The influence of trauma on the growing septal cartilage

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SUMMARY

In 34 children biopsies of the nasal septum which had formerly been traumatized by force or surgery, are histologically examined. The long-term reactions of the injured septal cartilage can be described by loss, incomplete and complete regeneration of cartilage. In most cases the regeneratioen of the cartilage is undirected, thus causing deformation of the nasal septum.

IN children to the nasal framework is mainly built up by hyaline cartilage which increases by appositional and interstitial growth. The growth potential of this septal cartilage was demonstrated by Peer (1945) who transplanted a piece of septal cartilage without perichondrium in a 7 years old boy and measured an increase in length and width of the removed transplant 1.5 years later. In a recent study (Pirsig, 1975) the regenerative potential of surgically traumatized septal cartilage of 8 children after conservative septoplasty was shown by histological methods.

In the literature we could not find investigations on the long-term effect of nasal injury on the behavior of the septal cartilage in children except for some clinical observations which Wexler (1963) summed up: "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 further correction".

This study will add some information on the morphological background of this clinical experience in describing histologically some alterations of the growing septal cartilage of children with old nasal injuries.

MATERIAL AND METHODS

Seventy-four specimens of septal cartilage from 34 children (26 boys, 8 girls; aged 5.2 to 14.5 years, 50% younger than 10.5 years) have been examined under the lightmicroscope. From 26 children the biopsies were taken in septoplasty when signs of old septal trauma were found such as incomplete or complete fractures, organized hematomas, cartilaginous defects, scar tissue or atrophic mucoperichondrium. From 8 boys the septal biopsies were taken at subsequent nasal operations which were necessary because of new nasal obstruction 1.2 to 3.9 years after the

Figure 1: a: Girl (14/3 y). Subtotal loss of septal cartilage by septal abscess with 3 years. Horizontal section through scar tissue between the mucosal flaps. Regenerated cartilage at the border of the cartilaginous defect (1) and in the dense scar tissue (2; 3).

b: Boy (13/4 y). Frontal section through subperichondral area of the septal base where 2 years ago a basal strip of cartilage had been excised. Regenerated cartilage in scar tissue with signs of metabolic disorders: unmasked matrix and polymorph chondrocytes. (A; B. Hematoxylin/eosin; bar 0.1 mm).

first septoplasty (Pirsig and Knahl, 1974). These 8 cases are examples for surgical trauma and have been described in detail in a former paper (Pirsig, 1975). The specimens were excised from areas of septal trauma, i.e. from the free caudal end of the septum, from the deviated septal base on the premaxillary-maxillary crest, or from fractured or angulated bends in the valve area where strips of cartilage were removed to relieve the tension of the deviated septum. In 3 cases of cartilaginous defects by septal abscess thickened scar tissue between the mucosal flaps was excised and studied. In cases of a second septoplasty biopsies were taken from the formerly created septal defects where excessive growth of cartilage could be found to cause nasal obstruction. In some specimens there was left some of the innermost layer of the perichondrium attached to the excised cartilage, because in children it is impossible to perform an exact separation between cartilage and perichondrium.

The samples of cartilage were fixed in formol-alcohol and embedded in paraffin. The 5 to 7 μm thick sections were stained with hematoxylin and eosin, Giemsa, 1% Astrablue and toluidineblue-pyronin (Trump et al., 1961). Some sections were treated with periodic-acid-Schiff reagents according to the method of Hotchkiss and McManus to localize carbohydrate-protein complexes and glycogen in the cartilage.

RESULTS

The long-term reactions of the growing septal cartilage to trauma by force or surgery may finally result in loss, incomplete and complete regeneration of cartilage. One can find all three modifications in one case (fig. 2c). Thus it is difficult to give exact numbers for the single types of reaction in our material. In most cases we find the incomplete cartilaginous regeneration.

Loss of septal cartilage is observed in cases of severe injury in the caudal end of the septum (fig. 2c) or after septal abscess (fig. 1a), but also in the areas of surgically created defects (fig. 4b). The cartilaginous defect is replaced by fibrous tissue (fig. 2a; 2c-1; 4b) of different density and contents of blood vessels. In the 3 cases of septal abscess there was a denser fibrous tissue with only a few vessels (fig. 1a).

In most of our biopsies we could find *incomplete cartilaginous regeneration* in the areas of the destroyed cartilage. This type of regeneration shows small islands of cartilage within the fibrous tissue (fig. 1a) or in continuation of the original cartilage (fig. 1b; 2c-2; 3; 4b). In some cases the appearence of the regenerated cartilage is very different of its normal cartilaginous surrounding (fig. 2c-2), but very often it is similar to that of the normal young cartilage (fig. 1a; 3; 4b).

Thus the exact transition from the original cartilage to regenerated cartilage cannot easily be determined (fig. 3). In 6 cases where nasal injury occurred within the first three years of life we found newly formed compounds of cartilage beside the original septal cartilage in the submucosal connective tissue (fig. 4a). This ectopic cartilage looks like normal young cartilage except for its undirected growth and the granulation tissue between its cartilaginous islands.

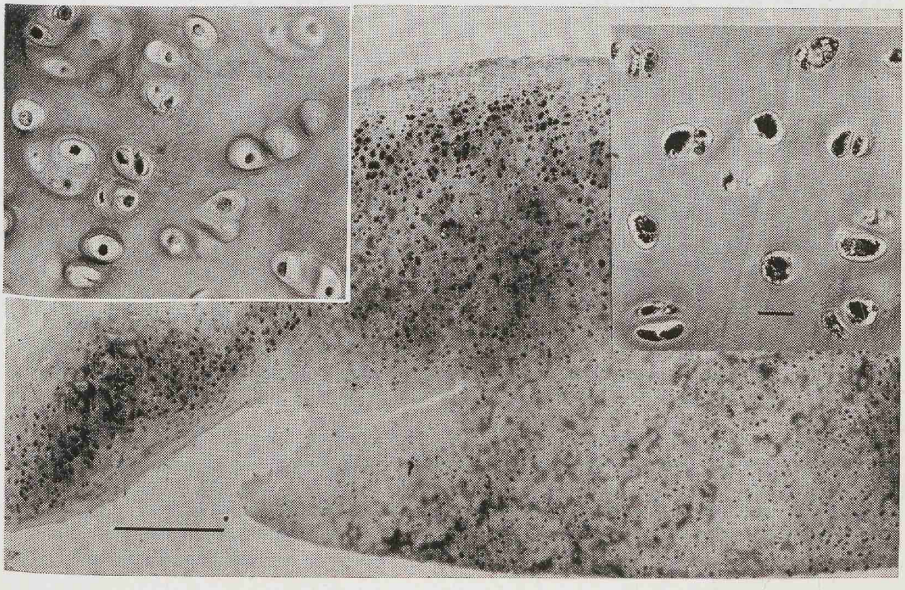
Figure 2: a: Girl (5/9 y). Nasal injury 2 years ago. Horizontal section through a vertical strip from valve area. The cartilaginous defect is filled by dense connective tissue (arrow).
b: Boy (9/2 y). Nasal trauma in early childhood. Frontal section through septal base. The defect (arrow) is completely repaired by new hyaline cartilage.
c: Girl (12 y). Nasal trauma 2 years ago. Horizontal section through caudal end of the septum. One defect (1) is filled by granulation tissue, another (2) is incompletely replaced by new cartilage. Fresh surgical lesion (3) through the anterior septal pole with young chondrocytes. (A; B; C. Hematoxylin/eosin; bar: 0.2 mm).

Complete cartilage regeneration is rare and means that the defect is totally filled by cartilage which could be distinguished from the original cartilage only by histochemical methods. In our example (fig. 2b) there is even a columnlike orientation of the regenerated cartilage.

If complete interruption of the cartilage occurred by trauma or surgery there has never been observed a complete cartilaginous healing of the defect in our material.

Always a small fibrous bridging of at least 0.2 to 0.3 mm width will persist between the partially regenerated borders of the septal cartilage (fig. 4b).
Regenerating cartilage differs from normal growing cartilage of the growing septum by histological and histochemical criteria: Mainly single elliptic or round chondrocytes of small diameter are embedded in matrix areas. A distinction of territorial and interterritorial matrix is often difficult (fig. 2c-2; 3 inset; 4a). The distance between two chondrocytes may cover a wide range (compare fig. 2c-2 to fig. 3 left inset). In other sections isogenic groups of chondrocytes with a high rate of division are already located in the subperichondral zone (fig. 1a; 4b). With a few exceptions (fig. 2b) there is a random arrangement of the chondrocytes of the regenerated cartilage (fig. 1a; 1b; 2c; 3; 4a; 4b). Histochemically the young, chondrocytes in the area of repair have less periodic-acid reacting matrix compared to older chondrocytes (fig. 3 insets). The metachromasia of the cartilage matrix is intensified, while basophilia and periodicacid reaction is diminished (fig. 2b; 3; 4b). In four cases the connective tissue is characterized by numerous vessels, invading the young cartilage. As signs of metabolic disorder the chondrocytes show polymorphia and an unmasked matrix shows different histochemical behavior (fig. 1b). In two cases of regenerated cartilage after surgical trauma we found small areas

Figure 3 : Boy (12/6 y). Oblique-horizontal section through the trimmed caudal end of the septum which had regenerated partially 1.2 years after septoplasty, thus causing new subluxation. The transition of the regenerated cartilage with defect (left) and original septum (right) cannot be determined. (Hematoxylin/eosin; bar: 0.5 mm). Insets: Different contents of periodic-acid-Schiff reacting granula in the chondrocytes of the regenerated (left) and original (right) cartilage. (PAS-reaction; bar: 15 μm).



of dead chondrocytes enclosed by young cartilage without blood vessels (fig. 4b). In all specimens there could not be observed calcification as a sign of degeneration in the cartilage.

COMMENT AND CLINICAL CONCLUSIONS

The regenerative potential of the septal cartilage in children after trauma by force or surgery is the main finding of this study. This is in contrast to our everyday experience with injured septal cartilage in adults. The few histologically examined cases of traumatized septa in adults (Zuckerkandl, 1892; Fuchs, 1932; Fry, 1967; Hellmich, 1973) show a fibrous healing of the cartilaginous defects and practically no regeneration of cartilage.

The histological and histochemical appearence of the incompletely or completely regenerated cartilage is similar to that of other hyaline cartilage in repair (Graumann, 1964). In regenerating cartilage the random arrangement of the chondrocytes is more frequently found than in normal growing septal cartilage. It would be of interest to investigate the internal mechanical tensions of this new cartilage. Fry (1967) who studied this question in the septum of the adult has proposed an explanation why the distortion of an incompletely fractured nasal septum may worsen with the passage of time. In many of our cases the regenerated cartilage shows a behavior like incompletely fractured cartilage.

There are some smaller differences of the regenerated cartilage depending upon the history, i.e. trauma by force or surgery, time of injury, perichondritis following septal abscess. Regeneration seems to be stimulated when injury happened in early childhood, or when the chondrogenic tissue is not too much altered by trauma or infection.

The regeneration of cartilage mainly arises from the perichondrium. In cases of perichondritis and cartilaginous necrosis the submucosa and the perichondrium are severely altered. This explains the dense scar tissue with only a few vessels between atrophic mucosal flaps and the minimal regeneration of cartilage within this scar tissue. This scarring can partially be prevented by the immediate implantation of preserved homologous cartilage in cases of fresh septal abscess, as has been shown by clinical experience (Masing and Hellmich, 1968; Huizing, 1970).

When creating small cartilaginous defects during septoplasty it is important to preserve as much perichondrium as possible, thus, to a certain extent, cartilaginous regeneration will be stimulated during the growth of the septum. In some cases after septoplasty, as reported in another paper (Pirsig, 1975), this regeneration can be excessive or undirected and will cause new obstruction (Wexler, 1963, Pirsig and Knahl, 1974).

On the other hand and specially in early childhood cartilaginous regeneration can arise from loose connective tissue replacing for instance a small submucosal hematoma outside the perichondrium. In such cases the newly formed cartilage may be broader than the original septum and can imitate a "second" septum. After removal one can always find a floppy plate of cartilage mixed with con-

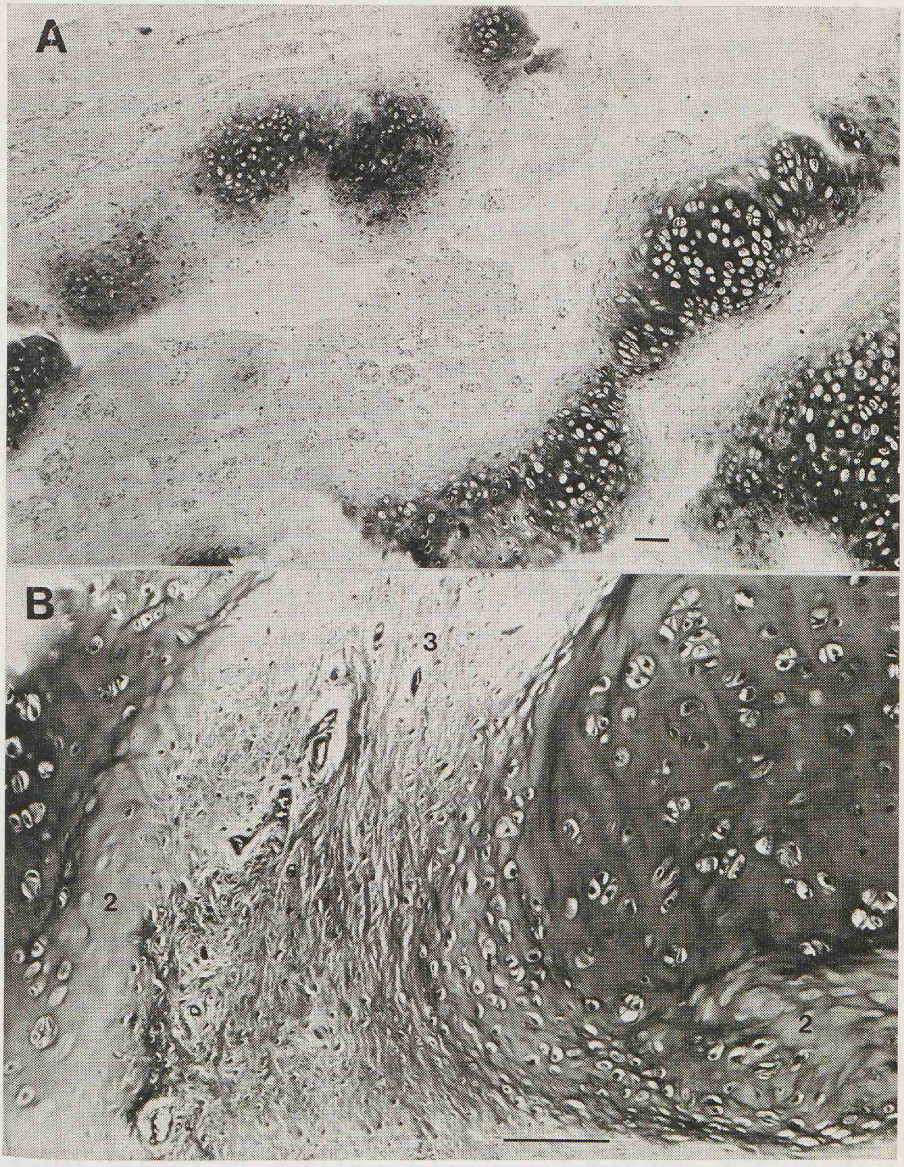


Figure 4: a: Boy (8/11 y). Nasal trauma with one year resulting in a "double" anterior septum. The second septum is built up by islands of regenerated cartilage and connective tissue with numerous blood vessels. (Hematoxylin/eosin; bar: 0.1 mm).

b: Boy (8 y). Horizontal section through a vertical septal defect of the valve area resulting from excision of a cartilage strip 1.7 years ago. A fibrous bridge (3) of about 0.2 mm width connects the borders of the septal cartilage which show regenerated cartilage (1) and small areas of dead chondrocytes (2). (Toluidineblue/pyronin; bar: 0.1 mm).

nective tissue. Therefore this floppy plate is of no use in septoplasty to build up a new septal support.

Except for the better regenerative potential in the younger child there could not be observed marked differences of age, as well as of sex. But our technique of taking only small biopsies does not justify quantitative considerations. A common finding in children and adults is that complete cartilaginous fractures never heal by a cartilaginous bridge. Inspite of the cartilaginous regeneration at the borders of the septal fragments in children there is always a fibrous bridge between the two fragments as in adults (Zuckerkandl 1892).

ZUSAMMENFASSUNG

Bei der Septumkorrektur von 34 Kindern wurden Proben aus dem Nasenseptum gewonnen, wenn dieses durch Gewalt oder Chirurgie vor mindestens einem Jahr traumatisiert worden war. Die Biopsien wurden lichtmikroskopisch und histochemisch untersucht, wobei als Reaktionen auf das Trauma am häufigsten inkomplette und selten komplette Knorpelregenerationen gefunden wurden. Das Knorpelregenerat wächst meist ungerichtet und ist dadurch oft Ursache für eine Verlegung des Nasenlumens. Auch im Narbengewebe nach Knorpelnekrosen durch Septum Abszess ist im geringen Ausmass regenerierter Knorpel zu finden. Konsequenzen aus diesen Befunden für die Septumkorrektur werden diskutiert.

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