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Morphologic aspects of the injured nasal septum in children

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SUMMARY

Biopsies from the septal cartilage in children have been examined histologically to study the influence of trauma, surgery, septal abscess, and transplantation on the growing cartilage. Loss of cartilage, complete, but mostly incomplete regeneration of the defects are the main reactions. A regenerative potential mainly arising from the perichondrium plays an important factor for restoring the septal structure, often in a deforming and excessive way. Even preserved cartilage implanted immediately into the septal abscess, may be transformed into autogenous cartilage if the perichondrium is preserved.

Traumatization of the growing nose results in a deformation of the nasal structures with functional disturbances and cosmetic problems. However, trauma is only one factor which induces these deformations of the nasal region. We have to consider hereditary influences as well as the intrinsic and extrinsic factors of growth analyzing the nasal deformity. In spite of many experiments in growing animals we are not able to separate these different deforming influences and their interdependence in a single patient. Thus we cannot predict the influence of surgery alone when done in a growing nose although we have some long-term results of this surgery in children (details see Pirsig, 1977).

We have always to be aware of this weak point in our arguments when claiming for functional septorhinoplasty in children. To obtain good arguments against or for such a surgery we need a detailed statistical comparison of different populations including racial, hereditary, environmental and pathological data, but such a study is unrealistic for the moment.

Morphologic studies of single cases, on the other hand, may give essential information of the effects of trauma in the nasal region; however, such studies on the human septum are lacking in the literature.

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Therefore, within the last 6 years, we have made biopsies of the nasal septum in about hundred children during septorhinoplasty and have studied these speciment by light miscroscopy. Details on methods have been published previously (Pirsig, 1975; Pirsig and Lehmann, 1975).
All these children had a history of nasal trauma or septal surgery. In this paper we shall confine to some histological aspects of the growing cartilage and its perichondrium, especially their reaction to trauma, surgery, inflammation, and transplantation.

TRAUMA

Histologically the long-term reactions of the injured septal cartilage can be described by loss, incomplete, and complete regeneration of the cartilage. All three alterations are sometimes observable in one case (Figure 1B, 2), but in most cases we find incomplete cartilaginous regeneration. As we have reported of these reactions in detail recently (Pirsig and Lehmann, 1975) in this journal, we shall add only some summarizing remarks on this topic.
Loss of the septal cartilage is mainly the result of an infection of the injuried

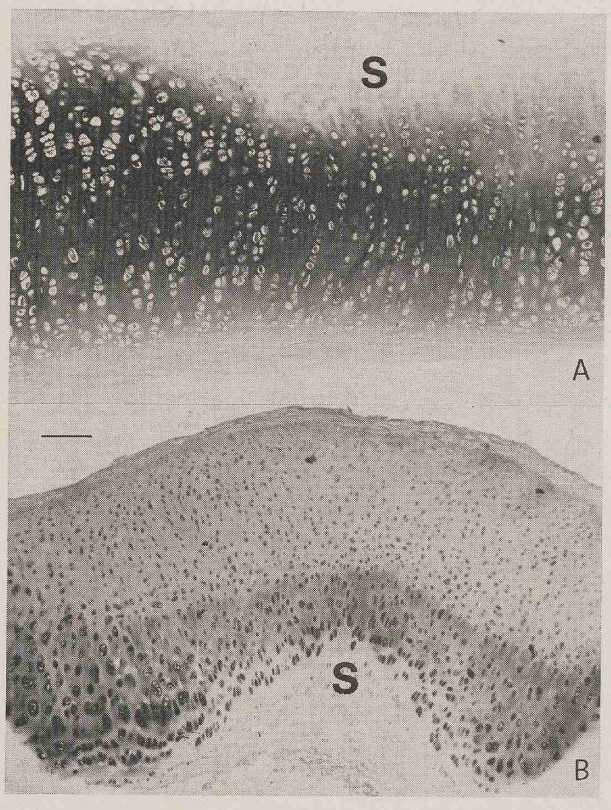

Figure 1A.
Boy (12 y), nasal trauma in early childhood. Biopsy from septal base. The incomplete cartilaginous defect is nearly completely repaired by new hyaline cartilage (S).

Figure 1B.
Boy (8/7 y), nasal trauma some years ago. Biopsy from a vertical incomplete septal fracture. The defect is filled by connective tissue (S) causing a bending of the cartilage. (A, B: hematoxylin/eosin; bar: 0.2 mm).

area which may cause a total necrosis of the cartilage as in cases of septal abscess. Loss of cartilage especially at its surface or within defects may be the result of cartilaginous resorption by invading granulation tissue during wound repair. The cartilaginous defect is replaced by fibrous tissue of different density and contents of blood vessels (Figure 1B). This fibrous scar may produce deforming forces on the surrounding cartilage both in incomplete and in complete septal fractures. In most biopsies there is no clear border between the surrounding perichondrium and these intracartilaginous scars which explains our difficulties of separating the perichondrium from this traumatized cartilage during septoplasty.

In most biopsies we find incomplete cartilaginous regeneration in the areas of the destroyed cartilage. This means that small zones of regenerated cartilage and fibrous tissue fill the defect, the new cartilage often in continuation of the original cartilage.

Complete cartilage regeneration is rare and means that the defect is totally filled by cartilage which can be distinguished from the original cartilage only by finer histochemical methods or by the arrangement of the chondrocytes (Figure 1A). If a complete interruption of the septal cartilage occurred by trauma or surgery we could never demonstrate a complete cartilaginous healing of the defect in our material.

When nasal injury takes place in early childhood, cartilaginous regeneration may arise from small torn pieces of perichondrium in the neighbourhood of the regular septal cartilage (Figure 2). This regeneration may be very ex-

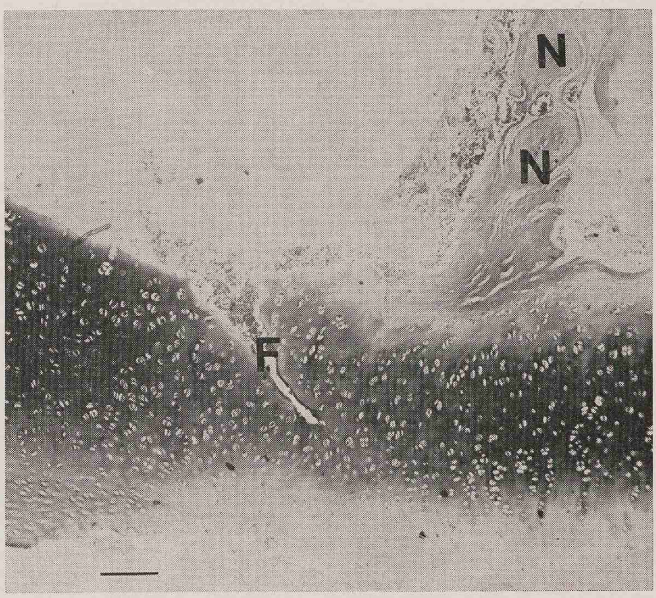

Figure 2.
Boy (12 y, same as in fig. 1A). Biopsy from injured septal base with fresh surgical lesion (F) and two islands of regenerated hyaline cartilage (N) within the injured perichondrium (Hematoxylin/eosin; bar: 0.2 mm).

cessive resulting in a separate "second" septal plate, consisting of small islands of cartilage, connective tissue and vessels. All our biopsies with this excessive paraseptal cartilaginous regeneration are from children with a history of nasal trauma in the first three years of life. Ohlsén (1978) has reported of the potential of the perichondrium in the auricle to create cartilage, even for the case of a free perichondrial graft, and has shown its potent force for restoring the normal anatomy of the auricular cartilage in congenital deformities.

INFLUENCES OF SURGERY

In a previous paper (Pirsig, 1975) we could show histologically that regeneration of the septal cartilage takes place at the resected borders of the cartilage in children by appositional and interstitial growth. Often during septoplasty we resect a vertical strip of the septal cartilage of 2 to 3 mm width to get rid of the tension of the deviated septum. Some of these children have to be reoperated some years later because of new nasal obstruction sometimes just in the area where the cartilaginous strip had been removed years ago. The former defect is usually filled by new cartilage expect of a fibrous bridge of 0.1 to 0.3 mm width which connects the regenerated borders of the septal cartilage (Figure 3). In some cases we see during the reoperation that these two borders can overlap each other thus forming a broad compound which produces the nasal obstruction.

The cartilaginous regeneration seems to arise mainly from the perichondrium which is left intact during septoplasty, but there are also signs for interstitial cartilaginous growth. Except of the more immature stage there is no histochemical difference between the regenerated and the original septal cartilage. The random arrangement of the regenerated chondrocytes and the numerous isogenic groups near to the perichondrium (Figure 3) helps to mark off the new cartilage from the normal cartilage with its most columnlike order of its chondrocytes.

The cartilaginous regeneration following surgery is of different amount in various sites of the child's septal cartilage: there can be excessive growth in the zones of the vertical strip-defects, and marked growth at the borders of the caudal end, while regeneration is not so marked at the base of the septal cartilage.

In all specimens of septal cartilage after surgical trauma the regressive changes at the cartilaginous surface were minimal or lacking.

From these morphological observations we conclude that partial cartilaginous regeneration takes place in the growing septum following smaller surgical defects if the perichondrium is preserved. In many cases the regenerated cartilage may fit into the septal structure, but there are examples of un-

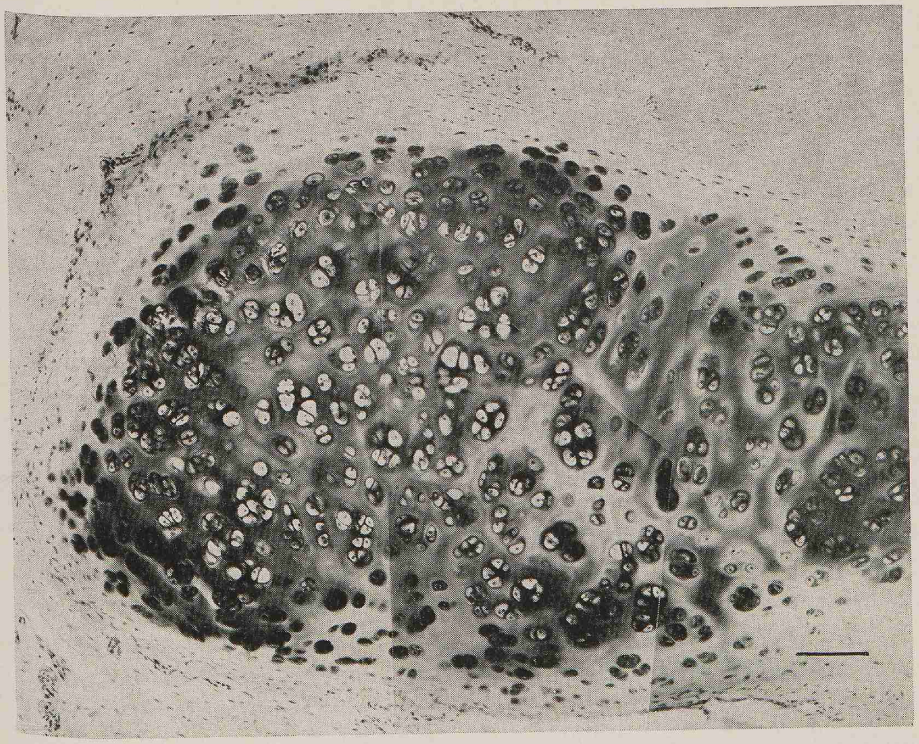

Figure 3. Regenerated cartilage of about 1 mm length in a resected septal border 2/10 years after septoplasty in a 11/9 y old boy. Like a cap the perichondrium is surrounding the new cartilage the diameter of which is larger than that of the original septum visible on the right (Hematoxylin/eosin; bar: 0.1 mm).

directed and excessive regeneration, too. Both morphologic findings correspond to the clinical experience which was summed up by Wexler (1963): "The growth potential of the septal cartilage is undetermined in any one case, but as a rule the remaining septum continues to grow and may even produce an obstruction on one side or many years later, which may need a further correction".

SEPTAL ABSCESS

Although the clinical entity of the septal abscess was recognized in 1830 by Cloquet a satisfying treatment has not been found before the sixties of our century: In Europe Huizing from Leiden and Masing from Erlangen, inspired by discussions on this subject during the Nasal Surgery Course given by Cottle and associates in Leiden 1963, implanted preserved cartilage immediately into the cleaned pocket of the septal abscess. They were surprised how well the implant was taken and the typical shrinkage of the nose

was prevented. In 1965 Masing reported of his first successful implantations in children with septal abscess, Hellmich and Huizing had the same experiences.

The septal abscess may lead to a total loss of the septal cartilage including the upper lateral cartilages, because the cartilage is resorbed. Usually when draining the abscess via the hemitransfixion we find a hole in the septal cartilage. The cartilaginous remnants around this hole consist of a bluish shining paper-thin frame of dying hyaline cartilage from which a biopsy is demonstrated in Figure 4. We find a resorption of the healthy cartilage by the enzymes of the white blood cells which causes destruction of the cartilage within a few days. The perichondrium shows signs of heavy inflammation and is covered with granulation tissue which should be grossly removed when cleaning the pocket of the abscess.

Drainage of the abscess alone – the usual acute therapy formerly – leads to a saddle nose by scar formation between the two mucoperichondrial layers. We have examined these septal scars in some cases years after drainage of the septal abscess in childhood. Islands of new cartilage are scattered between dense connective tissue and single vessels (Figure 6). In these cartilaginous islands the chondroblasts and chondrocytes are randomly arranged. As there are no signs of resorption or regression in this new cartilage, we conclude that these islands have been regenerated from the surviving perichondrium in the years following the septal abscess.

Thus we can speak of a certain regenerative potential of the septal perichondrium in children although it has been damaged by inflammation and by the following scar formation. Of course these islands of new cartilage within the scar can not prevent the formation of a saddle nose.

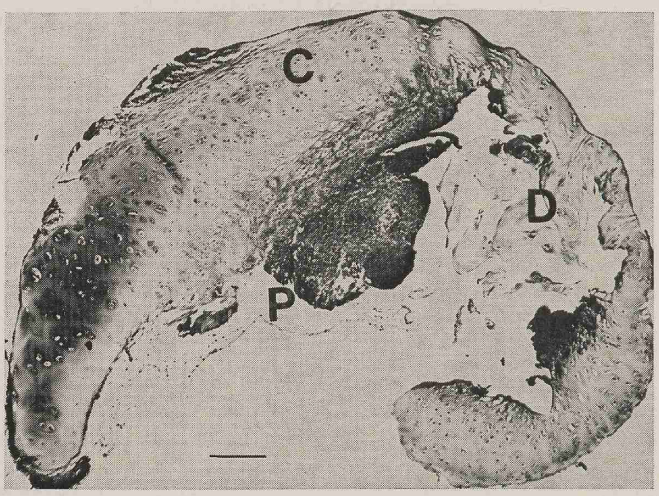

Figure 4.
Boy (7/9).
Septal abscess following trauma 10 days ago. Biopsy from necrotizing septal cartilage. Parts of intact cartilage (C) near to dead cartilage (D) and pus (P). (Hematoxylin/eosin; bar: 0.2 mm).

When we treat the septal abscess with drainage of the pus, removal of granulation tissue and of necrotic cartilage, and immediate implantation of preserved cartilage we usually get good functional and cosmetic results. In one of our cases of an 11 year old boy we found no septal cartilage ten days after trauma and implanted three pieces of rib-cartilage (preserved in Cialit® 1:5000) to reconstruct his septum. 4 Years later the boy of 15 complained of breathing difficulties during physical exercise. His nose had a normal size and shape. We reoperated because of some slight septal obstruction in the valve area and found to a large extent nearly normally looking autogenous cartilage, only a little crooked and disfigured and with a thick block formation in the valve area. We removed parts of this cartilage and reimplanted autogenous rib-cartilage to reconstruct his septum again. His nose is normal today, two years later. Histology of the removed cartilage was more surprising than the intraoperative findings: The place where we had implanted the preserved cartilage four years ago, was indeed largely filled by regenerated autogenous cartilage. In some parts as seen in Figure 5 remnants of the implanted preserved cartilage could be observed. They were surrounded by connective tissue and autogenous new immature hyaline cartilage. Even zones of direct transition between the autogenous and preserved cartilage could be found. In periodic acidleucofuchsin stained sections a lot of glycogen is demonstrated in most of the autogenous chondrocytes, while no glycogen is present in the chondrocytes of the preserved cartilage. Astrablue stained sections reveal another difference: the chondrocytes of the regenerated autogenous cartilage have red stained nuclei as compared to the chondrocytes of the preserved cartilage with lacking nuclei. Furthermore differences in the size and arrangement of the chondrocytes in both types of cartilage are clearly visible (Figure 5).

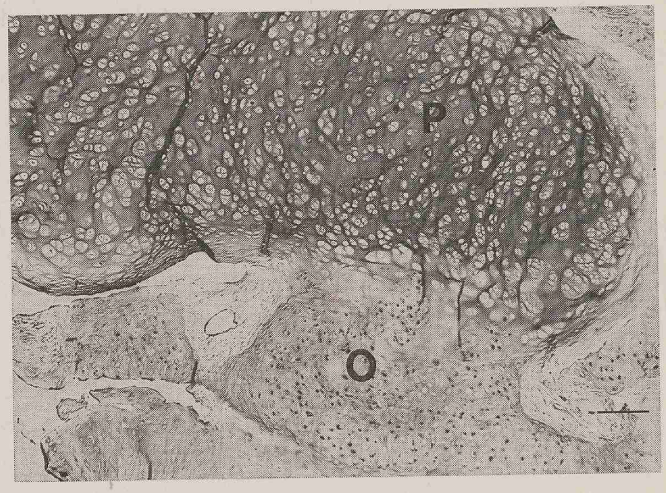

Figure 5.
Boy: Immediate implantation of preserved cartilage into septal abscess at 11 years. Removal of parts of this implant at the age of 15 years: Preserved cartilage (P) in transition into autogenous regenerated cartilage (O). (PAS-reaction; bar: 0.2 mm).

From the intraoperative and histological findings of this case we may conclude that in children preserved cartilage after immediate implantation into septal abscess is slowly replaced by autogenous cartilage from the surviving perichondrium in spite of total loss of the original septal cartilage. This explains our clinical experience that most of the children, whom we implanted preserved cartilage immediately into the septal abscess, need no further exchange of this cartilage after some years of growing, because the regenerated autogenous cartilage grows at nearly the same pace as the child's nose.

ECTOPIC TRANSPLANTATION

Each rhinosurgeon has his "bitter experiences" after transplantation of small pieces of septal cartilage into the nasal dorsum to correct a small saddle. Some months later a small hump may arise from such an autogenous implant – even in adults – because of the regenerative potential of the remaining perichondrium attached to the transplanted cartilage. Among our biopsies we have single cases in which this regeneration of cartilage with hump formation can be demonstrated after transplantation into the nasal dorsum. Our interest was more directed to the reactions of the transplanted septal cartilage without perichondrium.

In 1945 Peer reported of a 7 year old child in whom he transplanted a piece of septal cartilage without perichondrium ectopically and measured an increase of the transplant after 1.5 years. We transplanted a small piece of septal cartilage without perichondrium subcutaneously into the retroauricular fold in 6 children aged 7 to 14 years. This graft was gained from a vertical cartilaginous strip and stored for a future reoperation. The implants were removed after 2 to 5 years and were serially sectioned. They showed no increase in size.

Histologically the alterations of the implants can be described in a scale of reactions from minimal cartilaginous regeneration to ossification. Signs of surface resorption by granulation tissue were only minimal in all specimens. In some cases there was a partial cartilaginous regeneration around the original cartilaginous core (Figure 6B). In one case we noticed a partial calcification of the septal cartilage, in another case we found a nearly total transformation of the cartilage into laminated bone (Figure 6C). These findings are in contradiction to Peer's observations and to our expectations according to which more resorption of the transplanted cartilage without perichondrium was supposed. On the other hand we know that it is very difficult to remove all perichondrium from a septal cartilage in a child. The innermost layer is always fixed to the cartilage and seems to be the protector against massive resorption on one side, and the source of the minimal car-

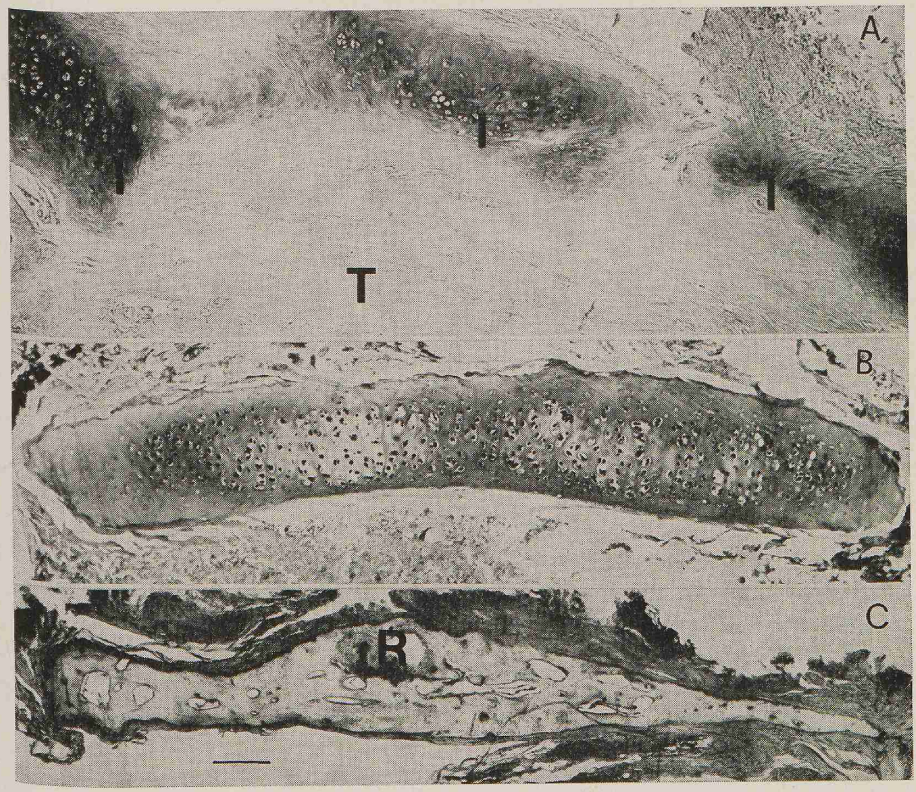

Figure 6.
A. Girl (14/3), subtotal loss of septal cartilage by abscess with 3 years. Horizontal section through scar tissue between the mucosal flaps. Islands of regenerated hyaline cartilage (I) within dense connective tissue (T). (Astrablue).
B. Boy: Retroauricular transplantation of septal cartilage without perichondrium at 7 years. Removal of the implant after 3 years. Minimal cartilaginous regeneration at both ends with signs of resorption at the surface. PAS-reaction.
C. Girl: retroauricular transplantation of septal cartilage without perichondrium at 12/9 years. Removal of the implant after 5/3 years. Transformation of the implant into laminated bone except of some cartilaginous remnants (R). Toluidineblue/ pyronin. (Bar: 0.2 mm).

tilaginous regeneration on the other hand. Perhaps this imcomplete removal of the perichondrium from the graft explains the finding of Peer of an increase of the ectopically transplanted septal cartilage.

CONCLUSIONS

In children we observe a partial regeneration of the septal cartilage following spontaneous or surgical trauma.

The regenerated cartilage shows a random arrangement of its chondrocytes

and may grow excessively and indirectly thus producing nasal obstruction. The main source of this cartilaginous regeneration is the perichondrium. Infection and surgical trauma of the perichondrium may reduce this regenerative potential. As in the auricle cartilaginous regeneration may arise from isolated pieces of septal perichondrium.

If the incomplete cartilaginous defect is mainly replaced by fibrous tissue structural alterations of the surrounding cartilage as bending and angulation are observed.

In septal abscess the regenerative potential of the perichondrium may help a transformation of preserved immediately implanted cartilage into autogenous hyaline cartilage in children.

Ectopically transplanted septal cartilage with perichondrium may have a regenerative potential, while cartilage without perichondrium has nearly no growth potential and undergoes regressive alterations.

ZUSAMMENFASSUNG

Biopsien aus dem Septumknorpel von Kindern wurden histologisch untersucht, um die Auswirkungen von Trauma, Chirurgie, Septumabszeß und Transplantation zu studieren. Die typischen Reaktionen sind Knorpelverlust, komplette und am häufigsten inkomplette Knorpelregeneration. Dabei spielt das Perichondrium die Hauptrolle als regeneratives Potential, wobei der regenerierte Knorpel nicht nur zur Wiederherstellung der normalen Septumstruktur dient, sondern oft deformiert und im Überschuß gewachsen zur Nasenobstruktion beiträgt. Auch konservierter Knorpel kann bei Kindern, wenn er sofort bei der Therapie des Septumabszesses implantiert wird, in autologen Knorpel transformiert werden, wenn das Perichondrium erhalten bleibt.

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