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Reimplantation of autologous septal cartilage in the growing nasal septum

I. The influence of resection and reimplantation of septal cartilage upon nasal growth: an experimental study in rabbits

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SUMMARY

The effects of restoration of the dorso-ventral continuity of the nasal septum on the growth of the nose was investigated in growing rabbits.
Submucous resection of the middle third of the septal cartilage resulted in characteristic growth disturbances of nose and maxilla. Reimplantation of the resected strip of autologous cartilage did not restore the normal development of the nose. The implants however did prevent septal perforations as seen after resection of cartilage only and showed a considerable growth in dorso-ventral direction.

INTRODUCTION

The abnormal development of the nose after septal surgery in young children was described already by Hayton (1916) and later by Ombrédanne (1942). Therefore septal surgery with the old resection techniques (Freer, 1902; Killian, 1908) in children was delayed as long as possible. This traditional caution decreased with the introduction of septal correction procedures (Cottle, 1951; Goldman, 1956; Masing, 1971). Before abandoning the conservative appproach to septal surgery in children, it is important to know whether or how these modern septal correction techniques do disturb the further growth of the nose.

There is insufficient clinical evidence to support the reduced caution with septal surgery in children (Jennes, 1964; Pirsig and Knahl, 1974; Pirsig, 1977). In most cases the follow-up period is too short and does not extend after completion of the adolescence growth spurt. Huizing (1979) described the follow-up period of a boy, who developed characteristic growth disturbances during his adolescence growth spurt 12 years after septal correction.

Experimental studies in the last two decades suggest an important role of the septal cartilage in the postnatal growth of the nose and maxilla (Sarnat and Wexler, 1967a, 1967b; Ohyama, 1969; Kremenak and Searls, 1971; Kvinnsland, 1974; Verwoerd et al., 1976, 1979b).

A series of experimental studies in rabbits on growth of the facial skeleton (Verwoerd-Verhoef, 1974; Urbanus, 1974; Mastenbroek, 1978) lend support to the hypothesis that the "extra" postnatal growth of the midface depends mostly on the growth of the cartilaginous nasal septum (Verwoerd et al., 1979b). This "extra" growth will not occur when the antero-posterior continuity of the nasal septum is disturbed. Submucous septal resection and correction procedures in young animals lead to shortening and other typical anomalies of the nose and maxilla (Nijdam et al., 1979; Rhys Evans, 1981).

In modern corrective septal surgery in patients the original structure of the nasal septum is respected as far as possible, although resection of small horizontal or vertical strips of cartilage is of common use. However, larger deviated parts of the septal cartilage sometimes need to be removed, followed by reimplantation. If necessary, this resected cartilage has to be crushed, trimmed to size or rotated before reimplantation. Using the above mentioned septal corrective procedures, an experimental study was performed in growing rabbits, to answer the following questions:

- what effects does a discontinuity in the septal cartilage have on the growth of the nose and maxilla, when a 1 cm vertical strip in the middle of the septal cartilage is resected.
- does repair of the continuity of the septum by autologous septal cartilage after this type of resection lead to restoration of the normal growth pattern of the nose and maxilla, does "processing" or position of the implant make any difference with regard to the development of the nose and maxilla.

In this first article the results of reimplantation of nonprocessed autologous septal cartilage in its original position will be described. In a second paper the efffects of reimplantation of crushed and rotated autologous septal cartilage will be discussed.

MATERIALS AND METHODS

In this study, which links up with the earlier experiments on growth of the facial skeleton (Verwoerd et al., 1980), experimental groups of 15 animals and a control group of 20 young female New Zealand white rabbits were used.

The operation took place at the age of 4 weeks.

Under general anesthesia with nembutal, a vertical fissure was made in the left os nasale, just caudal of the sutura naso-frontalis using a 1 mm burr, followed by an incision of the sutura internasalis. As a result of this procedure, the greater part of the left nasal bone could easily be rotated laterally.

After incising the nasal mucosa and upper laterals, submucoperichondrial tunnels were made on both sides of the middle third of the septal cartilage.

Former experiments of Nijdam (1979) demonstrated that this "tunneling" technique did not disturb the normal growth of the facial skeleton.

In group I, a submucous resection of a 1 cm vertical strip in the middle of the septal cartilage was performed (Figure 1).
In group II, this submucous resection was followed by immediate reimplantation of the cartilage strip in the same position, using a catgut fixation suture (Figure 2).
The postoperative mortality was 8: 1 due to cardiac arrest during surgery and 7 by gastro-enteritis, before the end of the experimental follow-up period.
At the end of 24 weeks, the full grown animals were sacrificed. After inspection of the severed head, the nasal septum was studied from both sides, before and after removal of the muco-perichondrium by way of the orbita and apertura piriformis. Via these portals measurements were made of the position and size of the defect or implant.

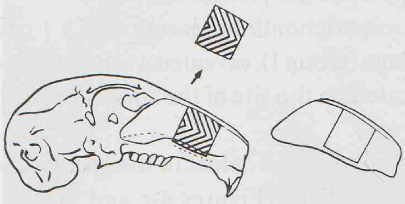

Figure 1. Submucous resection of a 1 cm vertical strip in the middle of the septal cartilage.

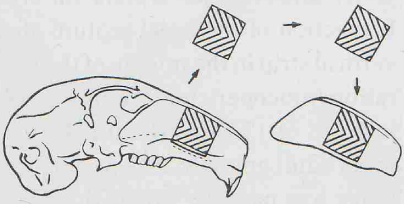

Figure 2. Submucous resection of a 1 cm vertical strip in the middle of the septal cartilage, followed by immediate reimplantation of this cartilage strip in the same position.

Then the skulls were studied and described with a standard protocol of 26 items, followed by a geometrical study. For this geometrical method, 19 standard points were marked on standardized photographs of the lateral side of the skull. These points could be measured by the construction of a rectangular co-ordinate system with the reference line (SSO-SL, see Figure 3) through the synchondrosis spheno-occipitalis and the sutura lambdoidea as ordinate (Verwoerd et al., 1979a).

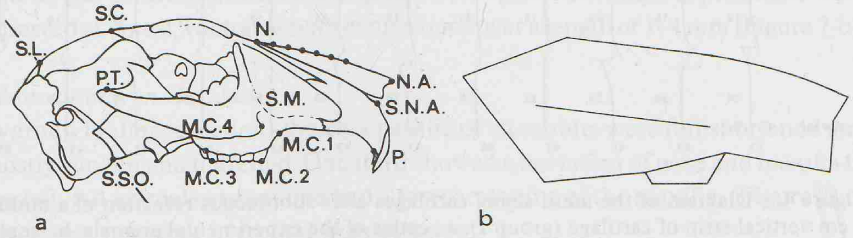

Figure 3. a. Lateral side of the skull of a rabbit. 19 points are defined by the construction of a rectangular co-ordinate system. The ordinate is formed by a line through the most caudal point of the spheno-occipital synchondrosis (S.S.O.) and the most cranial point in the lambdoid suture (S.L.) The abscissa is a perpendicular line in S.S.O.
b. Diagram based on the mean co-ordinates of the measuring points.

To eliminate differences in size of the skulls, the co-ordinates of all measuring points followed a norming procedure with regard to the reference line (SSO-SL). Of each point a 95% confidence area was plotted in the form of an ellipse in order to assess the scatter (Nolst Trenité, 1984). For the statistical evaluation, the Hotelling T^2-test and the Student T-test were applied.

RESULTS

In group I 12 skulls and in group II 10 skulls could be studied 20 weeks after operation.

Observations on the septum via orbita and apertura piriformis.

Inspection of the nasal septum after submucoperichondrial resection of a 1 cm vertical strip in the middle of the septal cartilage (group I), revealed a septal perforation (mucoperichondrium + cartilage), located on the site of the surgical defect in 9 out of 12 cases (Figure 4-b).

In all adult animals, except one, the surgical submucous defect in the septal cartilage was partially filled with newly formed cartilage (Figures 4-c and 5).

Small deviations of the septum (Figure 4-e) existed.

Measurements of the septum (Figures 4-e and 4-f) revealed a smaller dorso-ventral distance between the cartilage resection borders (0-6 mm) than just after resection of this strip (10 mm).

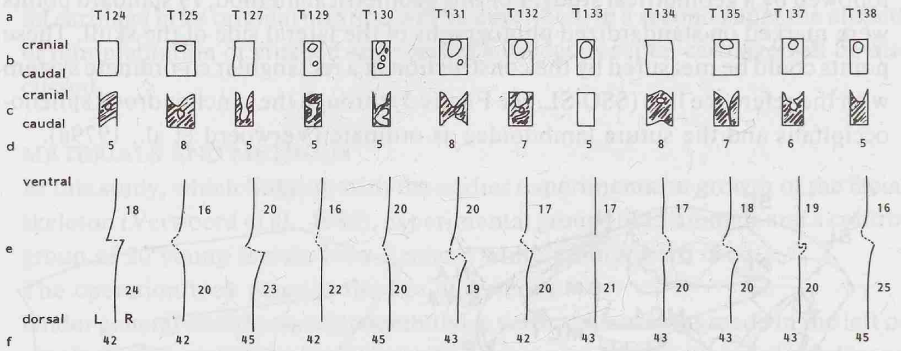

Figure 4. Diagram of the adult septal cartilages after submucous resection of a middle 1 cm vertical strip of cartilage (group I). a. codes of the experimental animals, b. septal perforations at the site of the surgical defect, c. new cartilage (shaded areas), d. distance in mm between resection borders, e. section of the septal cartilage (continuing line) and new cartilage (dotted line) in a horizontal plane (half way the height) with length in mm of the dorsal and ventral parts of the septal cartilage, f. distance in mm between the most dorsal and ventral point of the septal cartilage. Deviations to the left (L) and right (R).

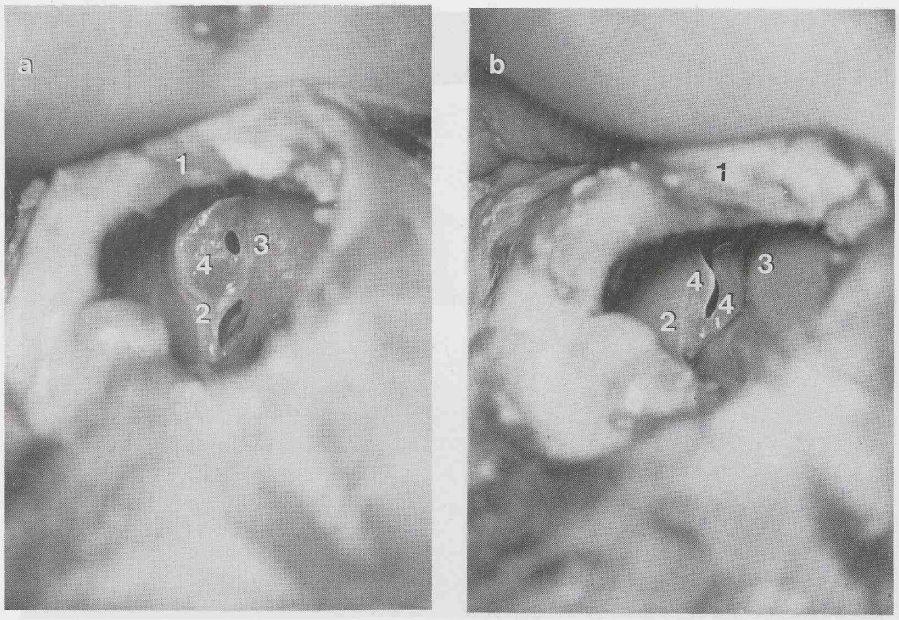

Figure 5. Transorbital view (left side) of the surgical defect a. skull T124 (group I), b. skull T137 (group II). 1. orbital rim, 2. ventral resection border, 3. dorsal resection border, 4. new cartilage formation.

After reimplantation (group II) the septa showed no perforation of mucoperichondrium, but a "pin point" perforation of the cartilage on the site of the catgut fixation suture of the implants (Figure 6).
In this group, small to large deviations of the septum were observed (Figure 7-b). The implants had obviously grown (from 10 mm up to 15–18 mm) in dorsoventral direction and showed macroscopically the same thickness and consistency as the original septal cartilage. The implants, in most cases, lacked a correct end-to-end connection with the original septal parts. Cartilage duplications were observed at dorsal, ventral or both connections over a length of 1–4 mm (Figure 7-b).

Observations on the skull
In group I (after resection) the ossa nasalia of all rabbits were foreshortened and mostly sunken and flattened. One third showed a deviation of nose and maxilla to the left. All animals except one had a foreshortening of the maxilla, (Figure 8) in four cases resulting in frontal malocclusion.
In group II (after reimplantation) more than half of the skulls showed foreshortening of the nose and a flattened and sunken nasal bridge. Deviations of the nose and maxilla were observed in about one third of the animals (always to the left). Distinct foreshortening of the maxilla occurred in two rabbits.

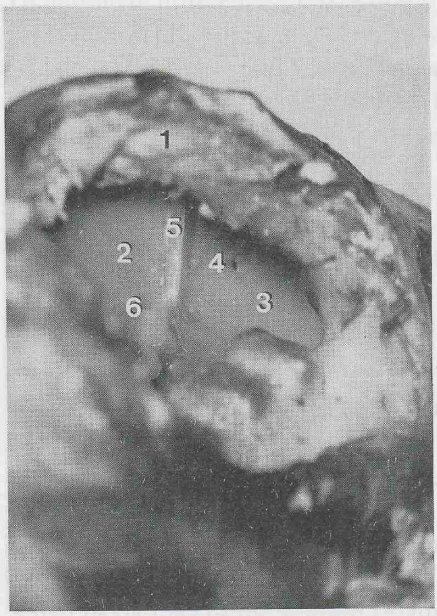

Figure 6. Transorbital view (right side) of a septal cartilage with cartilage implant (skull T29, group II).
1. orbital rim,
2. dorsal part of the septal cartilage,
3. implant,
4. "pinpoint" perforation,
5. dorsal free border of the implant,
6. vomer.

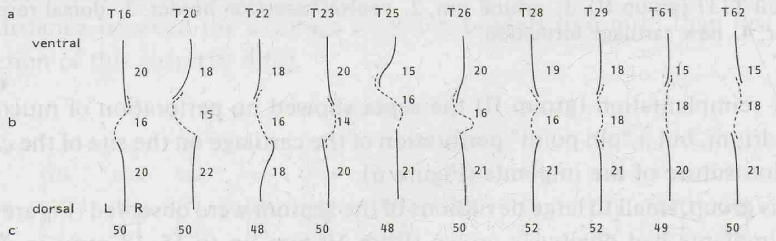

Figure 7. Diagram of the adult septal cartilages after immediate reimplantation of the resected cartilage in the same position (group II). a. codes of the experimental animals, b. section of the septal cartilage (continuing line) with implant (dotted line) in a horizontal plane (half way the height) with length in mm of the dorsal and ventral parts of the septal cartilage and implant, c. distance in mm between the most dorsal and ventral point of the septal cartilage. Deviations to the left (L) and right (R).

Geometrical and statistical results

As a result of the geometrical study, Figures 9a and 9b show the skull diagrams of group I and II compared with the control group. The skull diagrams were created by connecting the mean positions on the 19 defined points on the lateral side of the skull, after the norming procedure. The ellipses around these points represent the 95% confidence areas of the scatter of the X and Y co-ordinates of these points. There is a distinct foreshortening of the nose in both series, though more evident in group I. This is in concordance with the morphological observations. The fore-

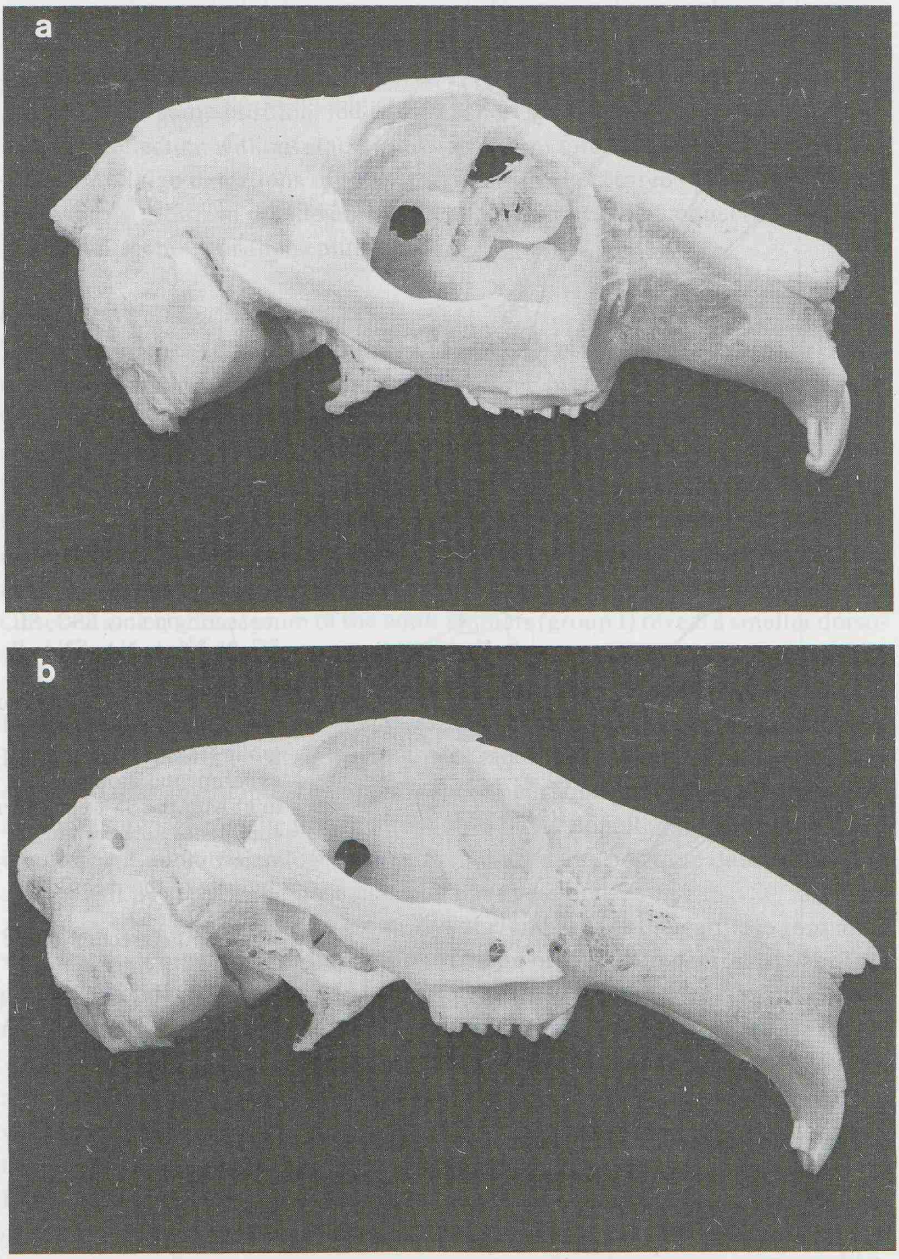

Figure 8. a. Lateral side of the skull of a rabbit (T131, group I) with a shortened sunken nose and shortening and deflection of the maxilla.
b. Lateral side of the skull of a rabbit from the control group with normal length of the nose and maxilla and normal convex contour of the ossa nasalia.

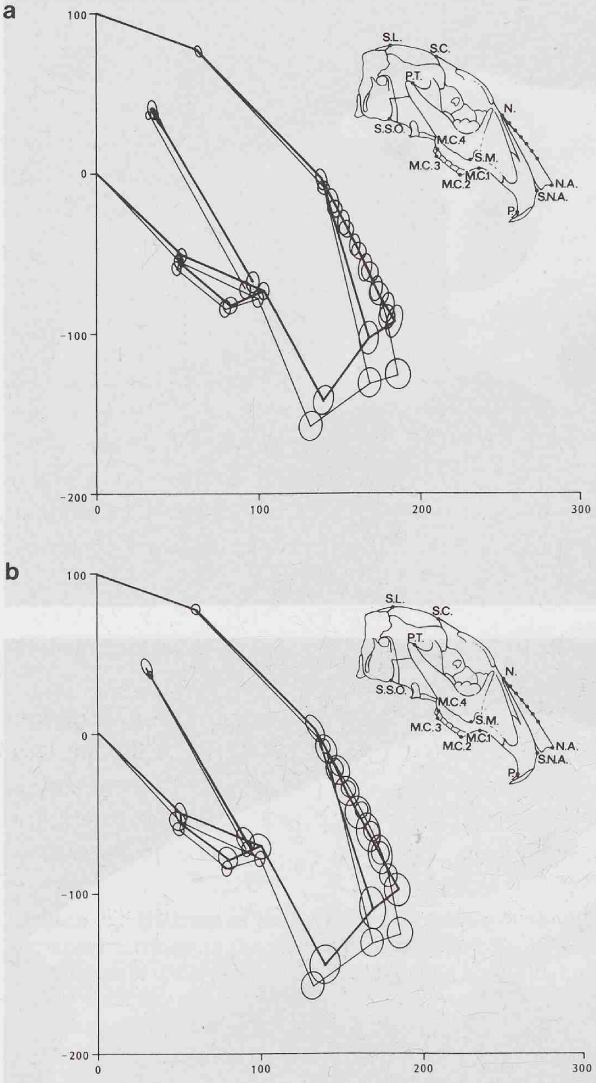

Figure 9. Diagram of the mean co-ordinates of the measuring points SSO, SL, SC, N, N1-6, NA, SNA, P, MC_1, MC_2, MC_3, MC_4, SM and PT on the lateral side of the skulls of the control group (thin line) and experimental group (thick line) with the 95% elliptiform confidence areas of the variety of the X and Y co-ordinate of the measuring points (U_x, U_y).

a. group I (resection of the middle 1 cm strip of septal cartilage),
b. group II (reimplantation of this resected strip of cartilage).

shortening of the maxilla is statistically significant only in group I (Nolst Trenité, 1984). Both groups show a deflection of the maxilla, which could not be observed by previous morphological study.

The results of the experiments can be summarized as follows:

- submucous resection of a 1 cm vertical strip in the middle of the septal cartilage resulted in a foreshortening of the nose with a flattened sunken nasal bridge. The maxilla is foreshortened and deflected. A frontal malocclusion appeared in one third of the animals. Deviations of the septum and small perforations

close to the surgical defect were present. The surgical gap in the cartilaginous septum was partially filled with newly formed cartilage.

- submucous resection with immediate replacement of this strip of septal cartilage, in the same position, led to a foreshortened, sunken and flattened nose with a deflection without statistically significant foreshortening of the maxilla. Small to large deviations of the septum nasi had occurred. The implants had obviously grown in dorso-ventral direction, but lacked a connection with the original sections of the septum.

COMMENTS AND CONCLUSIONS

The consequences of a discontinuity of the septal cartilage on the growth of the nose and maxilla are obvious and specific. After submucous resection of a 1 cm vertical strip in the middle of the septal cartilage the foreshortening of the nose and maxilla is less severe than in the similar experimental group described by Nijdam (1979). His results corresponded to those of Mastenbroek (1979), who resected septal cartilage with the covering mucoperichondrium. Different degrees of cartilage regeneration and scar tissue formation at the site of resection are a possible cause of the difference in results.

Observations on the septum of the adult animals (group I) reveal a smaller dorso-ventral distance between the cartilage resection borders of the surgical defect, likely due to growth of the remaining septal cartilage (Figure 4-e).

Reimplantation of autologous septal cartilage in exactly the same position (group II) does not prevent foreshortening and saddling of the nose, although less extended than in group I. The maxilla shows no significant growth disturbances in length, but a change in growth direction, a deflection. Repair of the continuity by reimplantation of autologous cartilage, in the same position, does not restore the growth pattern of the nose and maxilla to normal.

An interesting observation in group II is the viability of the cartilage implants, showing their growth potential by 50% increase of the dorso-ventral length. This growth potential of autografted cartilage of the nasal septum does confirm experimental studies by Bernstein (1973) and Kvinnsland (1973).

After submucous resection of the middle 1 cm strip, the remaining septal cartilage deviates slightly, whereas after reimplantation more extended deviations were found. There is probably a causal relation between the larger deviations and the observed growth of the cartilage implants.

How far can these experimental results be of any use towards the clinical attitude of the E.N.T.-surgeon? Basically the growth of the midface of the used experimental animal follows the same pattern as that of the human being (Verwoerd-Verhoef, 1974; Verwoerd et al., 1979b).

Although the rabbit nose, with its extremely long nasal bones reveals, after submucous septal resection, a disturbance in growth more distinct than the nose of a

human being, the basic pattern, an underdeveloped nose (foreshortening and saddling), seems similar to observations mentioned by Hayton (1916) and Ombrédanne (1942).

Reimplantation of septal cartilage between two mucoperichondrial layers is often practiced in septal surgery in order to prevent septal perforations. The effectiveness of the procedure was never experimentally studied. The results of group I and group II clearly demonstrate that reimplantation of cartilage reduces septal perforations to a minimum.

Small to large septal deviations after reimplantation (group II), using the septal correction techniques, coincide with the clinical observations of Pirsig (1977) and Huizing (1979).

In about 20% of their cases a recurrence of large deviations, causing nasal dysfunction, was observed.

The growth disturbances of the rabbit nose after reimplantation of autologous cartilage, are significant but less severe than those after septal resection only.

The results of these experiments stress the fact that septal surgery in children even with the modern techniques may well lead to a disturbance of the further development of the nose.

ZUSAMMENFASSUNG

Untersucht wurden die Folgen der Wiederherstellung der dorso-ventralen Kontinuität des Septumknorpels auf das Wachstum der Nase bei jungen Kaninchen.

Resektion des mittleren Drittels der Septumknorpels resultierte in charakteristischen Wachstumsstörungen der Nase und des Oberkiefers.

Reimplantation des resezierten Stückes des autologischen Knorpels führte nicht zur Wiederherstellung der normalen Entwicklung der Nase.

Die Transplantate verhinderten jedoch die Entstehung von Septumperforationen, die beobachtet wurden, wenn das mittlere Knorpelstück nicht reimplantiert wurde. Ferner zeigten diese Transplantate eine bemerkenswerte Wachstumstendenz in dorso-ventraler Richtung.

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