Implantation and transplantation in reconstructive nasal surgery

E. H. Huizing, Leiden, the Netherlands

THE implantation and transplantation of various materials have acquired increasing importance in reconstructive nasal surgery during the few last decades. The present article summarizes some of the experience we have accumulated over the last twelve years and gives a survey of the technique employed in our Department at the present time. Many of the underlying principles are based on the work of Cottle (e.g. 1948, 1954, 1958) and in addition, valuable contributions and suggestions of several other authors have been incorporated into our present techniques (Hinderer, 1968, 1971; Tucker, 1968; Barelli, 1963; Masing and Hellmich, 1968; Hellmich, 1970, 1972).

The idea of implantation of material into the nasal structures is not new. Implantations into the nasal dorsum were carried out many centuries ago, while the technique of submucous implantation into the nasal cavity for ozaena dates back about fifty years. During the last ten to twenty years, however, great progress has been made in the development of new methods of implantation and transplantation of various types of materials. Although many of these techniques are still in the experimental stage, others can by now be considered to have been sufficiently tested and may be accepted as safe and effective.

I. CHOICE OF MATERIAL

Many kinds of material have been used for implantation into the nose in the past. At present, the most important are bone, cartilage, and certain alloplastic materials. The use of alloplastic implantation material is highly controversial. Each new development in this field has been announced with enthusiasm, but in most cases the positive preliminary communications were followed by reports of disappointing results. In fact, the ideal alloplastic material for implantation into the nose has not yet been found. Some materials become brittle, others are too stiff, and in an appreciable number of cases they are sooner or later expelled. Another problem is that of the long-term possibility of induction of malignancies. Autogenous material is therefore preferred by many authors and certainly in our group. Some specialists use spongiosa taken from the iliac crest, others rib cartilage. Both methods have the disadvantage of requiring two operations. This has

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induced many surgeons to use heterogenous bone and homogenous cartilage, particularly when small amounts of material are required. Heterogenous bone (e.g. calfbone) is, however, reabsorbed to a considerable extent.
The use of special techniques can reduce this disadvantage, as shown by the results obtained with processed bone such as Boplant^{R} (Squibb) and Kiel-bone^{R}. In spite of this progress, processed heterogenous bone cannot yet be considered the material of choise for implantation. At present, homogenous cartilage is considered by most authors to be the best material for implantation into the nasal structures.

II. IMPLANTATION AND TRANSPLANTATION IN SEPTAL RECONSTRUCTION

In corrective septum surgery four phases are to be distinguished: 1. mobilization of the septal skeleton; 2. resection of redundant or irreversibly deformed cartilage and bone; 3. repositioning of the remaining parts; and 4. reconstruction of defects.

1. *Mosaic type of reconstruction*

When parts of cartilage and bone have to be removed it is imperative to reconstruct the septal skeleton as accurately as possible. In most primary septum operations enough material is available from the patient himself for reimplantation. For this purpose pieces of bone are modelled as much as necessary with a bone scissors and a Cottle crusher.
After application of an internal nasal dressing and cleansing of the septal space of blood by suction, the fragments are inserted into the septum and placed

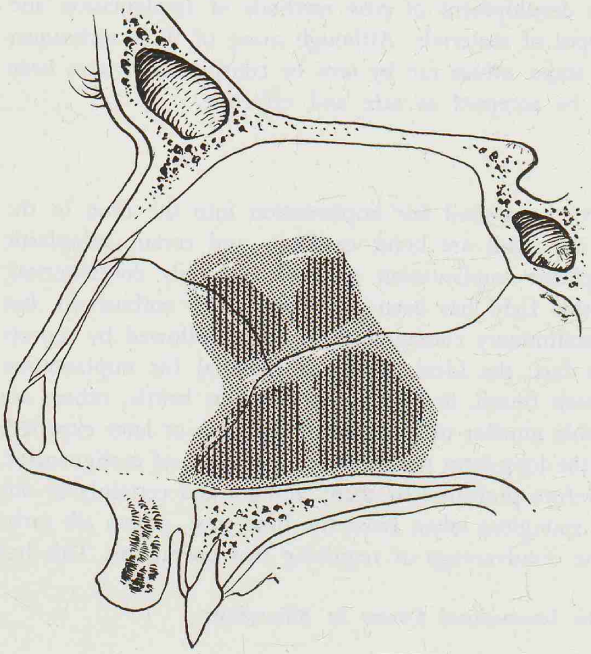


Figure 1. Mosaic-type of septal reconstruction. Platelets of (slightly crushed) bone are reimplanted into the septal space after application of an internal nasal dressing. This technique of reconstruction helps to prevent septal atrophy and sagging of the cartilaginous vault.

on the left mucosal blade in a mosaic-like pattern (Figure 1). This method of reconstruction has been used for all uncomplicated primary septal operations in our Department since 1963.

In reoperations, the amount of autogenous material is usually insufficient. In that case homogenous septum or rib cartilage can be used, rib cartilage having the advantage of greater stiffness and long-term survival. It is very difficult, however, to make thin flat platelets of this type of material and special techniques are required. Septum cartilage, on the other hand, does not survive as cartilage but will be transformed into connective tissue.

Reconstruction of the septum (re-)implantation of bone and cartilage has proven its value in many ways:

a. It restores the necessary thickness and stiffness of the septum. If no material is implanted the mucosal blades grow together, and this can lead eventually to atrophy and metaplasia of the mucosa. When the skeletal defect is large, fluttering of the septum during inspiration may also occur.
b. Implantation of material helps to prevent sagging of the cartilaginous dorsum and the nasal trip, primarily because of the mechanical support it provides, but also because it prevents retraction of the connective tissue of the muco-pericondrial layers. This effect can be compared with that of a multiple Z-plasty, by which the retraction forces are divided over all directions.
c. When lesions in the mucosa are made implantation of material greatly diminishes the chances of a permanent perforation. In this situation slightly crushed cartilage probably deserves preference over bone, because the mucosa seems to heal more easily over cartilage.

2. *Plate-type reconstruction*

In some patients the septum is deformed in such a way that reposition of its parts is impossible and (sub)-total removal of all septum cartilage is required to obtain a straight septum. This situation demands extensive reconstruction, because otherwise it will result in serious functional and cosmetic disturbances. In these cases reconstruction with bone or cartilage will not provide sufficient support. Some authors use strips of cartilage, which are sutured to the mucosal flaps.

Since 1968 we have used a technique of reconstruction employing a plate of bone taken from the perpendicular plate or the vomer. With a 7-mm chisel, a large piece of bone is take from the bony part of the septum. Outside the nose, this bone plate is modelled into the required form. With a drill, 3 to 4 small holes are made in the ventral and caudal borders of the bony plate, which is then fixed with 3—0 chromic catgut in the dorsum, the columella, and the nasal spine (Figure 2).

Sometimes, for better fixation, a groove is drilled in the premaxilla. Recently, we started to use Histoacryl® for fixation of the plate to the maxillary-premaxillary crest. The defect made in the perpendicular plate or the vomer is reconstructed by reimplantation of superfluous cartilage, as described above.

Total reconstruction of the cartilaginous septum by transplantation of a bone-plate has been used by us in 20 cases up to this moment. The results are satis-

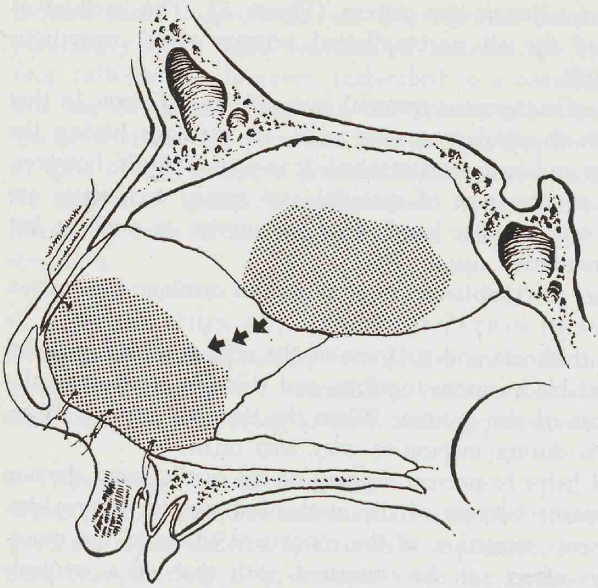


Figure 2. Plate-type of septal reconstruction. A bony plate taken from the l. perpendicularis is transplanted and fixed into the anterior part of the septum and the columella. This method of reconstruction is used after (sub-)total removal of the cartilaginous septum.

fying. The transplanted bone does not become reabsorbed. In two cases this was confirmed histologically. (Figure 3).
In some of the patients an additional correction of the cartilaginous dorsum by implantation of crushed bank-cartilage was performed six months after the septal reconstruction.

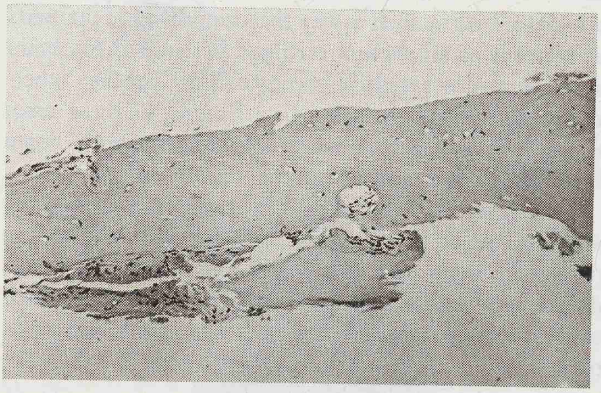


Figure 3. Biopsy taken from a plate-type of septal reconstruction one year after surgery.

3. *Implantation in the treatment of septal abscess*
Septal abscesses are well known for their destructive effect on the shape and function of the nose. In the fully developed adult nose they lead to sagging of the cartilaginous vault, flattening and broadening of the lobule, columella, nares, and internal ostium, which impedes nasal function. In children a septal abscess severely disturbs nasal growth and leads to underdevelopment of various parts

of the nose: the external pyramid remains short and broad and lacks prominence, the nasalia are broad and flat, and the cartilaginous dorsum sags while the lobule remains wide and broad.

Formerly, treatment of a septal abscess was concentrated entirely on the immediate effects of the disease itself. At present, we include measures to prevent or at least limit the destructive effects of this condition, which occur during healing and are the result of retraction of scar tissue.

The therapy currently used is as follows. After puncture for bacterial culture, the abscess is opened by means of an incision parallel to caudal end of the septum. Pus and necrotic material are removed. The septal defect is then reconstructed with autogenous bone taken from the perpendicular plate or with bank cartilage (rib). A loose internal dressing soaked in saline is applied into both nasal cavities. The incision is left partially open for drainage. Antibiotics are given intramuscularly in high doses for about ten days.

In longstanding cases with badly damaged mucosal membranes the reconstructive phase of the treatment may be postponed for two or three days and carried out as a secondary procedure. Follow-up findings in children treated between 1963-1970 support the hypothesis that the late destructive effects of septal abscesses can at least partially be prevented by the use of this technique.

III. IMPLANTATION IN THE NASAL DORSUM

1. *Severe saddling of the bony and cartilaginous pyramid*

Implantation of material into the nasal dorsum in patients with a severe saddle deformity of the bony and cartilaginous dorsum is one of the oldest procedures in corrective nasal surgery. The first attempts to apply this type of implantation were made many centuries ago.

General agreement has not yet been reached, however, as to the technique and the material of choice. With respect to the technique, implants with a L-configuration are being discarded more and more widely. They lead to a rigid nasal pyramid with an immobile lobule, which gives the nose an unnatural appearance. Moreover, these types of reconstruction are highly subject to traumatic fractures and dislocation.

Concerning the type of implant material, there is considerable dispute. At present, the following materials are being used: 1. bone, autogenous (iliac spongiosa) or processed (Boplant^{R}, Kiel-bone^{R}), 2. rib cartilage (autogenous or homogenous), and 3. alloplastic materials (teflon, silastic et al.)

For the reasons mentioned above (see I), many authors prefer organic material, either autogenous or homogenous. Autogenous spongiosa taken from the iliac crest has been widely used. We too have obtained satisfactory results with this material. The main problem encountered with this technique is the occasional reabsorption of the graft. Another disadvantage is the additional operation required to obtain the material. Rib cartilage grafts do not become reabsorbed to any great extent, and from this point of view deserve preference over bone grafts.

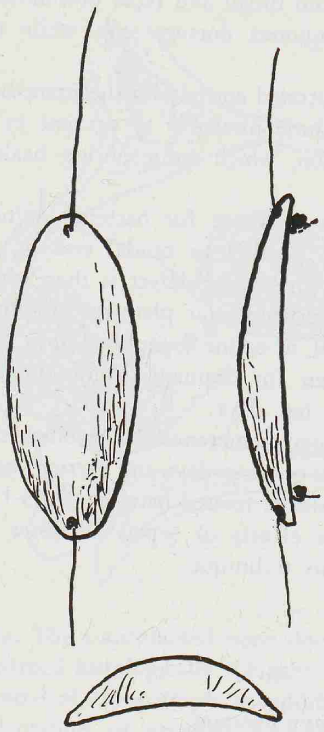


Figure 4. Graft of homogenous rib cartilage with guide - (c.q. fixation -) sutures for implantation in cases of saddling of the nasal dorsum.

If the patient's own rib cartilage is taken, the technical problem of making a straight graft out of a curved rib has to be solved, and the disadvantage of the additional operation remains. Therefore, like others, we are using homogenous rib cartilage from the bank. Reabsorption of this material too appeares to be negliglible, and an operation to optain it is not required. Besides, the ample amount of material available greatly reduces the problem of making a straight graft.

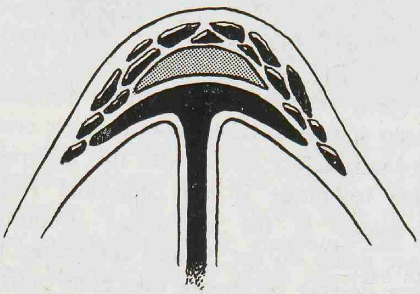


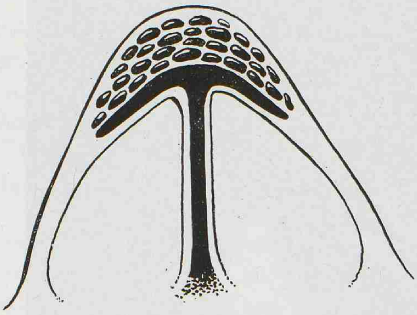
Figure 5. Interposition of crushed autogenous (c.q. homogenous) cartilage between rib cartilage graft and skin.

In our experience important factors for the application of this technique are:

1. wide undermining of the skin of the nasal dorsum throught two IC-incisions and a right-sided hemitransfixion,
2. fixation of the cartilage graft by means of guide sutures through both ends to avoid sliding (Figure 4), and
3. interposition of crushed cartilage between the graft and the skin (Figure 5). Autogenous septum cartilage is to be preferred for this purpose, but homogenous septum or rib cartilage can be used too.

2. *Sagging of the cartilaginous dorsum*

Sagging of the cartilaginous dorsum is a condition with which every rhinologist is familiar. Its most frequent cause is a submucous septum resection in which resection of the greater part of the cartilage was performed without subsequent reconstruction. It is also encountered after septal abscesses and haematomas, and as a result of atrophy of the upper lateral cartilages after trauma.
In patients with limited sagging an implantation of crushed septum cartilage often appears to suffice (Figures 6a and b). The best results are obtained, in our experience, with the patient's own septal cartilage, which if available is certainly to be preferred to other materials.
The cartilage is crushed to a pliable soft substance and is the cut into pieces measuring about 4 x 4 mm (Figure 6c). It is introduced into the dorsum



Figures 6a and b. Limited sagging of cartilaginous vault. This type of deformity can best be corrected by implantation of crushed cartilage. Preferably autogenous septum cartilage is used.

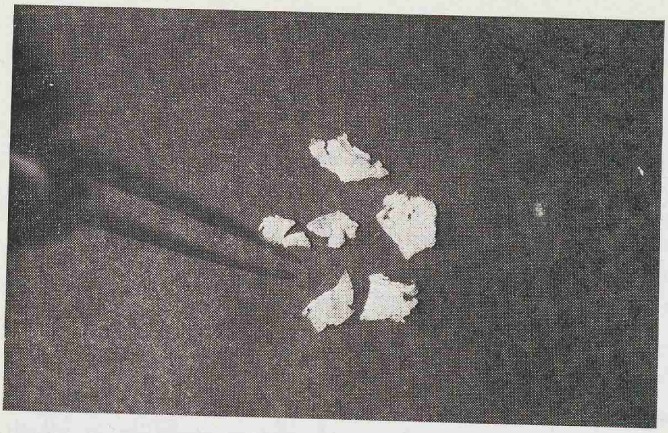


Figure 6c. The cartilage is cut and crushed to small pliable pieces.

through IC incisions and/or as a hemitransfixion molded into the desired form and fixed in place by a tape dressing. Over a period of 2 to 3 months the crushed cartilage will be partially transformed into connective tissue, thereby slightly diminishing in volume. A small overcorrection at the operation is therefore desirable.

Care must be taken that the cartilage is thoroughly crushed and completely freed

Figure 7. Growth of autogenous septum cartilage 3 years after implantation into the dorsum. Care should be taken that autogenous cartilage is thoroughly crushed and freed from perichondrial fibres.

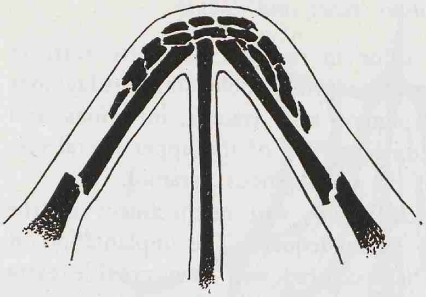


Figure 8. Implantation of crushed cartilage between an open bony dorsum and the skin in order to improve the quality and the thickness of the soft structures overlying the dorsum.

from perichondrial fibres. If these two conditions are not fulfilled, the material may become visible or palpable through the skin and growth may even occur (Figure 7).

If no autogenous cartilage is available, septum cartilage or rib cartilage from the bank may be employed. In that case greater reabsorption has to be reckoned with. The degree of this reabsorption differs widely and cannot be easily predicted. Sometimes, a little overcorrection appears to be sufficient. In other patients an additional implantation proves to be necessary. This secondary procedure should not be carried out too early, i.e. not within 4 to 6 months.

3. *Reconstruction of the bony dorsum after hump removal*

Resection of a bony hump with a saw, chisel, and/or rasp frequently results in what is called an open nasal roof. Although a defect of this kind can be closed by infracture of the medial sides of the nasal bones, some irregularity of the bony dorsum always remains. The same holds when the surgery of the hump does not lead to a completely open roof. In both conditions the interposition of crushed septum cartilage has proven to be of great value (Figure 8), because:

1. it prevents direct contact between the skin and the periosteum or even the mucosa of the internal nose, thus preventing development of the so-called open roof syndrome (local atrophy and pain, especially when the nose is exposed to cold air);

2. it masks small irregularities on the bony dorsum; and

3. its adds to the thickness and natural colour of the overlying skin. As is well known, the skin overlying a hump is usually thin due to the excessive bone growth. In these patients cartilage implantation of crushed cartilage can contribute appreciably to good results.
   If this implantation is carried out well and to a sufficient degree, the skin will be freely movable over the bony dorsum postoperatively.

4. *Correction of atrophy of the cartilaginous vault and lobule*

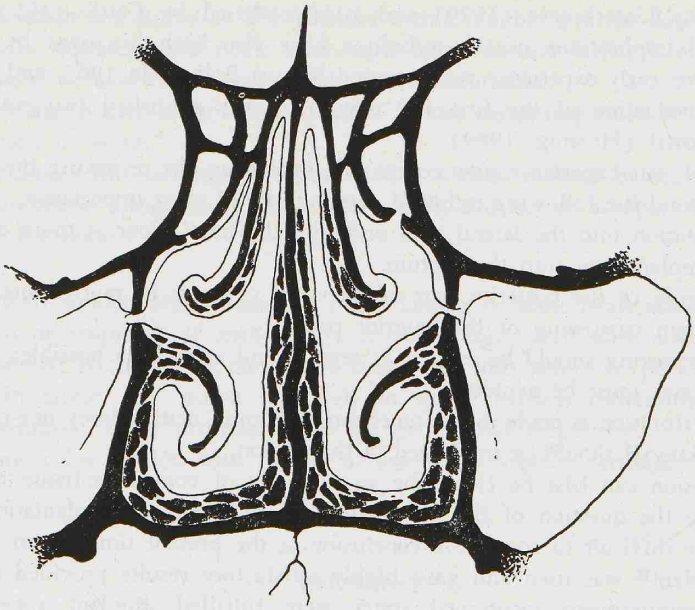
Implantation of cartilage can be of great value in cases of extensive scarring with retraction and depression of various parts of the lobule and cartilaginous dorsum. Deformaties of this kind are very common after trauma, infections, and repeated surgical procedures. They can be limited to one of the upper lateral cartilages or ala, or involve the greater part of the cartilaginous pyramid.
In these cases surgical correction with mobilization and readjustment of the various elements of the nose will generally be inadequate. The implantation of crushed cartilage in places where atrophy has occurred will then provide extra support and stiffness, add to the quality of the skin, and mask the deformities.

IV. IMPLANTATION INTO THE COLUMELLA

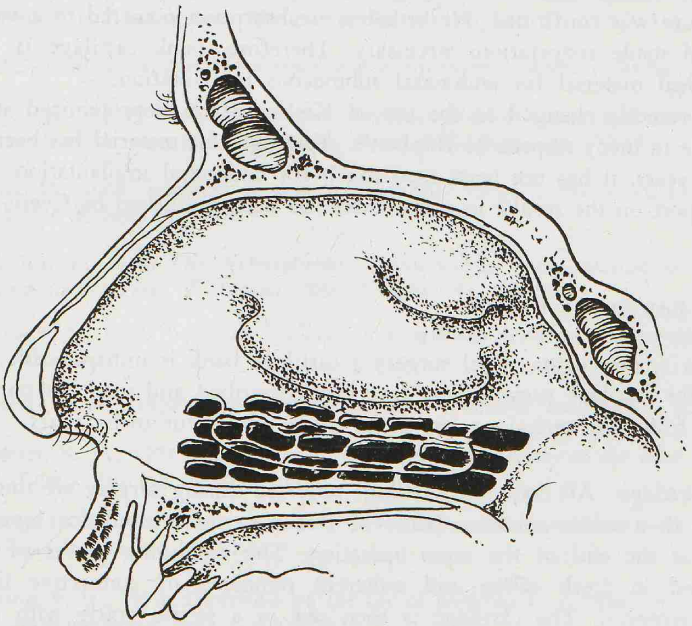
In the repair of a retracted columella two methods can be extremely useful: 1. reconstruction of the nasal spine, and 2. implantation of a strip in the columella between the two medial crura. For a more general information about the surgery of the retracted columella the reader is referred to Hinderer (1971).
In reconstructing the nasal spine a piece of bone can be implanted in front of the premaxilla. Frequently, part of a septal spur or spine can be adapted for this purpose. If autologous bone is not available, a piece of processed bone (Kiel-bone®) may serve equally well. It is essential to fixate the piece of bone in the proper place. For this purpose, a chromic catgut 3-0 guide suture attached to the implant and pulled through the skin at the base of the columella is used. Basal bunching sutures may help to keep it in place. Recently, in special circumstances, we have glued the implant to the maxilla by means of Histoacryl®. Spine repair is a rather simple procedure and proves to be very effective in diminishing the retraction of the columella base and enlarging the nasolabial angle. For reinforcement of the columella itself, a quandrangular strip of cartilage or bone can be implanted. In our experience the results obtained with septum cartilage are disappointing. This material is too flaccid and is partially reabsorbed. In our hands the use of autogenous bone taken from the perpendicular plate has given better results. After the bony plate has been trimmed to the desired dimensions, two holes are drilled in it through which the implant is fixed by means of two transcolumellar sutures.
Another possibility is the use of a strip of rib cartilage from the bank. In our experience this method should be considered inferior, because despite every precaution, strips of rib cartilage always tend to curl.

V. SUBMUCOUS IMPLANTATION IN THE NASAL CAVITY

In the treatment of atrophic rhinitis and ozaena, narrowing of the nasal cavity by submucous implantation is generally accepted as the best method of treatment available at present. Since 1962 we have made use in our Department of what could be called an All-Walls Implantation Technique. This method was originally



Figures 9a and 9b: Method of narrowing the internal nasal cavity by submucous implantation.



described by Unterberger (1929) and later modified by Cottle (1953). The details and implications of the technique have also been discussed by Barelli (1963). Our early experience was reported by van Bolhuis in 1967, and a more extensive evaluation of the first 102 operations was published two years later in this journal (Huizing, 1969).

As of 1974, our experience now covers 152 operations. In reviewing the results, we have found the following technical details to be of great importance:

1. Implantation into the lateral wall and into the nasal floor is more effective than implantation into the septum.
2. Narrowing of the posterior part of the nasal cavity is of much more importance than narrowing of the anterior part.
3. The narrowing should be carried as regular and smooth as possible; creation of recesses must be avoided.
4. If a perforation is made in the mucoperichondrium neither bony nor cartilaginous material should be implanted in this region.

The lesion can best be closed by an underlay of connective-tissue material. Concerning the question of the best material for submucous implantation, it is much more difficult to come to a conclusion at the present time. From 1962 to 1972, Boplant^{R} was used and gave highly satisfactory results provided that the technical requirements mentioned above were fulfilled. Boplant appeared to be reabsorbed very little, and reoperations for this reason have been extremely rare. Histological follow-up studies showed that the material was incorporated (Huizing, 1969). Since Boplant was taken out of production by the manufacturer, however, other material had to be sought. On the basis of the experiences of others, we chose bank rib cartilage. The very good acceptance of this material reported in the literature was confirmed. Nevertheless, reabsorption occurred to a very great extent and made reoperations necessary. Therefore, bank cartilage is certainly not the ideal material for endonasal submucous implantation.

We have recently changed to the use of Kiel-bone^{R}, a deproteinized spongiosa comparable in many respects to Boplant^{R}. Although this material has been known for many years, it has not been used much for endonasal implantation. A preliminary report on the results in a few cases has been published by Cvejic (1969).

VI. THE CARTILAGE BANK

In modern reconstructive nasal surgery a cartilage bank is indispensable. Various methods for cartilage preservation have been described and used. In our Department the following technique has given good results for many years.

Septum cartilage. All bone and cartilage removed during surgery are immediately immersed in a saline solution. Some of this material is used for septal reconstruction at the end of the same operation. The remaining pieces of cartilage are washed in fresh saline and adherent remnants of connective tissue are carefully removed. The cartilage is then put in a sterile bottle with a 0,5‰

Cialit solution and stored at 4°C labelled with a number and the date of storage. Originally, cultures were made from each bottle several weeks later, but since the results were always negative this was discontinued.
The cartilage is used within three months. Before being implanted it is immersed and rinsed in saline.
Rib cartilage. Rib cartilage is taken from a human cadaver by an aseptic surgical procedure within 24-36 hours after death and before autopsy. The criteria applied for donors are:

1. relatively sudden death caused by brain damage or acute heart disease, without infection or suspicion of malignancy. 2. young age, preferably under 40.
The material is cleared of connective tissue, cut into pieces of prescribed sizes, rinsed in saline, and stored separately in sterile bottless containing a 0.5‰ Cialit solution. These procedures too are carried out aseptically.
The same rules applied with respect to use as for septum cartilage.

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Dr. E. H. Huizing,
Department of Otorhinolaryngology,
University Hospital
Leiden, the Netherlands.