Clinical Study

Healing of Bone Defects by an Osteopromotion Technique Using Solvent-dehydrated Cortical Bone Plate: A Clinical and Radiological Study

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Osseous defects of the jaws following trauma, cysts, infection or congenital deformity may show poor osteogenesis and the affected area may never be completely filled with bone. It is widely accepted in guided tissue regeneration that physically halting soft connective tissue proliferation into bone allows bone regeneration. This concept is called the "osteopromotion principle." The purpose of the present study was to evaluate the effect of solvent-dehydrated cortical bone plates as a barrier to allow bone regeneration by assessing the osteopromotion principle. 30 patients (18 male, 12 female) with cystic lesions of the jaws were assigned to two different groups. The patients in Group A were treated by enucleation. In Group B, were treated by removal of the lesion and placing a solvent-dehydrated cortical bone plate on top of the cyst cavity to avoid ingrowth of connective tissue. Both groups were evaluated radiographically using spiral-computed tomography (CT) before surgery and 12 months postoperatively. In group B, all cystic cavities showed complete bone healing in 12 months. At the same period, invasion of the soft connective tissue were observed in the patients treated only by enuclation. This study demonstrates that solvent-dehydrated cortical bone plates can be used as a barrier in treatment of cyst cavities and they hinder ingrowth of connective tissues and promote successful bone healing.

Key Words: Osteopromotion, bone regeneration, cyst, solvent-dehydrated cortical bone plate

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Jaw bone defects often occur as cysts, congenital anomalies infection, neoplasm, trauma and surgical procedures. Repair of local bone defects in the jaw is a complex process. Spontaneous healing or to somehow interfere in order to promote the healing process has been a matter of controversy in maxillofacial surgery.

Osteogenesis in bone defects of the jaws begins with the formation of a blood clot, which is later replaced by osteogenic granulation tissue. In small defects, the blood clot is replaced by immature bone within a few weeks.[1] Although bone defects normally heal by bony union, incomplete healing often ensues clinically. This is largely due to rapid ingrowth of connective tissue from the periphery into the defect.[2] Ingrowth of connective tissue into such defects prevents the formation of new bone, causing anatomic aberrations and functional disturbances, often requiring re-entry operations.

Various techniques and biomaterials have been introduced for solving these problems. One of them is the osteopromotion technique. According to the principle i.e. to mechanically prevent connective tissue ingrowth into the bone defect, and thus allowing bone cells to grow and subsequently produce bone.[3–6] Barriers of different types and materials, both resorbable and non-resorbable, have been tried and used to obtain proper bone regeneration.[3–6] Recently, this technique has been introduced clinically as an augmentation and regeneration technique in conjunction with the use of oral implants.

Bone grafts are frequently used in a variety of oral and maxillofacial surgical procedures. The main purpose in reconstruction is to repair the defect with natural bone or with any graft, which can replace natural bone. Bone substitutes can either be placed into the defect alone or in combination with a covering membrane underneath the soft tissue flap.[7–9]

Optimal compatible grafts can be obtained from the patient's own body.[10] Some disadvantages of autogenous bone grafts such as amount limitation in graft material and donor-site morbidity have led to the search for bone graft alternatives.[11] Initially allografts were only used in cases where autogenic grafts were not an option. Allografts are now parts in all routine clinical maxillofacial surgical procedures.

Allogenic bone grafts may be obtained from living human beings and cadavers, using the process of freezing, freeze drying, autoclaving and decalcification.[12] Solvent-dehydration has become a popular technique in recent years.[13–15]

Odontogenic cysts are usually assessed by conventional radiographs. However, these methods often fail to yield detailed information. More recently, computerized tomography (CT) examinations have been used to obtain detailed information.[16] Axial and coronal CT images better depict tissue contrasts and provide better delineation of the buccal and lingual cortical margins.

The aim of this study was to evaluate the effect of solvent-dehydrated cortical bone plates as a barrier to allow bone regeneration in bone cysts of maxillofacial area by assessing the osteopromotion principle and preventing ingrowth from soft tissue cells.

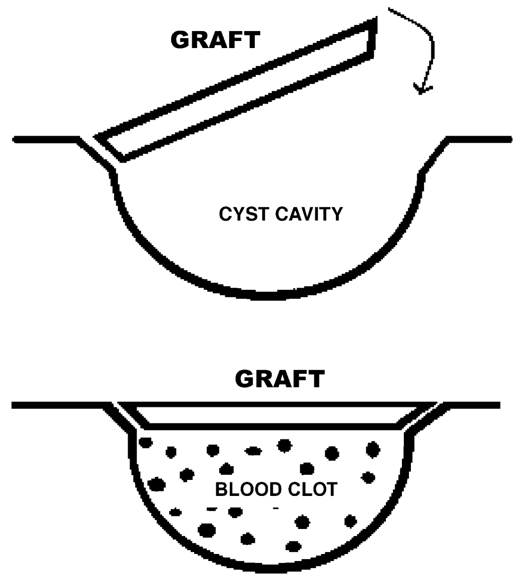

Fig 1 Schematic drawing illustrating the closure of the cyst cavity by solvent-dehydrated cortical bone plate after removal of the cyst.

Materials and Methods

Between 1998 and 2004, 30 patients with cystic lesions of the jaws treated by the authors were randomly assigned to 2 groups. Table 1 summarizes the general clinical data of the patients in Group A and in Group B. All patients were of general health. Patients in Group A were treated only by enucleation. In Group B, following enucleation solvent-dehydrated cortical bone plates (Tutoplast, Tutogen Medical GmbH, Neunkirchen, Germany) were reamed and shaped to fit the size of the cavity, and tightly adapted to the top of the cavity (Fig 1). Tutoplast cortical bone plates (Tutogen Medical GmbH, Neunkirchen, Germany) prepared by a solvent-dehydration technique are a human originated allograft. In the selection of donors and the preservation process, the tissue-storing standards of Germany and the USA are considered. The cortical bone plates were 20–50 mm in diameter and 1 mm high. The wound was closed in one layer using 3-0 silk sutures. Amoxicillin trihydrate + potassium clavulanate (2 g/24 h) was administered for 7–10 days postoperatively. All patients were evaluated clinically and radiologically. The factors evaluated included symptoms such as fever and malaise, and other complications. CT views were obtained with a spiral-CT scanner (Elscint, Twin, Haifa, Israel). The volume of the defect was estimated and evaluated by volume rendering techniques on the spiral-CT scans.[17]

Table 1. General Data on 30 Patients With Cystic Jaw Lesions

Group	*Site (Jaw)*	*Sex*	*Age (y)*	*Diagnosis*
A	Maxilla 9	Male 6	Range 16–60	Residual cyst 5
(n = 15)	Mandibula 6	Female 9	Mean 30.3	Radicular cyst 10
B	Maxilla 8	Male 7	Range 19–50	Residual cyst 2
(n = 15)	Mandibula 7	Female 8	Mean 28.3	Radicular cyst 13

Patients treated by only enucleation (Group A) and enucleation followed by placement of solvent-dehydrated cortical bone plates (Group B).

Statistics

Student's *t*-test was used for evaluating of the difference between Groups A and B. Paired comparison *t*-test was used to compare the preoperative and postoperative volumetric changes in Group B. Since complete healing was observed in Group A statistical evaluation was not performed. Data were presented as mean ± standard deviations (SD). $P < 0.01$ were considered to be significant.

Results

Age, gender, affected jaw, diagnosis and cyst size are all listed in Table 1. All surgical areas healed without incidents, and there were no apparent clinical differences in the healing patterns between

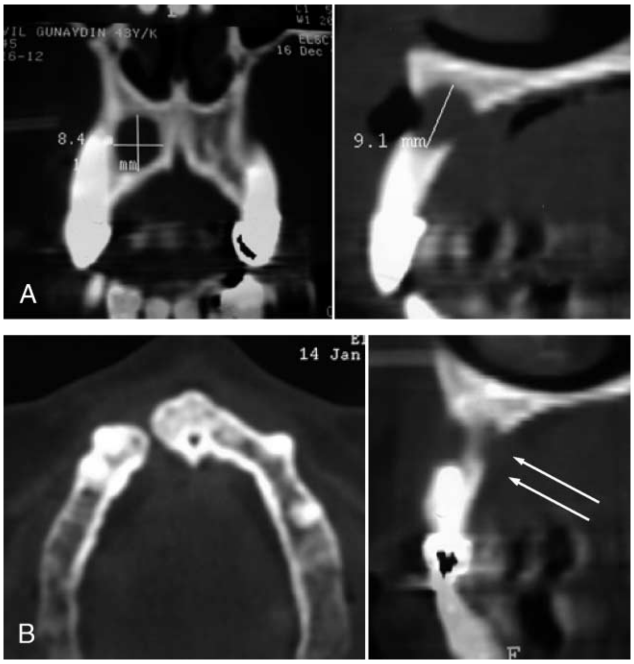

Fig 2 (A) Preoperative CT, showing a cyst in the maxilla, treated by only enucleation. (B) CT of the same lesion 12 months after treatment. CT shows the invasion of the connective tissue in to the cavity and partial bone healing.

groups A and B. Pre- and postoperative CT scans of cysts treated by only enucleation, are shown in Figure 2A, B. Pre- and postoperative clinical views and CT scans of cysts treated by enucleation and solvent-dehydrated cortical bone plates are shown in Figure 3A–D. The volumetric changes in the cystic area in groups A and B are shown in Table 2. In Group A (no cortical bone plates) the defects were still not completely ossified even after 12 months (Fig 2B). Only diminished somewhat in diameter ($P < 0.01$), an invasion of the soft tissue into the bone cavity was observed on the spiral-CT scans. In Group B, all cystic cavities showed complete bone healing in 12 months (Fig 2C).

Discussion

No bone healing or improper bone healing is a significant clinical problem in oral and maxillofacial surgery as well as orthopedic surgery.[2,6,8] The main problem for successful bone healing and the formation of new bone, in contrast to osteogenesis, is that connective tissue ingrowth and formation in the defect occurs rapidly. Such tissue reactions delay or prevent the formation of new bone, causing anatomical aberrations and functional disturbances.[18]

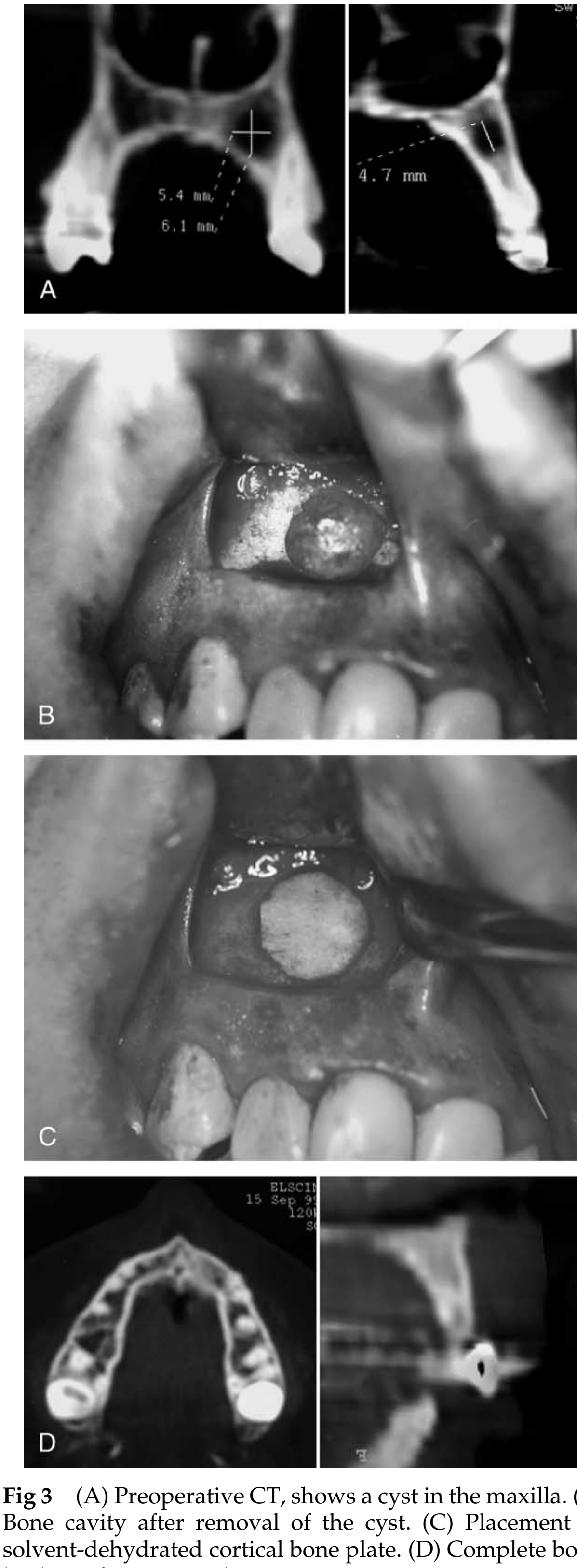

Fig 3 (A) Preoperative CT, shows a cyst in the maxilla. (B) Bone cavity after removal of the cyst. (C) Placement of solvent-dehydrated cortical bone plate. (D) Complete bone healing after 12 months.

Table 2. Changes in the Volume of Cyst and Bone Defect in Group A and Group B

	Preoperative Volume of Cyst (mL)	*Postoperative Volume of Bone Defect (mL) (12 mo)*	*Differences Between Preoperative and Postoperative Volumes (mL)*
Group A (n = 15)	0.920 ± 0.146	0.763 ± 0.132	0.1567 ± 0.0316*
Group B (n = 15)	0.909 ± 0.154	Complete healing	Complete healing

*$P < 0.01$.

A variety of bone grafts and biomaterials have been used for the reconstruction of bone defects. Autogenous bone graft is considered the best material.[19] However, an additional surgical procedure, with increased morbidity, is required to obtain the graft, and there may be insufficient quantities of autogenous bone for large defects. Therefore, the alternatives to autogenous bone, such as allogenic bone, xenogenic bone, lyophilized cartilage or alloplastic bone substitutes are increasingly considered.[20–22] Allogenic grafts have gained more popularity due to their organic content and reduced immunologic potential. When revascularization is good at both the recipient bone and surrounding tissues, this type of grafting material yields such results as good as expected with autogenic grafts.[23] Various forms of allogenic bone grafts have been employed in a number of oral and maxillofacial procedures. Although these studies have shown that these graft materials support and shorten the healing period, postoperative morbidity and complications have also been documented.[24,25] In addition, a concern about the application of bone grafts obtained from cadaveric sources to human has a potential of a transferable diseases, notably HIV, bovine spongiform encephalitis (BSE), Creutzfeld-Jacob disease, etc.[26] Although the closest donor surveillance cannot always eliminate concern about transmission of viral agents, and prions several reports have shown that demineralization, solvent dehydration and gamma irradiation processes destroy effectively all infective agents that may be present.[8,26] It is important that the cadavers selected as donors do not have any viral disease. The age range of the donor varies from 18–55 years old for males and from 18–45 years old for females. The first stage in preserving the tissue is the removal of cells and particles from it. The tissues are dehydrated with solvents such as sodium hydroxide, hydrogen peroxide, acetone and additional strong alkalis; in this way possible viruses are claimed to be eliminated.[23] During these processes osteoinductive protein loss is minimized. In the present study, solvent-dehydrated cortical bone plates were used to prevent ingrowth the connective tissue, in treatment of cyst cavities in jaws.

Re-entry procedures, to deal with incompletely healed bone defects, are common in oral and maxillofacial surgery.[27] A variety of suggestions have been presented with the purpose of solving these problems. Many techniques have been investigated in animal experiments and several of these have also been applied clinically.[5,18,26] The osteopromotion technique is one of the techniques used for this purpose. Similar successful results in bone regeneration have earlier been achieved by the membrane method in experimental models.[3] As defined by Linde et al[3] osteopromotion refers to the use of physical means to seal off an anatomical site in order to prevent other tissues, notably connective tissues, to interfere with osteogenesis as well as to direct bone formation. The osteopromotion method

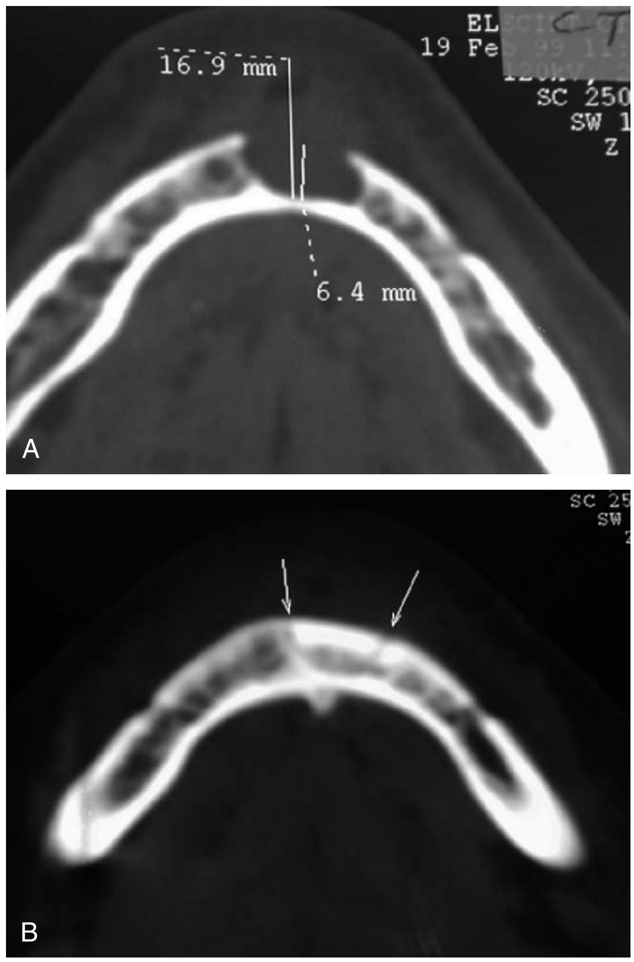

Fig 4 (A) A cyst cavity in mandibular anterior area. (B) Bone healing after placement of solvent-dehydrated cortical bone plate 12 months postoperatively.

has also been successfully applied clinically in placement of endosseous implants.[28]

Three biological processes are usually involved in new bone formation within a bone graft: osteogenesis, osteoconduction and osteoinduction. Osteogenesis requires surviving osteoblast and osteoblast precursors to repopulate within the defect and to form new bone. Osteoconduction involves replacement of the graft by osteoprogenitor cells from the host. Osteoinduction is a more recently recognized form of bone formation. The solvent-dehydrated grafts provide healing by osteoinduction, osteoconduction and resorption.[29]

In most studies on the regeneration of bone defects, such defects have been created and immediately treated by membrane placement or application of some other osteogenesis-stimulating treatment. Presumably, the rate of bone healing is determined by the degree of bone damage relative to the amount of soft tissue present. Dahlin et al[6] reported that even three weeks after the surgical induction of a critical size bony defect, bone regenerates, most likely because of the mechanical hindrance of a barrier to the ingrowth of connective tissue. Pecora et al[4] reported that as a mechanical barrier, the calcium sulfate disks allowed bone cells to fill osseous defects. The present study showed that the use of solvent-dehydrated cortical bone plates as a barrier could halt the ingrowth of soft connective tissue, in accordance with the osteopromotion principle (Figs 3A–D, 4A, B). In this study, none of the cysts treated by only enucleation showed a proper healing as the cases treated by cortical bone plates.

Cystic lesions in the maxillofacial region can be evaluated by standard plain radiographs. These methods are excellent but often fail to provide the detailed information, which is sometimes necessary for further management.[30] Two-dimensional imaging methods did not allow calculation of the cystic volume. With spiral-CT, it was easier to estimate the size of the cyst by assessing the slice thickness and cystic area at the cross-sectional image.[16] Cortical bone involvement in a cystic process can be assessed by cross-sectional scans. CT also provides specific information on the healing stage of the lesion. Cotti et al[30] reported that the panoramic radiograph did not accurately reflect the extent of healing.

CONCLUSION

Osteopromotion methods may be beneficial to the treatment of nonunion bone defects and cyst cavities of the jaws. Solvent-dehydrated cortical bone plates came out as an effective solution to serve as a barrier to halt ingrowth of soft connective tissue. This will promote successful bone healing.

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