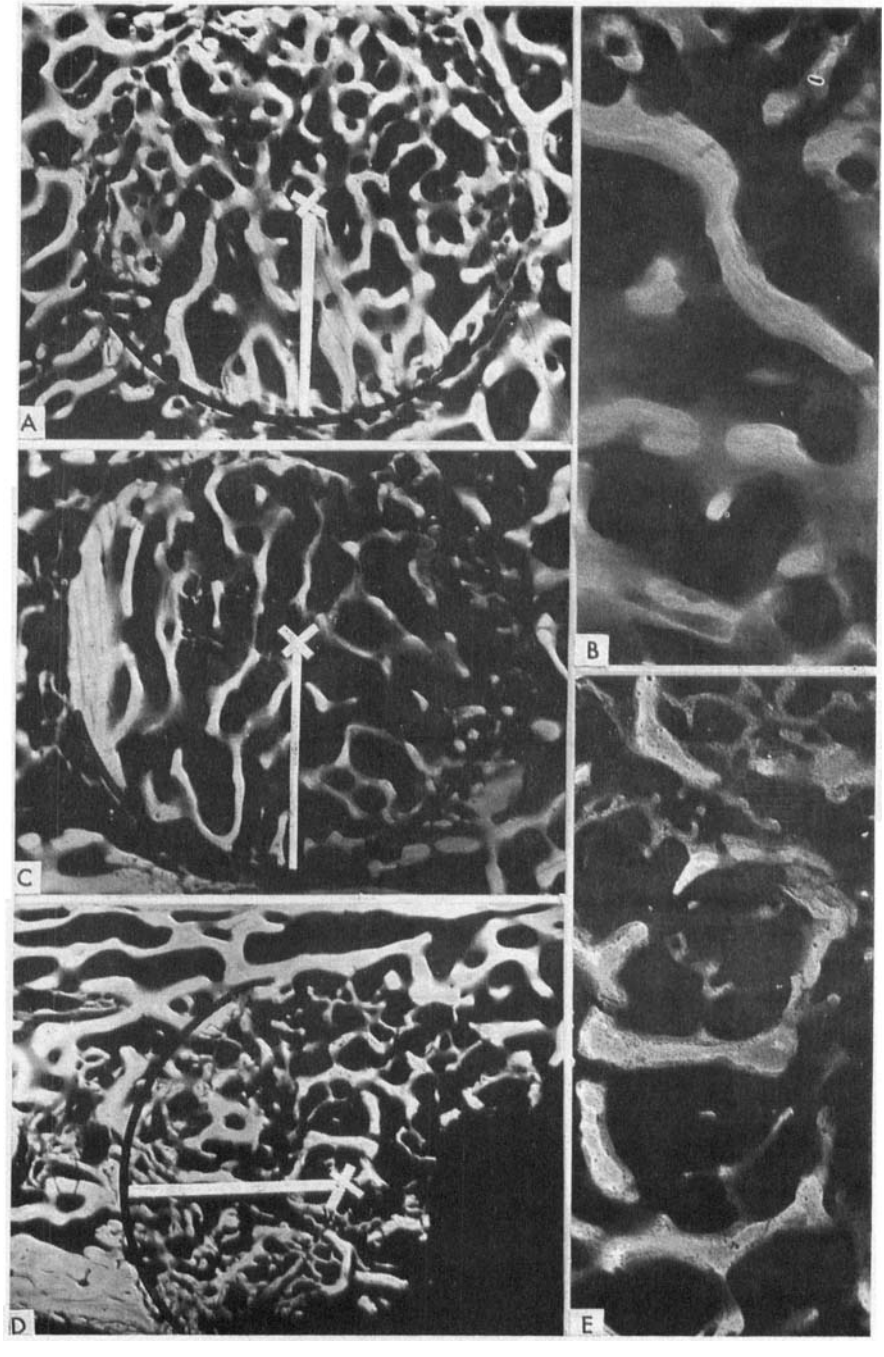
Figure 2. Spongiosa test on dog after 18 days. Microradiogram exposed at 20 kV and 20 mA for 10 minutes on Kodak M-R film in a Philips X-ray diffraction apparatus, Model PW 1009 with copper anode and nickel filter. All sections 80 microns.

A, C, D,—Survey pictures. *Ca.* × 10. Cross-sections of test plugs (*cf.* Figure 1).

B, E.—Details *ca.* × 45. *A, B* Autoplants. *C* Homoplants. *D, E* Kiel Bone. In *A, C* and *D* there is a peripheral zone of new, slender, poorly mineralized trabeculae (*grey*), connecting the host cancellous bone and the transplant. In *B* and *E* there is poorly mineralized bone (*grey*) seen as zones surrounding the more strongly mineralized trabeculae of the transplants (*white*).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logous plugs than in the others. Otherwise the pictures in the various test bodies were basically the same.

After *four weeks* there was no consistent difference between the three types. All the grafts were easily evaluated. The fact that this host dog was among the oldest—4 years—may explain the low osteogenetic activity in several of the plugs. In this dog, too, the bone formation in one of the slides was not very pronounced in the centre of the plugs, and in several of them the rims of vital bone were narrow.

In the *six-week specimens* the healing of the grafts was slightly more complete and there was difficulty in 2 cases in distinguishing the contours of the auto- and homoplants. The dead trabeculae were narrow, but they were present in all the grafts. The osteogenesis was possibly less intense than earlier, the inflammatory reaction in the marrow was less marked, and the marrow rich in fat. There was no difference in these respects between the three types of transplants.

After fixing in alcohol and embedding in methacrylate, ground sections[1] were prepared from some representative transplants from 2 of the dogs (Figure 2). The conventional microscopic findings were confirmed in principle. As a rule the individual transplants were more easily recognized in the microradiograms than in the routine sections. In all the transplants the gap between the host cancellous bone of the recipient and the trabeculae of the transplant was bridged by a zone of slender, poorly mineralized trabeculae (Figures 2 A, C, D), and similar structures often lined the coarse trabeculae of the transplant.

Table 1. Survey of the behaviour of the test material.
(Spongiosa test on the dog).

Criteria	Period of test			
	2 wk	18 d 3 wk	4 wk	6 wk
Callus formation	+ +	+ +	+ +	+ +
Formation of new bone towards the centre	+ +	+ +	+ +	+ +
Creeping subsitution	+ +	+	+ +	+ +
Sloughing reaction	—	—	—	—
Encapsulation	—	—	—	—

1 We would like to extend our thanks to Professor T. Arwill, Department of Oral Histology for placing his department's resources at our disposal.

From the cancellous bone experiments on the dog it is thus evident that new bone was being formed in the centre of the transplant after only 2 weeks (Table 1). However, even after 6 weeks the whole of the transplant had apparently not been replaced. The essential difference between the two- and six-week specimens is thus the reduction in inflammatory reaction and the extension of fatty bone marrow between the new cancellous trabeculae in the transplant. As expected, the new bone was not so well mineralized as the cancellous trabeculae of either the host of the transplant.

The Kiel Bone almost invariably displayed a peculiar picture, for the bone which had been macerated prior to buring dissolved during histological preparation, with the disappearance of many of the trabeculae. This feature differed slightly in the various microscope preparations. In these specimens the new rims of vital, cellular bone with their osteoblast zones surrounded empty spaces, which in the auto- and homoplants correspond to the non-vital trabeculae of the transplant. This feature has also been described by Bauermeister and Fuchs & Stegemann. The interpretation is confirmed by the microradiographic study, in which the non-vital trabeculae of the Kiel grafts are more strongly mineralized than those of the new bone. Otherwise the Kiel Bone in these experiments did not differ from the auto- and homoplants. In no case was there evidence of an appreciable foreign-body reaction, nor were there signs of sloughing or encapsulation. Thus, in all 3 types there was clear evidence of osteogenesis after only 2 weeks, with wide osteoblast zones, but there was also marked osteoclasia, even in the centre of the plugs, with vascularization and creeping substitution along the trabeculae of the transplanted cancellous bone. The amount of new bone seemed to vary slightly from graft to graft, and the cellular activity in several of them seemed to be quite as intense in the Kiel Bone as in auto- and homoplants.

As no quantitative determination of the new bone was made, the only conclusion that could be drawn from the experiments on the dog is that there was no consistent difference between the 3 materials as regards healing in the cancellous bone.

SPONGIOSA TEST ON MAN

To examine whether the findings in the dog are applicable to man the spongiosa test was performed in connection with 4 operations on the hip—3 of them on women and one on a man, 50 tto 70 years of age.

The operations were performed under spinal anaesthesia. Before the surgical wound was closed a small area of the greater trochanter was exposed and 3 plugs were inserted by the same method as that used for the dogs. The fresh autoplants, the homoplants and the Kiel Bone were placed in that order in the cranial—caudal direction. The homoplants for all 4 subjects were obtained from the same specimen of stored cancellous bone preserved at —20° for 4 months. The position of the plugs was marked with 2 small stainless steel pins. With these as a guide the area was exposed again after 3–4 weeks and the piece of trochanter containing the plugs—about 1 by 1 by 3 cm—was chiselled out. The cranical end was labelled with a steel wire suture. The preparation and the microscopic techniques were the same as for the experiments on the dog, except that no microradiography was performed. In none of the 4 subjects were postoperative complications encountered.

The cancellous bone of the greater trochanter of these patients differed considerably from that of the dogs. It was loose in structure, porous and brittle, and it was difficult to drill clean channels for the plugs. In 2 cases the cylinders of cancellous bone fractured during removal and 2 of the plugs loosened. All of the grafts could be identified and evaluated under the microscope except for one, only vestiges of which could be found.

The Kiel Bone was finer in structure and denser than the auto- and homoplants. In all cases the healing after 3–4 weeks was less advanced than it had been in the dog after only 2 weeks. In some cases osteogenesis had not extended to the centre of the plugs, the zones of vital new bone around the non-vital trabeculae being narrow and the cellular activity less intense. All the transplants displayed evidence of osteoclasis, with high osteoblastic activity around their trabeculae and no signs of fibrous encapsulation or sloughing (Figure 3).

The spongiosa test with Kiel Bone, homologous banked bone and fresh autologous bone in the 4 patients yielded similar results to those

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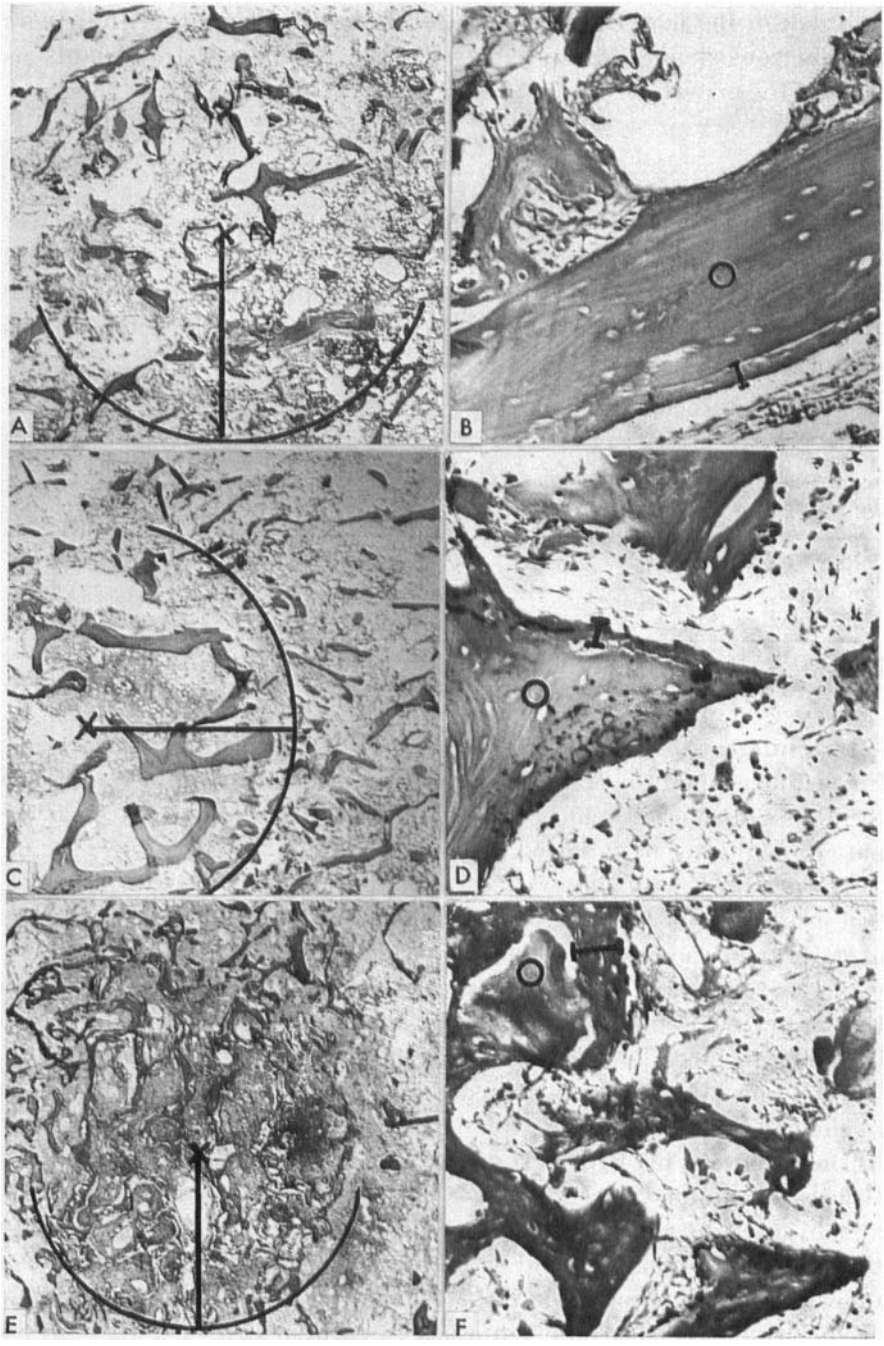
Figure 3. Spongiosa test on man after 3 weeks. Haematoxylin-eosin stain.

A, C, E.—Survey pictures: *ca.* × 10. Cross-sections of test plugs *B, D, F.*—Detail: *ca.* × 100. *A, B* Autoplants. *C, D* Homoplants. *E, F* Kiel Bone. From comparison of the survey pictures the finer structure of the Kiel Bone is evident. *B, D* and *F* contain narrow zones with new bone around the non-vital trabeculae of the transplants. (For notation see Figure 1.)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recorded in the dog. Healing appeared to be slightly slower, but there was no consistent difference between the 3 types of transplants as regards the criteria of healing considered.

CLINICAL EXPERIENCE

Between August, 1962, and October, 1963, Kiel Bone was used for transplants in 53 patients, for which the follow-up period is at present between one and 2½ years. The cases are divided into 3 groups with respect to the mechanical stress to which the grafts were exposed (Table 2).

Table 2. Clinical results obtained with Kiel Bone.

Requirements on the material	Number of operations	Results			
		Good	Uncertain	Poor	Infection
Obliteration of cavities	18	16	2	0	2
Low stress	11	8	1	2	0
High stress	24	9	4	11	5
Total	53	33	7	13	7

In a number of the cases the results were recorded as "Uncertain", for instance when the transplant had healed in spite of infection, when the follow-up period had been too short or, as in one case, when the patient could not be followed up.

The group "Cavity obliteration" contains 5 cases of cysts or tumours, 2 of osteomyelitis, 2 of necrosis of the femoral head and 9 other defects or cavities in connection with orthopaedic operations. Cancellous bone was generally used. The mechanical demands on the transplants in this group were small or nil, and a statisfactory result was recorded if there was incorporation, with no sign of an immunity reaction.

The "Low stress" group consisted of 5 wedge osteotomies, 3 of them in the calcaneus by Dwyer's method, 2 fractures of the calcaneus, one hip arthrodesis by Britton's method and 3 subtalar arthrodeses by Grice's technique. Cancellous bone was generally used and it was usually exposed to compressive stress. In one case a wedge placed in a tibia osteotomy collapsed and in another—a hip arthrodesis—there was no evidence of incorporation.

The "High stress" group comprised 16 pseudarthroses, 4 arthrodeses, and 4 posterior fusion operations in the lumbar spine. Cortical grafts

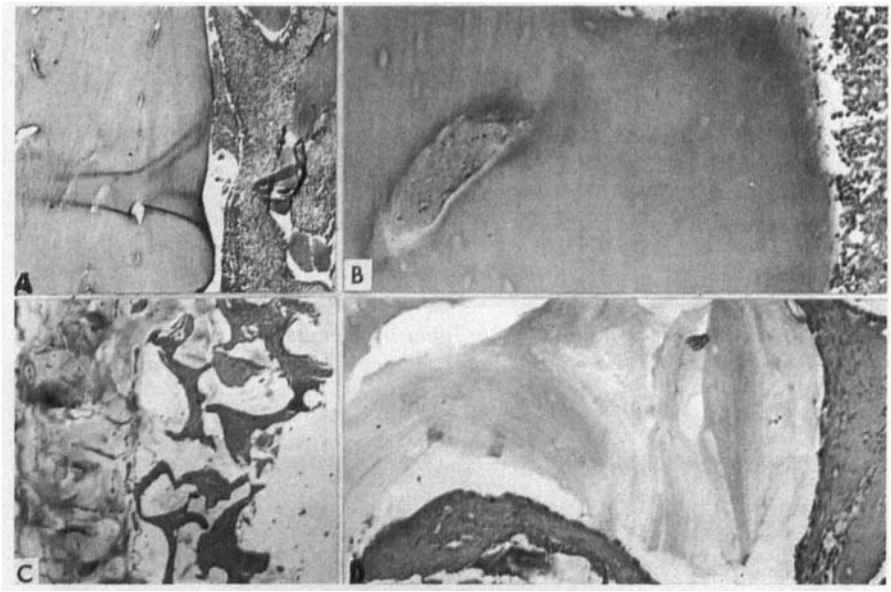

Figure 4. Cortical Kiel Bone graft used in pseudo-arthrosis operation, removed efter 8 months. Haematoxylin-eosin stain. A, C × 10; *B, D* × 40.

The cortical bone is dead and surrounded, like the cancellous trabeculae, by protein-rich inflammatory granulation tissue. In neither the cancellous nor the cortical bone is there evidence of osteogenesis.

were usually employed. Eleven of the 13 failures were in this group, as were 5 of the 7 cases of infection, some of them among the failures.

In 3 of the failures cancellous bone had been chosen in situations in which the mechanical stress proved to be so great that cortical bone would have been preferable. The importance of obtaining extensive contact with the surrounding vital bone has often been pointed out. In 2 of the cases, both tumour resections (one of them with intense irradiation), this requirement was not given due consideration and poor union resulted.

Among the failures in this group there were also 3 lumbar fusion operations and 3 cases in which cortical bone had been placed in grooves to serve as a bridge and to secure immobilization in the case of non-union (in-lay technique). In 5 cases the grafts had been removed after 8–15 months, and showed that the compact surface behaved like an inert sequestrum, although some, albeit inadequate, union had taken place between the cancellous surface and the surrounding bone. In one case the graft had fractured. Microscopic exami-

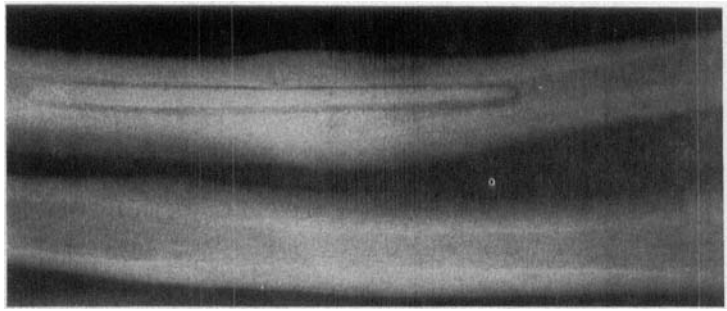

Figure 5. Cortical Kiel Bone used as an inlay transplant 8 months after a pseudo-arthrosis operattion on the radius. The pseudo-arthrosis has heated but the graft is still clearly outlined.

Figure 6. Wedge osteotomy by Dwyer's method, performed simultaneously in both heels for congenital club foot. Eight months after the operation the results was clinically satisfactory, and no difference could be seen between the two sides.

A. Cancellous Kiel Bone transplant still clearly outlined.
B. Autoplant; incorporation almost complete.

nation of the 5 specimens removed, all of which are thus numbered among the clinical failures, disclosed no evidence of osteogenesis in either the compact or cancellous parts. In the Haversian canals and between the trabeculae of the cancellous bone, organized granulation tissue was found which contained osteoclasts but not with osteoblast zones as in the spongiosa test, and there were no zones of new vital bone (Figure 4).

The inlay technique used in some cases was applied in 10 cases of non-unions, and in 7 of them there was solid union of the fractures.

Published radiographs of Kiel transplants often give the impression that healing took place with unusual rapidity. This seemed not to be so striking in the present study. Sometimes after more than one year grafts of compact bone, which are highly radiopaque, were surrounded by a distinct narrow, fairly radiolucent zone (Figure 5); even diced cancellous bone retained its sharp outline for a long period. In one case of club foot, in which a wedge osteotomy had been performed by Dwyer's method on both heels at an interval of a few days, autologous bone was used on one side and Kiel Bone on the other. After 7 months the latter was still more clearly distinguishable than the autoplant. Clinical examination, however, did not disclose any difference between the two sides (Figure 6).

DISCUSSION

In Maatz' spongiosa test, which was used in the present study, the healing conditions were standardized for the material under examination. By placing the transplant in cancellous bone the periosteal osteogenesis, which is often difficult to assess, is avoided, ideal growth conditions are obtained and it is possible to get an impression of the value of the transplant material in a matter of 2 weeks or so. Since our tests of Kiel Bone, like those by Bauermeister, were performed on cancellous bone the results are not directly applicable for clinical use, where cortical bone is often transplanted into a bed of like bone, and where the conditions for healing are therefore considerably less favourable than in the spongiosa test.

The present results bear out Bauermeister's view that in the spongiosa test on the dog cancellous Kiel Bone promotes callus formation, that 2 weeks are enough to obtain healing, with osteogenesis right to the centre of the bone plugs, and that the material apparently does not elicit a foreign-body reaction. In these respects there was no evident difference between Kiel Bone, fresh autoplants and homologous banked bone. Since, at the end of the 6-week observation period, the test materials displayed no difference in resorption of the non-vital bone trabeculae, it is impossible to judge whether the Kiel Bone was incorporated more slowly than the other materials; some of the radiographs would suggest that this was the case, the material appearing to retain its characteristic structure over a long period.

In contrast to Bauermeister's findings but in agreement with those of other authors (8, 9), Kiel Bone was found to contain a considerable

amount of protein; hence the deproteinization, said to be the chief reason for the maceration process, must be negligible. On the other hand, the hydrogen peroxide obviously resulted in denaturation, and deprived the heterologous material of its antigenic properties.

In the 4 cases in which the spongiosa test was performed on the greater trochanter in man the results were fundamentally the same as in the experiments on the dog, there being apparently no consistent difference in healing between the Kiel Bone and the auto- or homoplants. After 3–4 weeks healing was not so advanced as in the dogs after 2 weeks. In these experiments, too, cancellous bone was transplanted in beds of like bone.

The results of the clinical tests on Kiel Bone suggest that it is of value as a transplant material in cases in which the mechanical stress is within the limit for cancellous bone. Where greater strength is required, as in cases of non-union, cortical bone grafts have been recommended. These are strong and usually cut so that one surface has a thin layer of cancellous bone to facilitate union. In this group, too, good results were obtained with cortical grafts of Kiel Bone where high strength was required. In several cases, however, there was still no healing after as long as 8–15 months. Thus, although the instructions for the use of the material were not always adhered to, the present evidence suggests that the use of cortical grafts should be restricted to cases in which the circulation appears to be good and in which satisfactory fixation during healing can be achieved without relying on the graft. In the absence of these conditions, or where broad contact between the host tissue and the transplant cannot be obtained, Kiel Bone is hardly to be recommended.

SUMMARY

Kiel Bone is a material prepared from defatted calf bone macerated in hydrogen peroxide. To obtain an impression of the value of this material for transplants, experiments were performed on the dog and comparative examinations were made with a similar technique on man; experience of Kiel Bone was also obtained in clinical orthopaedic work on 53 patients over a period of 2 years.

In the experiments on the dog Kiel cancellous bone was compared with fresh autologous and stored homologous bone by means of the spongiosa test. As regards the 5 criteria for healing that were specially studied, and from microradiograms, it was evident that Kiel Bone did not differ essentially from the auto- and homoplants.

The results on man were similar.

It should be borne in mind that the spongiosa test provides optimal conditions for healing, and the results are therefore not directly applicable in practice. However, in the clinical work, too, the results obtained with cancellous Kiel Bone were usually satisfactory, and it would seem to be suitable for elimination of cavities; it also tolerates moderate compressive stress. Grafts of cortical bone were also used successfully where good contact could be obtained with vital host bone and where the mechanical stress was not excessive. On the other hand, the material proved unsuitable for bridging bone defects.

RESUME

L'os Kiel est un matériel préparé d'os de veau dégraissé, macéré dans du peroxyde d'hydrogène. Pour avoir une impression de la valeur de ce matériel pour les transplantations, des expériences ont été effectuées chez le chien et des examens comparatifs ont été faits avec une technique similaire chez l'homme; on a aussi expérimenté l'os Kiel en clinique orthopédique chez 53 malades pendant une période de deux ans.

Dans les expériences chez le chien, on a comparé l'os spongieux Kiel à l'os autologue frais et à l'os homologue spongieux stocké au moyen de l'épreuve spongieuse. En ce qui concerne les cinq critères de guérison qui ont été spécialement étudiés et en partant des microradiogrammes, il a été constaté que l'os Kiel ne diffère pas essentiellement des autotransplantations ou des transplantations homologues.

Les résultats chez l'homme ont éte similaires.

Il convient de rappeler que l'épreuve spongieuse fournit les conditions optima de guérison et les résultats ne sont donc pas directement applicables en pratique. Quoi qu'il en soit, dans le travail clinique également les résultats obtenus avec l'os spongieux Kiel ont généralement été satisfaisants et il semble qu'il soit approprié pour l'élimination des cavités; il tolère également des charges de compression modérée. Les greffes d'os cortical ont été utilisées aussi avec succès lorsqu'un bon contact pouvait être obtenu avec implantation d'os vital et lorsque la tension mécanique n'est pas excessive. D'un autre côté, ce matérial se montre impropre lorsqu'il s'agit de former un pont par-dessus des défectuosités osseuses.

ZUSAMMENFASSUNG

Kiel Knochen ist ein Material, das aus entfettetem in Wasserstoff Hyperoxid mazerierten Kalbsknochen zubereitet wird. Um einen Eindruck über den Wert dieses Materiales als Transplantat zu erhalten, wurden Versuche an Hunden vorgenommen und vergleichende Untersuchungen mit einer ähnlichen Technik wurden am Menschen gemacht. Erfahrungen mit Kiel Knochen wurden auch mittels klinischer orthopädischer Arbeit bei 53 Patienten über einem Zeitraum von 2 Jahren erhalten.

In den Versuchen an Hunden wurde Kiel Markknochen mit frischem autologien oder aufbewahrten homologen Knochen mittels der Spongiosaprobe verglichen. Hinsichtlich der 5 Heilungskennzeichen die besonders studiert wurden, und aus Mikroröntgenogrammen war es ersichtlich, dass Kiel Knochen sich nicht wesentlich von Auto- oder Homotransplantaten unterschied.

Die Ergebnisse beim Menschen waren gleichartig.

Man soll jedoch in Betracht ziehen, dass die Spongiosaprobe optimale Heilungsbedingungen schafft und dass die Ergebnisse daher nicht ohne weiteres in der Praxis anwendbar sind. In der klinischen Arbeit jedoch waren die mit Kiel Spongiosaknochen erzielten Resultate im allgemeinen zufriedenstellend, und er scheint zur Ausschaltung von Hohlräumenverwendbar zu sein. Er verträgt auch mässige Druckbeanspruchung. Transplantate aus Kortikalisknochen wurden ebenfalls mit Erfolg verwendet wo ein guter Kontakt mit lebensfähigem Wirtsknochen erhalten werden konnte und wo die mechanische Beanspruchung nicht übermässig war. Das Material erwies sich jedoch andrerseits als ungeeignet zur Überbrückung von Knochendefekten.

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