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EXPERIMENTAL EPIPHYSEAL INJURIES

Grading of Traumas and Attempts at Treating Traumatic Epiphyseal Arrest in Animals

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Epiphyseal injuries are common in children, but seldom cause permanent disturbances of growth except in the case of slipped upper femoral epiphysis which, however, is usually not of purely traumatic origin.

If a young child sustains epiphyseal arrest in one of the rapidly growing growth zones, an angular deformity and shortening result if the injury is peripheral in the growth cartilage. If the injury is localized centrally, only a shortening will result, but this shortening may become so severe as to be seriously disabling.

At our present stage of therapeutic ability the angulation may be corrected by osteotomy, its recurrence may be inhibited by rendering the epiphyseal arrest total, and the shortening may be treated by correcting osteotomies, epiphyseodesis or Blount stapling on the other leg, or bandaging. However, such treatment is often far from rewarding. It would be valuable, therefore, to be able to abolish the inhibition of growth, at least in those patients in whom a considerable proportion of the growth cartilage has remained intact.

There have been but few clinical reports to elucidate traumatic epiphyseal arrest. The explanation is that this injury is relatively uncommon, extremely varied, and that it is difficult to elucidate its pathogenesis as well as the development of the growth disturbances.

Aitken (1936) is usually quoted for his classification of epiphyseal lesions into three types. However, two of his types, which may entail permanent inhibition of growth, were based only upon 5 case histories.

But while clinical experience is scanty, recent years have brought

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a number of excellent experimental studies for elucidating the traumatology of the epiphyseal zones.

Ford & Key (1956) perforated the epiphyseal cartilage of young rabbits with a one-eighth of an inch drill. This did not cause any major shortening in spite of osseous or fibrous bridging between the epi- and metaphysis. When larger drills were used, the shortening became more marked.

Friedenberg (1957) performed major or minor partial resections of the periphery of the growth cartilage and surrounding bone. This was invariably followed by osseous bridging through the resected area, but in many cases growth continued, indicating that the bone bridge must have fractured owing to the pressure of growth.

Dale & Harris (1958) carried out manual epiphyseolysis on 80 rabbits. The separation always occurred between the growth cartilage and the metaphysis. During the first posttraumatic weeks the cartilage increased in height. Thereafter, enchondral ossification in the metaphysis was resumed, and 3 weeks after the trauma any trace of the injury had been obliterated.

Campbell et al. (1959) resected minor areas of the peripheral growth cartilage and surrounding bone without observing major deformities. After they had chiselled off a piece of the epiphysis, growth cartilage, and metaphysis, they seldom saw retardation of growth, if the fragments were reduced immediately. But if the fragments were deprived of blood supply or fixed in alcohol, permanent inhibition of growth resulted. On 15 dogs the metaphysis was resected as far as the metaphyseal limit of the growth cartilage. In some cases, this resulted in damage to the cartilage and a bony bridge, but in most cases there was no or only little retardation of growth. When piercing the cartilage with drills of varying sizes they often observed arrested growth after using the larger-bore drills.

Brashear (1959), creating epiphyseolysis manually on rats, observed the same cleavage of separation as other workers except centrally where he frequently saw injury to the germ-cell layer and the subepiphyseal bone. A small triangular metaphyseal fragment was often avulsed on the compression side, and often there were severe pressure necroses in the cartilage on this side. Non-penetrating injuries were associated with increased width of the growth cartilage which later ossified, either from the metaphysis or around vessels which from the perichondrium had invaded the highly hypertrophic cell columns.

After penetrating injuries, regeneration had first to take place from the surrounding cells.

Attempts at prophylaxis or at treatment of osseous bridging of the epiphyseal plate appear to have been made only by *Key & Ford* (1958) and *Friedenberg* (1957).

Key & Ford tried, unsuccessfully, to avoid bridging after reimplantation of growth cartilage grafts, packing the grafts in bone wax before reimplantation.

Friedenberg, resecting major or minor areas of the growth cartilage and surrounding bone, filled the resected area with bone wax or methyl metacrylate. He also tried resecting a 4-weeks old Phemister epiphyseodesis in a rabbit by filling the defect with bone wax. In no case did he succeed in avoiding osseous bridging.

The studies mentioned above have predominantly elucidated the histological development in the growth cartilage after trauma. No attempts have been made to inflict an epiphyseal injury which, without damaging a larger area of the growth cartilage than necessary, will cause permanent disturbance of growth with a high frequency.

It is apparent from the named publications that the cells in the growth cartilage possess a considerable ability for regeneration after pressure necroses, ischaemic necroses, and loss of substance. This has been confirmed by a number of investigations into vascular disturbances, including transplantations of the growth cartilage (*Lacroix* 1951, *Ring* 1955, *Troupp* 1961, *Heikel* 1961). The experimental results are in keeping with clinical experience of Phemister epiphyseodesis in children (*Goff* 1960, *Green & Anderson* 1957, *Nordentoft* 1964).

There is not agreement as to the area of the growth cartilage from which this regeneration occurs. *Langenskiöld* (1950) believed that an increase in the width of the cartilage is caused by cell division in the central areas, while *Lacroix* (1951) felt that regeneration of the cartilage cells takes place from the periphery, due to an accumulation of cells beneath Ranvier's perichondrial groove. *Rigal's* contention that growth in width takes place by interstitial cell division is compatible with the findings of *Brashear* (1959), *Heikel* (1961), and *Troupp* (1961).

It must be considered an established fact that premature arrest of longitudinal growth may occur either due to total degeneration of the cells in the growth cartilage or due to the setting up of a bone bridge between the epi- and metaphysis. It seems to have been accepted also that minor bone bridges may be fractured by the pressure of growth,

but that growth will be definitively arrested if the bridge is so strong that the growth pressure is unable to break it.

Experience with Blount stapling has revealed that the growth cartilage may maintain its growth potential through several years, although cellular proliferation has been inhibited by external fixation between the epi- and metaphysis. After stapling, growth is generally resumed when the fixation is removed. In osseous bridging of the epiphyseal plate the bridge may be expected to re-appear after resection. However, there is a theoretical possibility of inhibiting its re-appearance or of preventing re-fixation of the bony bridge to the metaphysis while regeneration of the cartilage cells in the growth cartilage is taking place.

This was attempted by *Key & Ford* and by *Friedenberg* by packing the defect in the cartilage with bone wax or the like. Another possibility is temporary blocking of metaphyseal vascular supply. This is obtained by placing a polyethylene membrane between the growth cartilage and the metaphysis or by resecting part of the metaphysis. This might weaken the attachment of the bony bridge to the metaphysis and inhibit the healing of spontaneous fractures in the bony bridge.

According to *Blout* (1954) most cases of epiphyseal arrest after removal of Blount staples are due to injury to the peripheral part of the epiphyseal plate and of the periosteum. It seems reasonable to investigate whether such injury influences the course after epiphyseal trauma. This might also elucidate the role of the peripheral versus the central part of the growth cartilage in cartilage-cell regeneration.

PRESENT INVESTIGATIONS

Object

(1) To devise a standardized epiphyseal trauma which entails permanent retardation of growth, but without injuring a larger area of the growth cartilage than necessary.

(2) To work out methods for counteracting posttraumatic osseous bridging of the epiphyseal plate and methods for breaking down and inhibiting the recurrence of osseous bridging.

Material and Methods of Examination

The experiments were performed on 45 animals, 5 of which died before the results could be finally assessed. Out of the remaining ani-

mals 6 were puppies and 34 albino rabbit young. As the experiments extended over several years, it was not possible to use animals of the same strain or in the same age or weight groups. In comparing the effect of various procedures, therefore, the results were as far as possible assessed on the basis of the growth of the two hind legs of the same animal.

The 40 animals were subjected to a total of 100 operations, 74 primary and 26 secondary procedures, all upon the proximal end of the tibia.

Metal markers were placed in the proximal tibial metaphysis on both sides.

X-ray control was performed at 1-week intervals during the first 4–6 weeks after the operation, thereafter at 2–4 week intervals.

Apart from the X-ray examinations during the operations, all the X-ray examinations were done on animals in the waking state. The rabbits were held sitting on the X-ray plate and the dogs were X-rayed, standing, from behind, since it proved impossible to fix alert animals on an extension table. Although completely uniform projections could not be obtained, the course of the growth curves shows that the inaccuracy of the measurements must have been within $\pm$ 2 mm in the great majority of cases. Post-mortem X-ray measurements on dissected bones can carry but minimal measuring errors.

After the experimental period was over, the tibiae were dissected, and the proximal tibial end sawn, in the frontal plane, into slices of approx. 2 mm. The slice which showed the most pronounced changes of the growth cartilage when viewed in a hand lens was fixed in 10 per cent formalin for 7 hours, decalcified for 8–10 days in equal parts of formic acid 40 per cent and sodium formiate 7 per cent. The decalcified preparations was cut into sections of 7 μ and stained with haematoxylin as well as by the van Gieson-Hansen method.

The cutting of the preparations, up to 2 $\times$ 3 cm large and also after the decalcification of somewhat varying consistency, caused a good deal of trouble. About one-quarter of the preparations got torn so that they were partially inapplicable for histological appraisal.

In the histological assessment stress was laid particularly upon demonstrating the presence of vascular or bony bridges (Figure 3) and upon assessing the activity of the cartilage. Normal differentiation of the cartilage cells co-existing with a normal arrangement of the metaphyseal vessels and of the primary bony trabeculae were used as criteria of normal function (Figure 1).

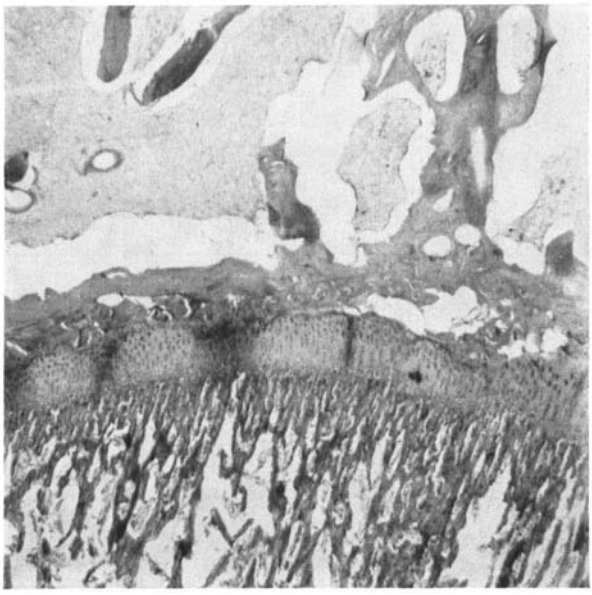

Figure 1. Normal, active growth cartilage from a rabbit. From the top downwards: Basement plate, growth cartilage, and metaphysis (haematoxylin-eosin. × 10).

A normal orientation is taken to mean that the columns of cartilage cells are arranged parallel to each other and to the long axis of the bone. In normal growth cartilage there is normal orientation and activity, but in a number of the preparations there was distinct activity in spite of a more or less marked disorganization.

Intermediate metaphyseal formation is taken to mean the phenomenon described by *Brashear*, viz. ossification arising from perichondrial vessels in an intermediate layer of the growth cartilage.

Continuity of the growth cartilage is taken to mean no vascular or bony bridging. This is not tantamount to the cartilage being organized or active.

Whenever an animal was first subjected to bilateral trauma followed by attempt at repair on one side, the choice of the side of the second operation was always done by a person who was not aware of the object of the study or of the course of the primary operation.

The effect of the procedures was assessed on the basis of X-rays, increment curves, and histological investigation of the growth zones.

METHODS OF OPERATION

(cf. Table 1)

(a) *Drilling*

Simple piercing of the growth cartilage was done with a 3 mm drill in rabbits and with a 4–5 mm drill in dogs, from the medial metaphysis through the growth

Table 1. Surgical procedures and effect on growth.

Group	Operation	Schematic presentation of operation	Number of legs operated upon: Isolated operations	Combined with or prior to other procedures	Total	Effect on Growth after isolated operations: None or slight	Marked
1	Drilling		8	8	16	8	0
2	Epiphyseolysis + Curettement		12	11	23	10(+1)	1
3	Epiphyseolysis + Drilling		2	2	4	0	2
4	Epiphyseolysis + Drilling + Curettement		17	11	26	4 (23.5%)	13 (76.5%)
5	Drilling followed by epiphyseolysis + resection of bone bridge		8	–	8	5	3
6	Epiphyseolysis + Curettement + resection of periosteum		8	–	8	6(+1)	1
7	Group 3 or 4 followed by reception of metaphysis		13	–	11	5 (61.5%)	8 (38.5%)

cartilage and into the epiphysis. In other cases the piercing was done through the growth cartilage into the epiphysis after epiphyseolysis had been carried out.

(b) *Epiphyseolysis*

This operation was performed through a longitudinal incision over the medial metaphysis. The epiphyseal line was easily located in all the primary operations, while in the secondary procedures this was often difficult. The periosteum was incised transversely just below the epiphyseal line in one-third to one-half of its periphery. By firmly grasping the epiphysis and metaphysis and simultaneously carrying the tibia into external rotation and valgus, epiphyseolysis could invariably be created. The separation occurred through the degenerative layer of the growth cartilage or through the primary calcification zone. In a few cases fracture occurred in the lateral corner of the metaphysis which accompanied the epiphyseal fragment.

The separation required somewhat varied force, but it was always easy in the primary operation on rabbits, somewhat more difficult in the secondary operation on rabbits and primary operations on the puppies, and often extremely difficult in the secondary operations on the puppies.

The metaphyseal width in the rabbits was about 15 mm and in the dogs about 35 mm—which explains the difference in the firmness of the metaphyseal attachment.

After reduction, the epiphysis was fixed by suturing the soft tissues. The maximum lateral displacement after reduction was 2 mm. No dressing was applied, and there was no instance of secondary dislocation.

(c) *Curetting of the Growth Cartilage*

After epiphyseolysis has been performed and the tibia had been carried into valgus, the growth cartilage was curetted as far as the basement plate in a circular area beneath the medial condyle, comprising about 10 per cent of the cartilaginous area. The limit between cartilage and basement plate was always extremely distinct.

(d) *Resection of Transepiphyseal Bone Bridges*

In this procedure epiphyseolysis, as described above, was first done. In all cases the preformed bone bridge became separated from the metaphysis and projected like a peg from the under aspect of the growth cartilage. This peg was removed on a level with the basement plate while sparing the surrounding cartilage as far as at all possible.

(e) *Resection of Periosteum and Perichondrium Medially on the Proximal Tibia*

This was done by removing the medial third of the periosteum and perichondrium with a sharp knife in the region of the epiphyseal line and on the proximal 8 mm of the tibia. The resection was carried so deep that the epiphyseal line stood out distinctly against the surrounding spongy bone.

(f) *Metaphyseal Resection*

This procedure was performed in one case by chiselling off a 4 mm high area of the metaphysis reaching to the under aspect of the growth cartilage. However, as

this procedure was felt to be highly traumatizing, it was done in the subsequent cases by sawing two tracks in the metaphysis, the upper one as close as possible to the growth cartilage, in practice 2–3 mm below it, and the lower track 4–5 mm inferior to the first one. The bone was sawn through one-third to one-half of its width with an electric circular saw, and the intermediate piece of bone was removed. In all cases a wide aperture to the medullary cavity was made.

RESULTS

(cf. Table 1)

(1) *Drilling*

The effect of this procedure could be assessed on 8 tibiae. Growth continued in all cases, entirely or almost unchanged.

Histological study at the end of 62–97 days revealed in 2 cases a cord of cartilage in the epiphysis, presumably generating from cartilage cells which had become displaced into the drill hole (Figure 2). In the other cases the histological appearances were normal.

Figure 2. Regeneration of cartilage in drill hole (arrow). A rabbit 76 days after drilling through the growth cartilage. Inferiorly on the left normal growth cartilage (haematoxylin-eosin. × 10).

(2) *Epiphyseolysis Combined with Curetting of the Growth Cartilage*

This was inflicted on 12 tibiae as an isolated injury. In one case it resulted in arrested growth, while in the others there was no or only transient retardation of growth.

Histological examination of 9 tibiae at the end of 77–105 days disclosed in one case a wide bone bridge surrounded by inactive cartilage. In one case the cartilage was narrow and inactive medially. Four preparations showed narrow bone bridges surrounded by normal cartilage, while in 3 cases no abnormalities were found.

(3) *Epiphyseolysis Combined with Drilling*

This was done bilaterally on 2 rabbits, in both cases followed by yet another procedure unilaterally.

The rabbits were observed for 82–88 days. Both exhibited arrested growth, and histology showed only scattered remnants or disorganized and inactive growth cartilage.

(4) *Epiphyseolysis Combined with Curetting and Drilling of the Growth Cartilage*

The effect of this procedure could be assessed on 17 tibiae. The animals were observed for 59–118 days after the operation.

Four (23.5 per cent) showed only transient but 13 (76.5 per cent) permanent arrest of growth.

Histological study of 11 animals revealed in one case no remnants of growth cartilage and in 5 cases only scattered, inactive remnants. One had a narrow rim of inactive cartilage with a wide, central bone bridge. In two cases the cartilage was active laterally, but inactive medially. One of the latter cases had a wide bone bridge. In one case only was the cartilage completely normal and in another case continuous and active apart from a remnant of bone peg surrounded by slightly disorganized cartilage.

(5) *Drilling Followed by Epiphyseolysis and Resection of the Bone Bridge*

This experiment included 8 rabbits. All the operations were unilateral, but bilateral drilling had been carried out in all cases 14–21 days previously.

The rabbits were followed for 45–79 days after the latter procedure.

As already mentioned, growth continued, unchanged, or with only a transient retardation, in all the control legs.

On the re-operated side growth continued unchanged in one case. In 4 cases a transient arrest of growth resulted in a shortening of 2–6 mm as compared with the control leg. In 3 cases permanent arrest of growth occurred in the entire growth cartilage or parts thereof. Histological examination revealed on the re-operated side entirely normal appearances in 2 out of 5 rabbits. Another two had only atrophic remnants of the growth cartilage peripherally around a wide, central bone bridge. In one case there was a narrow central bone bridge surrounded by normal cartilage, cartilaginous regeneration in the drill hole, and a small intermediary ossification medially in the growth cartilage.

(6) *Epiphyseolysis Combined with Curetting of the Growth Cartilage and with Resection of the Periosteum and Perichondrium Medially on the Tibia*

This was done on 8 rabbits one of which died at the end of 11 days, while 2 were followed for 25–31 days and the remainder for 77–79 days.

In 6 no or only transient retardation of growth occurred, while one exhibited severe varus deformity and gradually total arrest of growth.

Comparison with the control leg, which had been subjected only to epiphyseolysis and curetting, showed identical appearances (transient retardation of growth) in 4. In 2 the inhibition affected the side where periosteal resection had been done, the shortening being 2–3 mm compared with the control leg. In the case showing total arrest of growth the control leg went on growing normally. The remaining rabbits were not followed for a sufficient length of time to assess the effect.

Histology showed in the rabbit with total arrest of growth a narrow, disorganized growth cartilage with multiple bone bridges. Three had a narrow (1 mm) central bone bridge surrounded by normal cartilage (Figure 3). In 2 the cartilage was continuous and only slightly disorganized at the site of the curetted area. In the rabbit followed for only 11 days the epiphyseal cartilage was very tall medially, but in other respects this preparation was unassessable.

In 4 cases (including the one of 11 days' duration) the periosteum as well as Ranvier's perichondrial groove had regenerated. In 2 of these cases a major accumulation of cartilage cells was found in ample

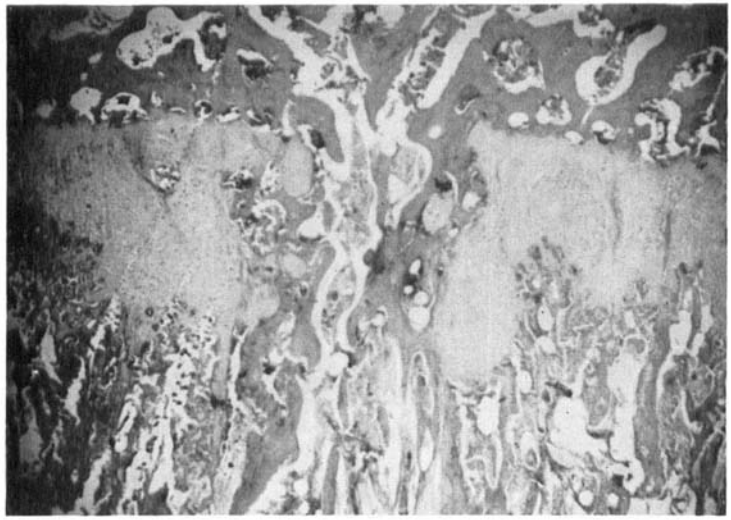

Figure 3. Bone bridge between epiphysis and metaphysis. Laterally to the bone bridge slightly disorganized, but active growth cartilage. A dog 118 days after epiphyseolysis, curetting, and drilling, followed by metaphyseal resection (haematoxylin-eosin. × 10).

ground substance deep into the perichondrial groove. In the remaining 3 cases the quality of the preparations did not permit a definite assessment of the structures on the medial side.

(7) *Metaphyseal Resection*

This procedure was carried out on 13 animals, 3 dogs and 10 rabbits. The primary injury inflicted on 2 of the animals had been epiphyseolysis and drilling, while the remainder had been subjected to epiphyseolysis, drilling, and curetting. All the primary operations were bilateral and all the secondary ones unilateral, done 21–29 days after the primary procedures.

Two of the rabbits were so old at the time of the procedure that their growth period had presumably been completed by the time the control period was over. Therefore, the effect in these cases could be assessed only on the basis of X-ray findings and growth curves. (In one of the cases the appearances were identical on both sides, while in the other case growth was more normal on the control leg).

In 4 cases growth conditions were clearly less abnormal on the reoperated side.

In 1 case growth curves and X-ray findings were identical but the histological examination showed the growth cartilage to be disorganized and inactive on the control side, while on the side of the metaphyseal resection it was continuous and active apart from a slight, central irregularity.

In 2 cases the findings were distinctly more abnormal on the side of the metaphyseal resection than on the control side.

In 6 cases the findings on the two legs did not differ definitely, 5 cases showing total arrest of growth and 1 case transient growth retardation on both sides.

The results are presented in Table 2.

Table 2. Effect of metaphyseal resection.

Improvement	Exacerbation	No change
5	2	6

The demonstrated effect is not statistically significant.

In 2 of the 4 cases where the appearance were distinctly better on the treated side, X-ray findings and growth curve prior to the secondary procedure seemed to indicate that the initial trauma had been more severe on the untreated side. In one of the 2 cases with exacerbation on the treated side, the same criteria indicated that the initial trauma had been more severe on this side.

DISCUSSION

After piercing the growth cartilage with a drill about one-fifth of the diameter of the growth cartilage, bone bridge formation in the drill hole was demonstrable in all 8 cases which were subjected to epiphyseolysis 2–3 weeks later. However, growth continued unchanged, or only transiently inhibited, on all legs which had not been subjected to re-operation and which have presumably at the same time also been affected with bridging. This must indicate that normally the pressure of growth will be able to break a minor bone bridge or rather tear it from the metaphysis.

The predominantly normal histological findings at the end of the experiment show that such minor bone bridges may disappear almost without leaving a trace.

Curetting of approx. 10 per cent of the growth cartilage caused permanent arrest of growth in only one of the 11 studied cases. At

histological examination the curetted area had, in the great majority of cases, filled with normally oriented and active growth cartilage, showing that the cartilage cells must possess a considerable ability for regeneration.

In these animals the basement plate was intact, while in those in whom curetting was supplemented by drilling through the basement plate 13 out of 17 (76.5 per cent) showed permanent retardation of growth—even when the drill had been of the same bore as that which had not caused major changes in growth when the drilling had been the only inflicted injury.

Epiphyseolysis and drilling without curetting were performed on only 2 animals, but caused growth arrest in both.

It may be concluded, therefore, that even fairly extensive loss of substance in the growth cartilage may be restored provided that the basement plate is intact. Minor injuries to the cartilage and basement plate rarely result in arrested growth if the cartilage is otherwise intact. On the other hand, damage to the cartilage, in the form of loss of substance and compression injuries associated with epiphyseolysis and combined with damage to the basement plate, involve a high frequency of growth arrest.

This observation indicates that the conventional technique of the Phemister epiphyseodesis, which aims at arresting growth definitively, should be supplemented by drilling of the basement plate.

The basement plate is a continuous, compact plate of bone with only a few and small holes admitting the vessels to the germ-cell layer of the growth cartilage. According to *Trueta & Amato* (1960) the formation of a bone bridge is invariably preceded by a vascular bridge. It is conceivable that a massive vascular bridge between the epi- and meta-physeal vascular system cannot be developed through the small apertures in the intact basement plate. On the other hand, an effusion can soon accumulate in the fracture-like slit which occurs when cartilage as well as basement plate are injured. This effusion may become organized, become traversed by vessels and undergo ossification into a solid bone bridge before regeneration of cartilage cells has occurred. In order to study this development in more detail it is necessary to supplement the technique by studying the effect of injections into the vessels at suitable intervals after the operations. However, this was beyond the scope of the present study.

To prevent contact between growth cartilage and metaphysis a thin membrane of polyester was inserted into the epiphyseolysis slit left by

cartilage injury in a number of animals. Owing to the small size of the anatomical structures, however, it proved difficult to place this membrane in the correct position. Infection occurred in several cases, and invariably there was a considerable tissue reaction around the membrane which in several cases became displaced. Accordingly, this technique had to be abandoned.

All minor bony bridgings after drilling procedures were followed by spontaneous normalization of the growth. On the other hand, resection of small bone bridges often resulted in severe inhibition of growth. The explanation is presumably that the growth cartilage had been exposed to a severe compression injury in the course of the relatively difficult epiphyseolysis at the secondary procedure.

Epiphyseolysis and curetting of the growth cartilage as an isolated procedure did not leave permanent arrest of growth. Resection of the perichondrium and periosteum on a level with the cartilage injury and in connection with this injury did not change the course. This indicates that an intact periphery of the growth cartilage does not play a decisive role in regeneration after loss of substance in the latter. The regeneration of a structure which corresponds morphologically to Ranviér's perichondrial groove, observed in several cases, confirms *Lacroix's* (1951) findings of regeneration of this structure. However, the course of growth does not indicate that it is of specific importance to the function of the growth cartilage as claimed by *Lacroix*.

The results of metaphyseal resection might indicate that in some cases this procedure is able to inhibit the development of a solid bone bridge. However, the results are not significant. To study in more detail the effect of this procedure, and perhaps elaborate the technique, this operation must be performed on a larger series of larger animals whose anatomical appearances correspond more to those in children. Furthermore the experiments must be supplemented by a series in which the vessels are injected and prepared at suitable intervals after the operation. On the basis of experience made so far, it is not justified to employ metaphyseal resection clinically in the treatment of posttraumatic growth arrest.

SUMMARY

34 rabbit young and 6 puppies were subjected to a number of mechanical injuries to the growth cartilage, followed by various procedures done with a view to affecting growth after the traumas.

Drilling through the growth cartilage with small-bore drills did not ever result in permanent arrest of growth—and curetting of approx. 10 per cent of the growth cartilage seldom.

On the other hand, epiphyseolysis as well as epiphyseolysis plus curetting of the cartilage caused permanent bony bridging in 76.5 per cent when the procedure was combined with drilling through the basement plate.

When combined with epiphyseolysis and curetting, excision of the periosteum and perichondrium on a level with the injury did not definitely alter the course.

Resection of minor bone bridges left by drilling aggravated the prognosis.

Resection of the metaphysis below a major injury to the growth cartilage resulted in somewhat, but not significantly improved growth as compared with the control leg which had been subjected to the same injury but without subsequent metaphyseal resection. Pending further studies, the clinical use of metaphyseal resection is not justified.

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