

Internal sinus augmentation using porous resorbable calcium phosphate ceramic material

Z. Nathanský¹, J. Strnad², P. Veselý³

Clin. Oral. Impl. Res. Vol. 14.4.2003, 6

Sinus lift allows predictable implant placement in severely deficient posterior maxilla. In the present study internal sinus lift was used as an alternative to the most commonly used lateral window approach. As an augmentation material porous, resorbable calcium phosphate ceramics (PORESORB-TCP) with intrinsic osseointensity were used. The osseointensity properties of the material are demonstrated by in vitro cell cultures and in vivo tests. Owing to the good X-ray contrast of the material the process of resorption and replacement by newly formed bone could be observed.

Over a time period of 2 years the internal sinus lift procedure was used with 22 patients who received 48 hydroxyapatite-coated implants (IMPLADENT, Lasak Ltd, Czech Republic). Clinically, all implants were successfully integrated, as supported by radiographic evaluation. The stability of implants was checked by a Periotest measurement. All implants are prosthetically loaded and fully functional. No complications arising from injury of the maxillary sinus mucous tissue were observed.

We consider the internal sinus lift method as minimally invasive and broadening the indication of dental implants in the posterior maxilla region. It was proven that calcium phosphate material can be successfully used as augmentation material for sinus lift without any addition of autogenous graft.

Introduction

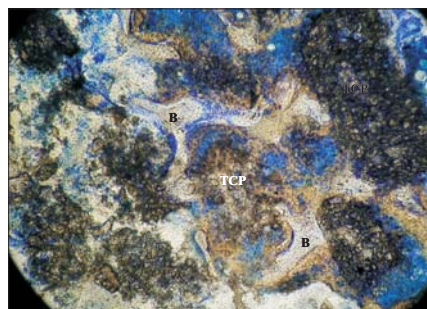
Sinuslift is a relatively recent method, which enabled applications of enosseal implants to be greatly expanded, because it allows the bone to be augmented at the place where it is most deficient. The classical sinuslift is an operation, which must be performed very carefully to avoid damaging the epithelium of the maxillary sinus. Indeed, damaging the mucous membrane principally deteriorates the healing prognosis, as well as the function of the implant. The primary sinuslift, which is understandably preferred, means that the operation of the sinuslift is performed at the same time as the introduction of the implant. This procedure requires the primary stability of the implant to be well secured by a certain layer of alveolar bone. If this layer is 4 – 8 mm thick, applying the internal sinuslift is considered, the whole operation being performed from the place, where the implant is to be introduced without opening the maxillary sinus by antotomy. Using this procedure, the operation is much less intrusive for the patient.

Materials and methods

Material characterisation (PORESORB®-TCP)

The structure of the material exhibits two types of porosity. Macropores of approx. 100µm in size and micropores ranging from 1 to 5µm. Micropores enable fast penetration of blood into the material and provide microrough surface favourable for cell attachment. The intergranular gaps of the packing from spherical granulates form a macro structure guiding the blood vessels, which supply the newly formed bone structures immediately with the necessary biochemical components. The resorption of calcium phosphate ceramics should take place at the same rate as that at new bone formation.

PORESORB-TCP is usually completely resorbed within 6 to 12 months and replaced by newly formed vital bone.



Histological section of PORESORB®-TCP granules in a bone defect (tibia of dog) 5 weeks after implantation. Section stained with toluidin blue. B-new bone, TCP- resorbing PORESORB®-TCP granules

Surgical procedure

Between 2000 and 2002, applying the internal sinuslift, we implanted a total of 48 IMPLADENT SHA-O implants, diameter 5 mm, in 22 patients (14 male and 8 female) and 18 Ankylos B implants, diameter 4.5 mm. We combined the IMPLADENT implants with PORESORB-TCP material (LASAK, Ltd., Prague, Czech Republic).

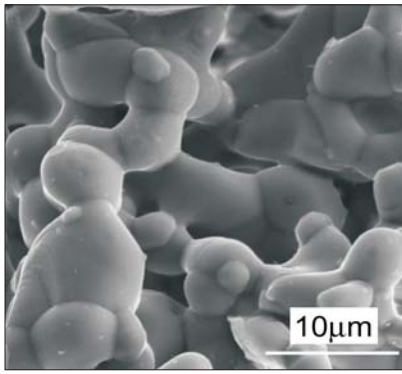
The preparatory work with drills of the same diameter as the future implant must be terminated 1 – 2 mm above the sinus floor. We then start working with bone condensers with a specially shaped head.

The maxillary sinus is penetrated bluntly by careful impacts, the cortical bone layer of the sinus floor being lifted together with its mucous membrane. The extraction of the condenser may only be accompanied by bleeding, not air bubbles, the presence of which indicates the creation of an oro-antral connection with damage to the mucous membrane. After sufficient separation of the membrane, when the condenser penetrates the sinus to a depth of 6 – 10 mm, the created volume is filled with PORESORB-TCP bioactive ceramics. Having filled it, we introduce the implant of a given, largest possible diameter and length (longer than 12 mm). The introduction of the implant increases the pressure in the sinus and removes more of the sinus membrane.

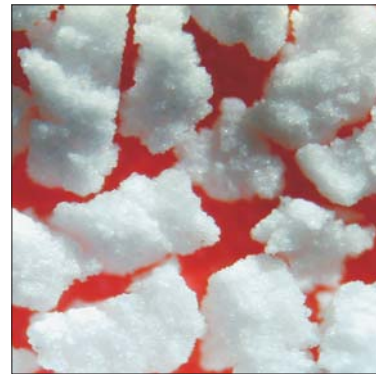
¹ Charles University, 1st Medical Faculty, Department of Stomatology, Kateřinská 32, Prague, Czech Republic

² Lasak Ltd., Papírenská 25, Prague, Czech Republic

³ Institute of Molecular genetics, AS, Prague, Czech Republic



SEM photograph showing the microstructure of PORESORB® - TCP



Granules of PORESORB® - TCP (particle size 0.3-0.6 mm)



Bone condensers IMPLADENT®



Application of the PORESORB® -TCP augmentation material

In most cases the primary stability of the implant is very good. It is secured by a bone layer more than 4 mm thick. Since implants of larger diameters (5 mm) are used exclusively in this procedure, it is nearly always necessary to commence the implantation with bone spreading. This spreads the spongy bone of the alveolar ridge of the upper jaw to the diameter of the implant. This spreading of the bone is simultaneously a very important factor for improving the primary stability of the implant. The primary stability enables the implant to be loaded gradually already after 3 – 4 months. The gradual loading is a process of getting the bone accustomed to the implant, in which during the first 14 days the provisional bridge does not reach the occlusion, and the patient is cautioned to eat soft food only. After another two weeks, the bridge has reached the occlusion, and the patient should still try to protect the implant by avoiding biting hard. After six weeks the patient may normally chew food, but avoid hard foodstuffs (nuts, etc.).

Clinical results

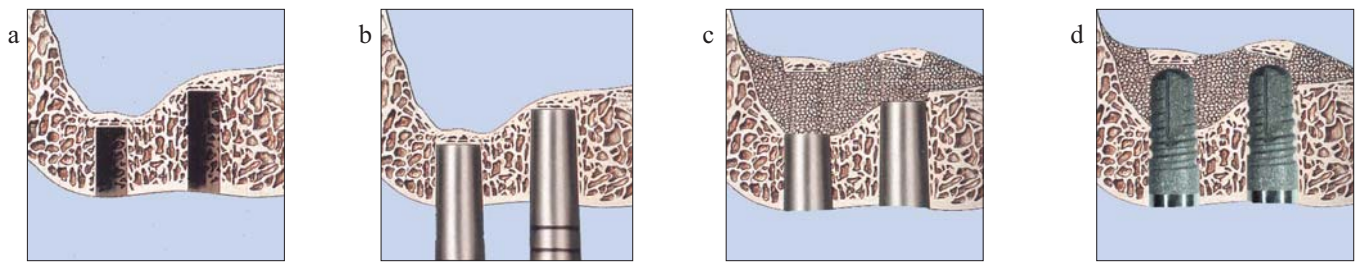
All implants are prosthetically loaded and the patients have no subjective or objective complaints. In the course of implant healing, an inflammatory complication in the region of the alveolar ridge of the upper jaw was observed in two patients. One patient complained of neuralgia of the 2nd branch of the trigeminus, most probably caused by irritation due to too robust an implant.

Complications associated with injury to the membrane of the maxillary sinus were not observed in our group of patients. The Periotest values ranged from -3 to 0. Post-operation X-rays show the filled area in the implant neighbourhood thanks to X-ray contrast. The contrast decreases after 2 years due to the resorption of the material and its replacement by the newly formed bone tissue.

Discussion

Our present experience indicates that the internal sinuslift is a considerate method, which can also be performed by a dentoalveolar surgeon. Thanks to a certain layer of alveolar bone, the stability of the implant is very good, which enables beginning loading after only 4 months. The loading is, of course, gradual by provisional bridges and requires certain restrictions on foodstuffs which are eaten. If the alveolar ridge is narrow, it must be widened at the beginning of the operation by expanders using the bone spreading method. The resorbable PORESORB-TCP augmentation material proved to be suitable for this application. We consider the greater X-ray contrast of PORESORB-TCP to be an advantage. Thanks to it the gradual replacement of this material by newly formed bone tissue can be monitored by X-ray. This is not possible, for example, with bovine hydroxyapatite.

The periotest values do not vary greatly during the healing of the implant and, in our opinion, are determined by the height of the alveolar ridge, the quality of the bone and length of the implant.



a) The preparation of the implant bed without damaging the mucous membrane of the maxillary sinus.

b) Introduction of condensers into the bed

c) The space created by lifting the base of the maxillary sinus together with the membrane is filled with the augmentation material.

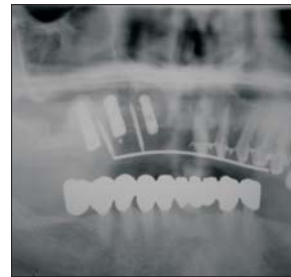
d) IMPLADENT® implants in situ



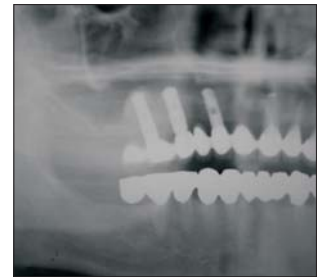
Postoperative x-ray



Situation 2 years after prosthetic rehabilitation



Postoperative x-ray



Situation 2 years after prosthetic rehabilitation

Evaluation of osteogenic activity of the PORESORB®-TCP in vitro.

Chicken embryo bone marrow from long bones derived cells were cultivated in vitro with pieces of TCP size of 0.3 mm. After initial cultivation for 4 days in standard culture medium (M) the ALP activity was measured and found to be at the same level in all selected combinations of treatment (Fig.1). Standard medium was then changed for Target media (D or V) and 3 days later ALP activity was found high in combinations of two factors - (TCP and osteogenic medium): TCP-D or TCP-V, while in single treatments: TCP-M and all controls without TCP be it M, D or V no particular raise of ALP activity was observed. This trend continued until day 16, and then declined as cultures grew old and started dying. On day 27 the remaining cultures were stained of intracellular activity of the ALP, which confirmed the previous findings of extracellular ALP activity. In Fig. 2 (picture width 300 mm) ALP positive cells around a piece of TCP in medium V are shown. Similarly positive cells were observed in bright field around TCP in medium D in Fig. 3a in bright field and in 3b in phase contrast.

Explanations:

TCP – synthetic, β -tricalcium phosphate (Poresorb - TCP)

Culture media: M- Standard medium (MEM + 5% calf serum + 5% fetal bovine serum)

Target media: V-Osteogenic medium : standard medium + 50 mm vitamin C/ml + 10 mM betaglycerophosphate;

D-Osteogenic medium D: Medium V + 1 nM

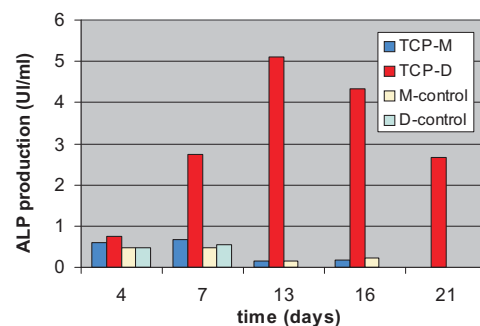


Fig. 1: Development of extracellular ALP activity of chicken bone marrow derived cells after treatment with TCP and osteogenic media

Dexamethasone.

ALP-alkaline phosphatase activity (assessed by BIO-LA-TEST Alkaline phosphatase 330: the measure in mkat/l of the catalytic concentration of the enzyme is the amount of released 4-nitrophenole)

Staining- cells were stained for intracellular ALP activity at the end of experiment using SIGMA Fast Red TR/NAPHTOL AS/MX Tablet Set (F-4523)

Conclusions

It was shown that the internal sinus lift method is minimally invasive and broadens the indication of dental implants in the posterior maxilla region. It was proven that beta tri-calcium phosphate (PORESORB-TCP) material can be successfully used as an augmentation material for sinus lift without any addition of autogenous graft. Thanks to the resorbability and good X-ray contrast of the material the process of new bone formation can be well monitored.



Fig. 2: (medium V) - ALP positive cells around TCP particles

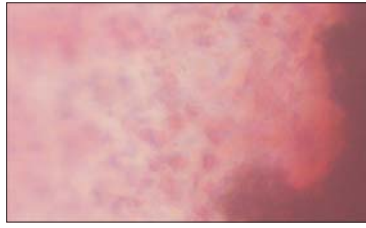


Fig. 3a: (medium D) – bright field

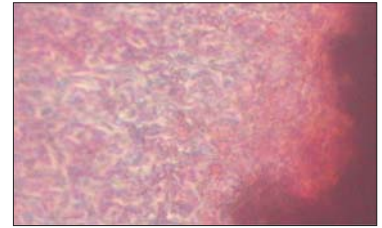


Fig. 3b: (medium D) – phase

Results of the in vitro experiments confirmed osseoinductive properties of TCP providing that there are three cooperating components of the assay system. The first component was the committed cells in this case derived from chicken bone marrow. The second component was the osteogenic medium in either of the two forms used here, and the last indispensable ingredient was the TCP material. Functionality of such a system depends largely on the conditions of the cells to be committed to osteogenesis as in some earlier

experiments these cells could start production of the ALP spontaneously. From this point of view the composed system described here apparently manifests higher potential for directing to osteogenesis even cells that are only weakly committed to osteogenic lineage.

Acknowledgements

The study was supported by the Department of Industry of the Czech Republic under the project number: FB-CV/64 FF-P/056

Literature

1. Meindl D.: Methodik und Ergebnisse der einzeitigen Sinusbodenelevation und Augmentation, *Prawissimo Journal* 3, 10-11, 2000
2. Jensen O.T.: *The Sinus Bone Graft*, Quintessence Publishing Co, 1999
3. Sethi A.: Die Oberkiefer-Alveolarkammspreizung, *Prawissimo Journal* 4, 24-27, 2001
4. Nathanský Z.: Vnitřní sinus lift - nové možnosti dentální implantologie. *Česko-slovenská stomatologie* (v tisku)
5. Poleník P.: The use of platelet rich plasma in regeneration of parodontal and bone tissue. *Quintessence Parodontologie*, II. 2002