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Advantages of Porous TiNi Materials for Dental Implants in Diabetes Mellitus Patients

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Abstract

Structural changes in osseous tissue under surgically modeled diabetes mellitus in rabbits are studied experimentally with the focus on macro- and microelemental composition. The effect of growth factors on regeneration of mucosa is analyzed in Brattleboro rats with inherited diabetes insipidus. Larger animals, dogs, were used to study the morphology of osseointegration with various implant materials under experimental surgical diabetes mellitus. The advantages of porous implants over other materials are shown.

1 Introduction

Diabetes mellitus (DM) is recognized worldwide as a socially significant problem, which is associated with a high rate of complications affecting viscera as well as the dentition system. Diabetes is presently defined as a complex of symptoms basically coming down to polyuria. There are three major types of diabetes: diabetes insipidus, Type 1 diabetes mellitus, and Type 2 diabetes mellitus. All the types of diabetes have different pathogenesis and share just one common syndrome - persistent, excessive discharge of urine. After transplantation of different organs 25 to 40% transplant recipients develop post-transplant diabetes mellitus. The ever growing number of patients suffering diabetes mellitus and the related early loss of teeth calls for development and introduction of most appropriate materials for dental implants.

2 Materials and Methods

All surgical manipulations on rabbits and dogs to model diabetes mellitus were performed under general anesthesia as regulated by Convention on humane treatment of animals. Initial narcosis – 2.5 ml of 0.05% calypso solution - was administered via ear vein, followed by main anesthesia using ether-air mixture. Once the operating field had been properly prepared, median laparotomy was performed and the stomach, pancreas and spleen were delivered through the operation wound. Next, pancreas was resected leaving its head and pancreatic duct intact and then the wound was stitched layer by layer until tightly closed. A total of 120 three-month-old male Chinchilla rabbits were used as a model to study changes in the osseous tissue depending on the age of rabbits and duration of diabetes and 27 diabetic Brattleboro rats with inherited diabetes insipidus were used to study tissue regeneration. Morphology of osseointegration with various implant materials under experimental diabetes mellitus was investigated on 30 mongrel dogs with surgical diabetes mellitus. Results obtained: It has been found that the organic component in the osseous tissue decreases in older animals while the inorganic (mineral) phase more than doubles with age (Table 1).

Table 1. Inorganic and organic components in the rabbit mandible depending on age

Age group, months	Mineral/dry bone weight, [%]	Organic substance/dry bone weight, [%]	Mineral/organic ratio coefficient
3	59,12±0,96	40,88±0,96	1.45
4	59,82±0.92	40,18±0,92	1.49
5	63,22±0,98	36,78±0,98	1.72
7	76,68±1,06	23,32±1,06	3.29

Osseous specimen of diabetes mellitus animals exhibit a notable depletion of the mineral phase already within one month after initiation of diabetes remaining below the initial level during further observation, which is an indication of diabetes associated osteoporosis of bone tissue (Table 2).

Table 2. Inorganic and organic components in the rabbit mandible depending on age and diabetes mellitus duration

Age group, months	DM duration	Mineral/dry bone weight, [%]	Organic substance/dry bone weight, [%]	Mineral/organic ratio coefficient
3	C	59,12±0,96	40,88±0,96	1.45
4	1	51,67±0,88	48,33±0,88	1.07
5	2	58,63±0,91	41,37±0,91	1.42
7	4	57,14±0,97	42,86±0,97	1.34

On the structural side of the bone composition, diabetes causes a significant elevation of potassium, copper, and nickel levels while the percentage of magnesium and zinc notably decreases. We would note that calcium and phosphorus phases in the mineral matrix of the bone have not been affected, which is an evidence for the stability of such structural component of the bone as hydroxyapatite.

Regeneration of oral soft tissue under diabetes conditions was studied on Brattleboro rats with a modelled acute and chronic trauma of the oral mucosa. Regeneration of oral tissue was stimulated by administering EGF, TGF, and IGF. Clinically, we observed rapid enhancement of tissue regeneration in the chronic wound. We also observed a noticeable decline in the mineral phase when using EGF and TGF while application of IGF increased the percentage of mineral component in the bone tissue. It was found that potassium and sodium levels in blood drop, particularly so when using EGF. The calcium level in blood appeared to go down under the effect of TGF and IGF, which is obviously due to its loss from blood, and grow under the effect of EGF [3].

We did not observe any tangible changes in the calcium/phosphorus ratio in the bone hydroxyapatite of diabetic animals. This encouraged us for experimental implant surgery. We used mongrel dogs in the experiment as they have sufficiently large volume of bone tissue in the mandible, which brings our experiment quite close to the problems of human dentistry. The materials used were standard implant materials such as titanium, nickelide titanium, and corundum. No osseointegration in the DM model animals was observed in the experiments with corundum implants (Fig.1) whereas titanium implants yielded good osseointegration outcome (Fig.2).

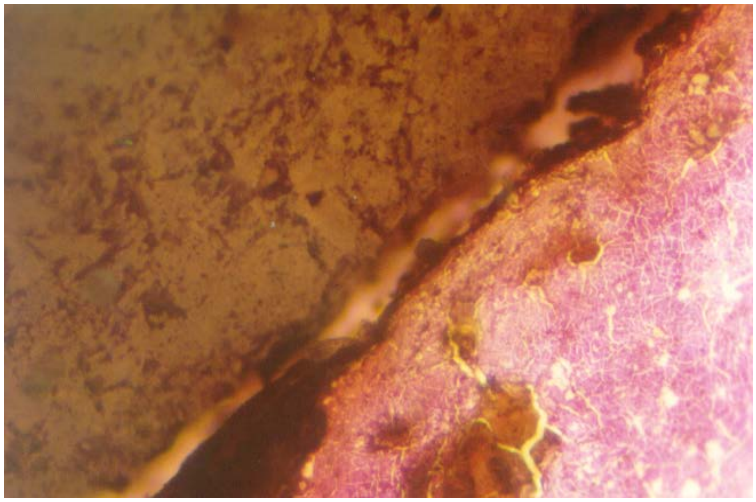

Fig. 1. Experimental diabetes mellitus, 3 months. Hematoxylin-eosin dye. X120.The corundum implant contacts the bone showing no signs of osseointegration

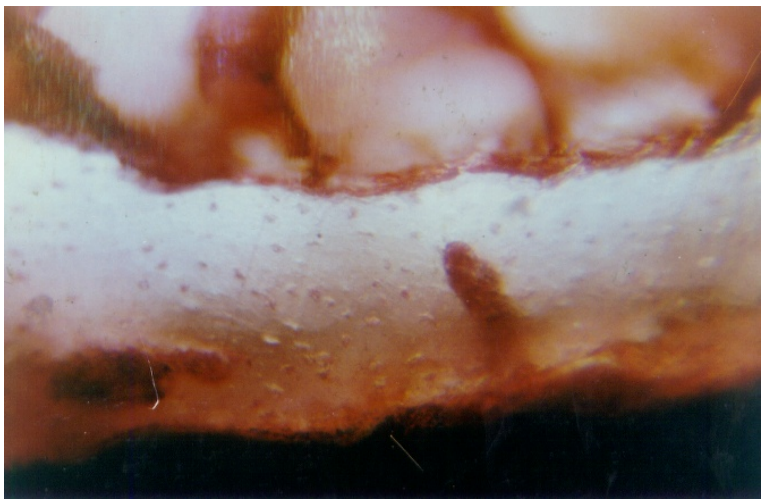

Fig. 2. Experimental diabetes mellitus, 3 months. Hematoxylin-eosin dye. X120. Integration of bone tissue with titanium

Integration of bone tissue occurred both on the surface of and inside the implanted porous titanium nickelide blocks. Already 1 month after surgery, implant pores were coated with fibrous connective tissue showing new bone tissue with ossification nuclei in the central area of larger pores (Fig.3). Under compensated diabetes mellitus, full osseointegration and blood vessels were observed in larger pores within 3 months (Fig.4) and bone integration in smaller pores occurred within 4 months (Fig.5) of the experiment.

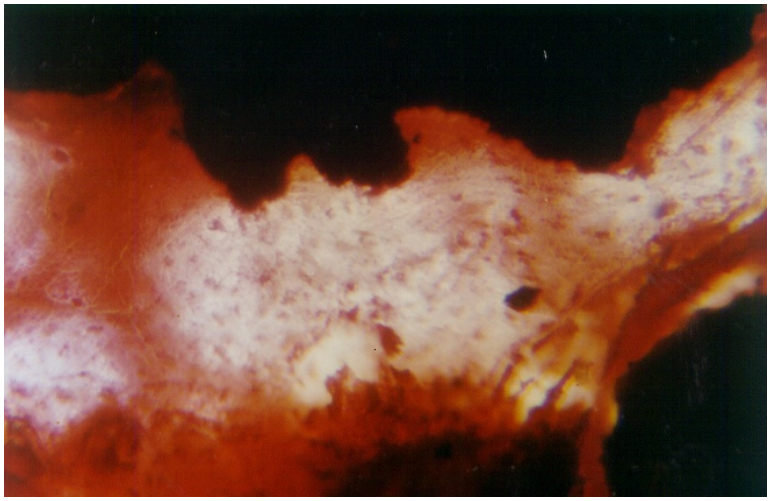

Fig. 3. Experimental diabetes mellitus, 1 month. Hematoxylin-eosindye. X120. The pore surface is coated with fibrous connective tissue. New bone tissue with ossification nuclei is observed in the central part of larger pores.

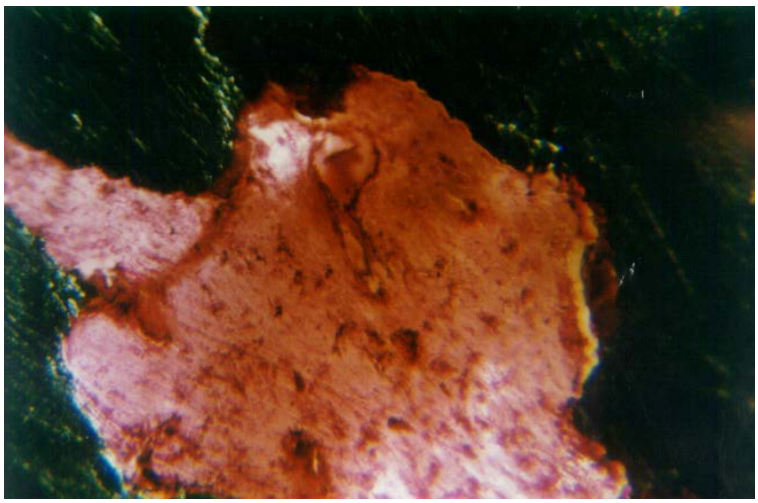

Fig. 4. Experimental diabetes mellitus, 3 months. Hematoxylin-eosin dye. X120. Full integration of bone tissue in larger pores with presence of vessels

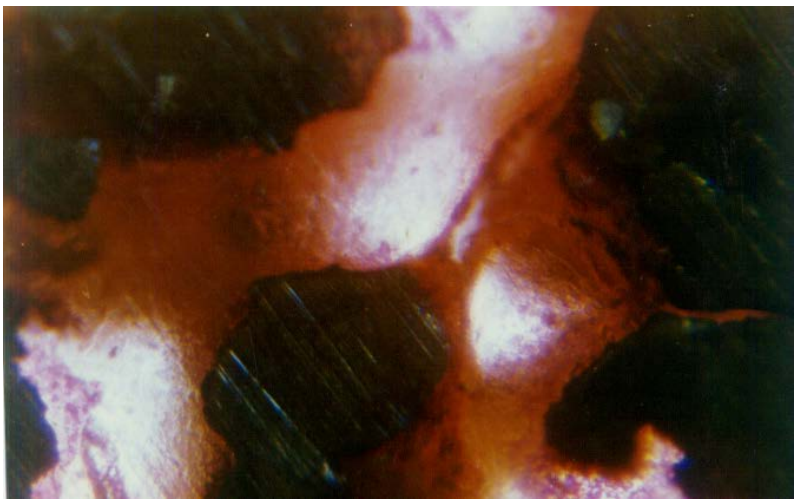

Fig. 5. Experimental diabetes mellitus, 4 months. Hematoxylin-eosindye. X120. Integration of bone tissue in smaller pores

Clinical approbation of porous nickelid titanium implants in diabetes mellitus patients has yielded good results [4, 5].

3 Acknowledgements

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