REVIEW ARTICLE

EVALUATION OF THE SUCCESS OF β-TRICALCIUMPHOSPHATE AND DEPROTEINIZED BOVINE BONE IN MAXILLARY SINUS AUGMENTATION USING HISTOMORPHOMETRY: A REVIEW

Rakesh V. Somanathan, Antonín Šimůnek

Charles University in Prague, Faculty of Medicine and University Hospital in Hradec Králové, Czech Republic: Department of Dentistry

Summary: Sinus lift operations have become a prerequisite for implantologists in the rehabilitation of atrophic posterior maxilla. Alloplasts and xenografts are the recent innovation in the world of grafting materials and have evolved in such a way as to compensate the need for autografts to be used in conjunction. In order to perfect the grafting materials, histomorphometry is the most often tool used to study the success of the augmentation. This article has tried to commemorate the importance of histomorphometry in maxillary antroplasty and also the success rate of β-tricalciumphosphate and deproteinized bovine bone as an augmentation material in maxillary augmentation.

Key words: *Sinus lift; Histomorphometry; β-tricalciumphosphate; Deprotenised bovine bone; Dental implants*

Introduction

Rehabilitation of severely atrophic maxilla with implants was a challenge for dental practitioners for a long time. Sinus lift surgery which was not a common procedure before was regarded as last resort. Now with the advent of latest surgical armamentarium and exhaustive studies on various graft materials, maxillary antroplasty has become more common. Autografts were preferred and used by many surgeons for bone augmentations from last two decades (18). Later it was found that allogenic, xenogenic or even alloplastic materials can be used for sinus lifts and were proved equally efficient. But evaluation and assessment of the success of the graft material was an enigma. X- ray findings were not enough to prove the exact amount of newly formed bone in a grafted area. Normal histological procedures fail to quantitatively evaluate osteogenesis and so a comparative study between various graft materials was arduous. But with the advent of histomorphometry, it is now possible to find out the exact amount of newly formed bone and also to evaluate the rate of resorption of graft material.

Sinus lift

In late 1960s Linkow reported implant placement into the posterior resorbed maxilla by intentional fracturing of the maxillary sinus floor using blade implants (9). But the first report about maxillary sinus floor augmentation for placement of implants was published in 1980 by Boyne and James (2). Several authors credit Hilt Tatum inventing the classic maxillary sinus grafting in early 1970s. This was a modified Caldwell-Luc surgery including creation of a superiorly based bony window on the lateral maxillary sinus wall that could be fractured inward while elevating the maxillary sinus and subsequent grafting. Endosteal implants were inserted into the grafted sinus after six months. Every sinus lift procedures done nowadays follow the same or either a similar technique as mentioned by Boyne and James.

Grafting materials

Bone grafting materials are generally classified as autografts, allografts, xenografts and alloplasts. Out of these, autografts harvested from the patient's own body (chin, hip, ribs etc) are regarded "gold standard" (6,15) because of the lack of antigenicity of the graft material. Allografts are transplants from a genetically non identical individual of same species which are "converted" to self by the host (11,12). Xenografts are transplants from one species to another. Bovine derived bone is a good example of xenograft. Alloplasts are synthetic chemically derived bone substitute. Most often this material is a form of calcium phosphate.

Histomorphometry

The term histomorphometry defines the quantitative description of the morphology of histological structures in tissue sections (14). It can be static or dynamic histomorphometry. Static histomorphometry involves the identification of cellular and tissue components for the measurement of length (mm), areas (mm^2) and/or cell counts (#/mm or #/nm). Dynamic histomorphometry in contrast makes use of fluorochromes, such as tetracycline, that are incorporated into bone at the front of calcification. These labeled sites can be viewed with U.V. microscopy. Specimens for histomorphometric analysis are taken by a vertical or horizontal approach (19). Local anesthesia is used to anesthetize the area and a 2 mm internal diameter trephine bur is employed for specimen collection. The bur is introduced through a short mucosal incision under copious cool saline irrigation. The bur shall be directed horizontally from the oral vestibule to the center of the graft, at least 3 mm above the supposed bottom of the alveolar recess. If implants are present in the grafted area, the bur shall be passed at least 1 mm away from the implant.

The harvested specimen is then fixed in an appropriate fixer (Burkhardt's solution), dehydrated in increasing concentrations of ethanol and embedded in methylmetacrylate, without decalcification. This specimen is now sectioned to several 4-µm sections using a microtome. Sections for quantitative histomorhometric study are stained with Giemsa stain and those for qualitative study are stained with stains like Gömöri and Ladewig stains. Special digitalization techniques and software (LUCIA M 3.0, Laboratory imaging, Prague, Czech Republic) are employed then for obtaining histomorphometric image and data (19).

Why histomorphometry?

Counting the histological structures is a frequently applied quantitative procedure in histology. But this procedure does not provide a morphometric description of individual histologic objects like a cell nucleus or a nucleolus. These measurements are needed for accurate analysis of rate of osteogenesis, rate of resorption of the graft material etc. Histomorphometry can be employed in these cases to analyze and measure morphometric parameters characterizing quantitative morphology of objects in two dimensional plane, for example, the cross sectional nuclear area, shape factors or the distance between two objects in plane (14). A histomorphometric result from a grafted sinus indicates the amount of newly formed bone, residual graft, fibrous and other connective tissue (15), and based on these data the success of the bone augmentation and that of graft material is assessed.

Results in connection with materials and healing period

Clinical and histomorphologic studies done on autografts, bovine hydroxyapatite (Bio-Oss, Geistlich), a xenograft and β-tricalciumphosphate (Cerasorb, Curasan), an alloplast, prove all these grafting materials are biocompatible, osseoconductive and can be used successfully in conjunction to implant rehabilitation (6,15,26). A six months short term study testifies 41% new bone formation from an autograft from chin (26). In 1993, Moy et al reported 59.4 ± 18.0% new bone formation and 40.5 ± 17.9% connective tissue in the histomorphometric analysis of sinus augmented with chin bone in six months (13). The quality of newly formed bone is also better when compared to bovine hydroxyapatite and β-tricalciumphosphate, as it is about 80% lamellar and is mature in nature (13).

Bio-Oss, a preferred grafting material has been studied extensively for past one decade. According to Valentini et al, histomorphometric studies show 28% bone, 44% connective tissue and 28% bovine hydroxyapatite (BHA) particles in a period of 6 months from 20 sinus lifts done in 15 patients (22). Norton et al reports it as 26.9%, 47.7%, 25.6% respectively after a period of 5.5 months average, from 22 trephines processed from 15 patients, treated with Bio-Oss (15). A ten year follow up study by Hallman et al, from 36 sinus grafts (21 patients), reports 29.8 ± 2.5% new bone formation in first 8 months, 69.7 ± 2.6% in the next one year and by the end of the study it was 86.7 ± 2.84%. The study also proved the rate of resorption of the graft material, BHA, to be 3.55% per month in the initial 2 years and then the value reached a mean value of 0.58% per month in the next 8 years (17). Although BHA is considered to be a resorbable material, it is not clear from the literature if the graft particles will undergo resorption and will eventually be replaced with autogenous bone (18). Moreover the bone found in conjunction with the BHA particles were mainly woven (6,20).

Studies using β-tricalciumphosphate (β-TCP) in sinus augmentation show around 29% new bone formation in 6 months in a histomorphometric analysis. When an osseoinductive factor like platelet rich plasma (PRP) was mixed with β-TCP the osseous regenerating capacity was increased to 38% (14). It was proved using histomorphometry the rate of resorption of β-TCP was 32–43% (16).

Therefore by comparing the data from six month healing period it can be testified that autografts are the one with maximum potential for new bone formation. Osteogenesis, which takes place in autograft, is a much faster process than osseoconduction (6,15) taking place in β-TCP and BHA. It is also clear that the osteoid volume is comparatively smaller in defects grafted using autografts and that the new bone formed is predominantly lamellar (14). But for implant treatment, amount of new bone formed is not the only concern. Autografts are not clearly visible in the X rays and so evaluation of the success of sinus augmentation and to plan the further steps in treatment becomes difficult (1). Furthermore two disadvantages of autografts hinder its usage as a primary graft material. First is the unpredictable rate of resorption of the graft and the second is the need for an additional surgical site (3,4,5,7,13,19,21) and resultant probability of donor site morbidity, such as limping, paraesthesia and anesthesia and residual defects (8). Grafting from chin can sometime result in significant reduction in pulpal sensitivity in the mandibular anteriors because of disturbances of inferior alveolar nerve function, lasting for as long as 12 months (25). However according to Lundgren, grafts from symphysis show less resorption compared to those from crista iliaca (10). But from the chin limited amount of bone is available for grafting. Some alloplasts like non resorbable hydroxyapatite are regarded to serve as an expander thereby adding to the bulk of the graft. The porous nature of some alloplasts provides a lattice work and thereby improving bone ingrowths (24,2). Therefore a combination of the graft materials was tried and recommended (20,23).

Individual studies on combination of bovine derived hydroxyapatite and autografts (in a rate 4:1) shows 21.2 ± 24.4% of lamellar bone, 10.2 ± 13.4% immature bone, 54.1 ± 12.6% connective tissue and 14.5 ± 10.3% graft material in a mean healing period of 6.7 months from 20 patients (6).

Conclusion

From these data it can be concluded that:

1. autogenous bone is a good grafting material with certain limitations for its use;
2. β-tricalciumphosphate can be used effectively as a sinus augmentation material;
3. compared to deprotinized bovine bone β-TCP requires shorter healing time and has faster resorption rate. A long term study is awaited using β-TCP as the grafting material and in combination with autogenous bone.

Acknowledgements

This study was sponsored by IGA MH CR (project No. NK7711-3/2003).

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Submitted July 2005.
Accepted April 2006.

Dr. Rakesh V. Somanathan, BDS,
University Hospital,
Department of Dentistry,
Sokolská 581,
500 05 Hradec Králové,
Czech Republic.
e-mail: drrakesh@gmail.com