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THE POSSIBILITIES OF ELIMINATING PREMATURE PARTIAL CLOSURE OF AN EPIPHYSEAL PLATE CAUSED BY TRAUMA OR DISEASE

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The phenomenon of a traumatic defect in an epiphyseal plate being filled out by bone tissue if there is simultaneous mechanical injury to both adjacent metaphyseal and epiphyseal bone was described by *Nové-Josserand* in 1894. The clinical importance of the post-traumatic formation of bony bridges between the epiphysis and the metaphysis in a tubular bone in a growing child is today well established.

In 1933 *Phemister* described his method for the operative arrestment of longitudinal growth of bones. This method implies that the area of fusion of the epiphysis and the metaphysis is large enough to arrest growth completely in the epiphyseal cartilage in question. Among others, *Abbot & Gill* (1942) and *Aitken & Magill* (1952) have described deformities resulting from post-traumatic partial closure of the epiphyseal plate in the distal end of the femur. *Salter & Harris* wrote in 1963 (p. 612): "After an epiphyseal plate injury, local growth may either cease immediately or it may continue at a retarded rate for a variable period before complete cessation. Furthermore, the growth disturbance may involve either the entire epiphyseal plate or only one part of it. The resultant deformity is progressive until the end of the child's growing period."

Concerning the prognosis of a traumatic deformity caused by a bony bridge formed between an epiphysis and a metaphysis in a growing bone the present author did not know of any definite exceptions from the rule formulated by *Salter & Harris* before the Case 1. described below was seen.

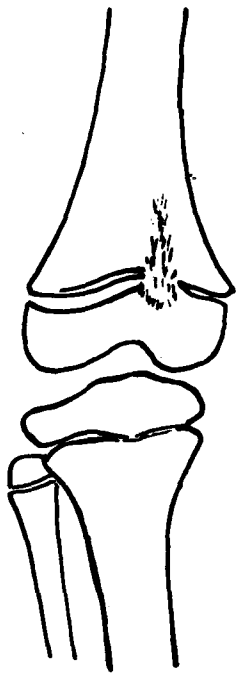


Figure 1. Case 1. Age ten years. Contour drawing of antero-posterior radiograph of the right knee. Note the bony bridge between the distal epiphysis and the metaphysis of the femur causing progressing varus and recurvatum deformity.

Case 1. H. N., a boy, born February 20, 1946. After a trauma to the right knee region in 1954 the boy was limping. X-ray examination several months after the injury gave a negative result. When the boy was seen for the first time by the present author on May 19, 1956 there was marked recurvatum and varus deformity in the right knee region. X-ray examination showed a bony bridge between the metaphysis and the epiphysis in the antero-medial part of the distal end of the femur (Figure 1).

In August 1956 the right knee could be hyperextended fifteen degrees more than the left and there were ten to fifteen degrees of varus deformity. The deformity was localized to the distal epiphyseal region of the right femur (Figures 2 and 3). The presence of a bony bridge between the metaphysis and the epiphysis was verified. The right femur was three centimeters shorter than the left.

On August 23, 1956, a supracondylar osteotomy of the right femur was performed and the deformity was corrected with slight overcorrection of the varus. The osteotomy consolidated in less than two months (Figure 3). The zone of partial epiphyseal closure of the distal femoral epiphysis was still visible in the radiograph.

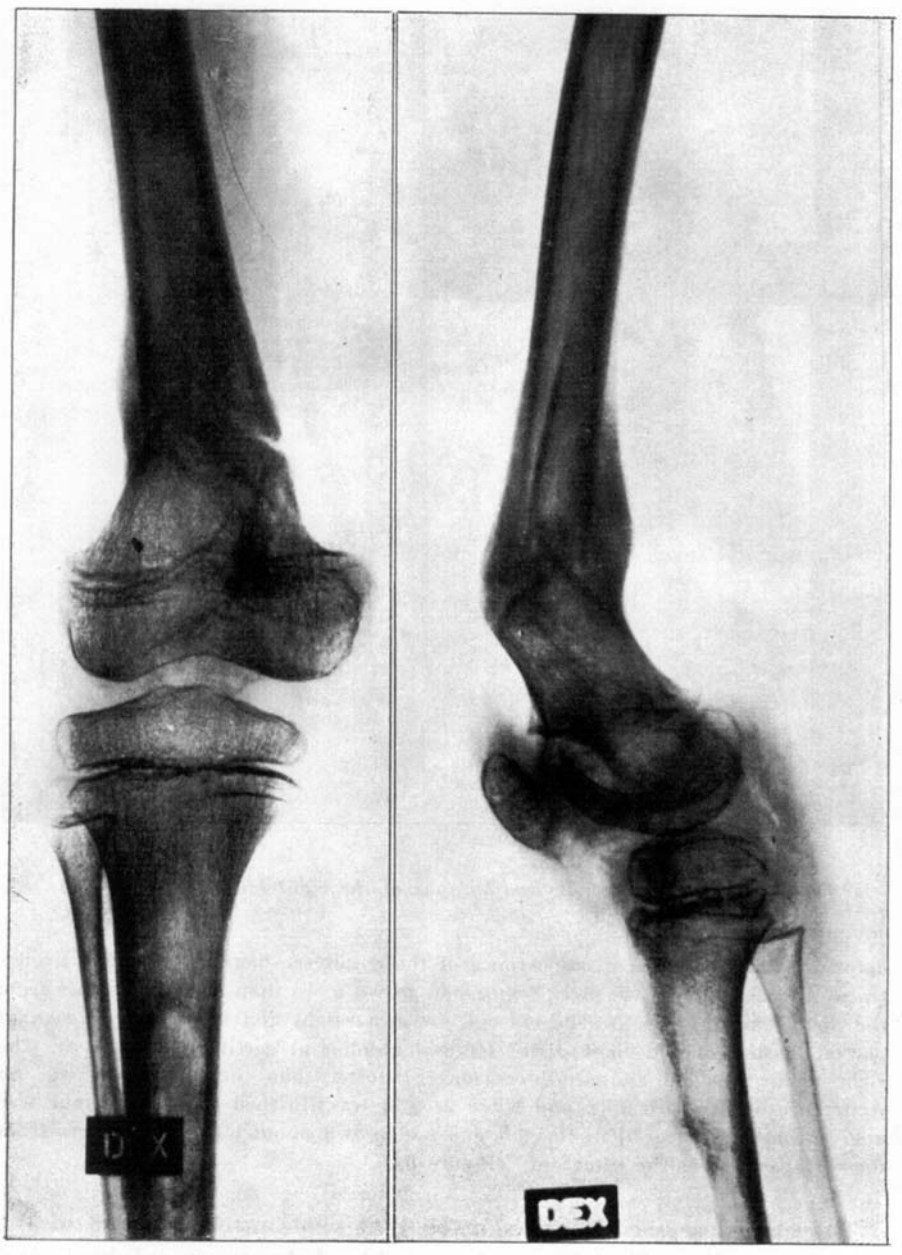
On the basis of general experience from similar cases the parents were told that recurrence of the deformity would probably occur and repeated osteotomy would be necessary. Repeated X-ray examinations showed no recurrence of the

A B

Figure 2. Case 1. A and B. Radiographs of the right knee. Age ten years.

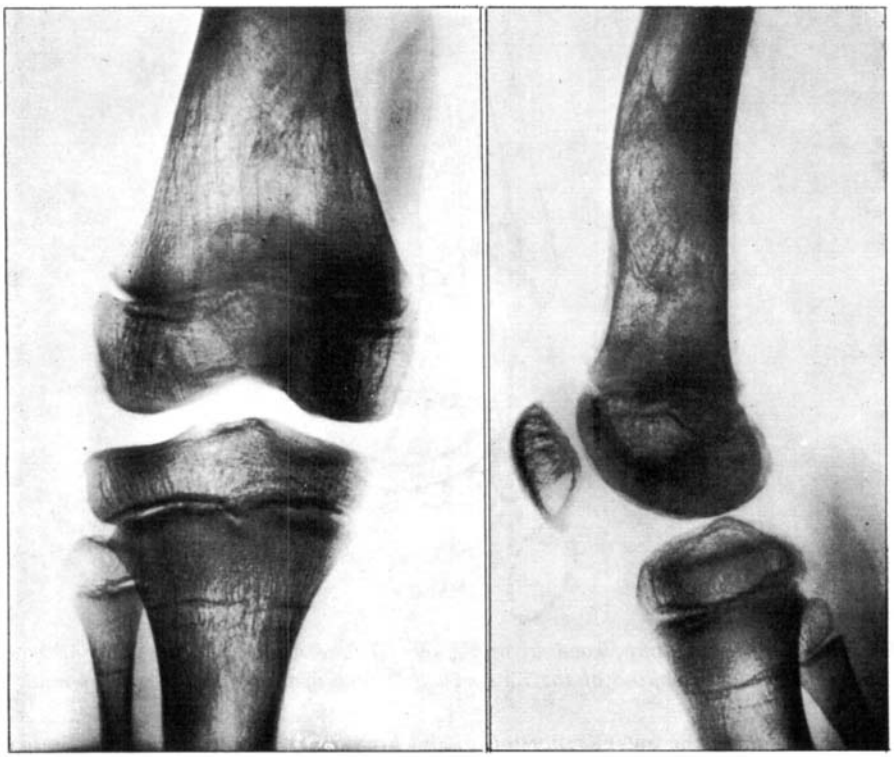
deformity but a gradual disappearance of the epiphyseo-metaphyseal bony bridge. Up to August 29, 1958, the right femur had grown more than two centimeters from the distal end (Figure 5). The extremity was straight and there was no sign of partial closure of the right distal femoral epiphyseal cartilage (Figure 4). The right femur was one-and-a-half centimeter shorter than the left. There was no recurrence of the deformity and when growth was finished the right femur was one centimeter shorter than the left and had grown about eight centimeters from the distal end after the osteotomy (Figure 6).

The case described above showed that spontaneous release of the growth-impeding effect from a bony bridge between an epiphysis and a metaphysis can occur even when it has caused a deformity requiring operative treatment. In 1963 *Blount*, after having seen the radiographs recommended that a report of this case should be written. The case



A B

Figure 3. Case 1. Age ten years and nine months. Radiographs of the right knee region two and a half months after supracondylar osteotomy of the femur and correction of the deformity. A. Antero-posterior view. B. Side view.



A B

Figure 4. Case 1. A. Antero-posterior radiograph of the right knee two years and four months after osteotomy. B. Side-view radiograph of the right knee two years after osteotomy. The bony bridge connecting the epiphysis and the metaphysis of the femur could no longer be seen.

also seemed to suggest the possibility of the restitution of normal growth in similar cases if an adequate operative method for eliminating epiphyseal closure in circumscribed areas could be found. In case 2, removal of a bony bridge between the epiphysis and the metaphysis in the upper end of the tibia was followed by a definite reduction of deformity by growth.

Case 2. A. K., a boy, born May 13, 1950. In March 1965 a deformity of the right knee was noticed. There was no history of trauma or severe illness. An older brother of the patient had a similar deformity in one knee.

At a clinical examination in June 1965, it was found that the right knee could be hyperextended twenty degrees more than the left. X-ray examination revealed a marked recurvatum deformity in the upper end of the right tibia (Figure 7).

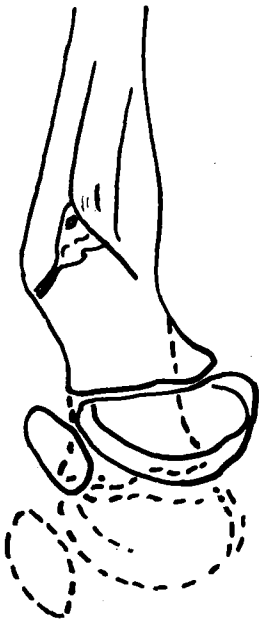


Figure 5. Case 1. Contour drawings of Figure 3 B and Figure 4 B showing normal growth of the lower end of the right femur in two years following osteotomy.

The distal end of the anterior portion of the proximal tibial epiphysis was found to be fused to the metaphysis (Figure 8).

As the patient's skeletal age was fourteen, or one year retarded, it was decided to try to resect the epiphyseo-metaphyseal bony bridge in order to eliminate the local growth-impeding factor producing progressive deformity.

On June 10, 1965 the proximal part of the beak-like anterior part of the upper tibial epiphysis was resected proximal to the insertion of the patellar tendon. It was controlled by direct vision that the bony connection between the epiphysis and the metaphysis was eliminated. The space occupied by the resected piece of bone was filled by free transplants of subcutaneous and infrapatellar fat tissue.

Two and a half months after the operation, tomography showed no reformation of a bony bridge between the epiphysis and the metaphysis (Figure 10). The recurvatum deformity gradually diminished. On november 15, 1966 the epiphyseal cartilages of the extremities were found to be closing. The recurvatum deformity of the right knee had diminished by about ten degrees and was no longer apparent enough to attract the attention of the patient or his parents (Figures 9 and 11).

DISCUSSION

There have been two ways of dealing with progressive deformities caused by partial closure of an epiphyseal plate. Repeated osteotomies with over-correction to delay the time of recurrence has been the

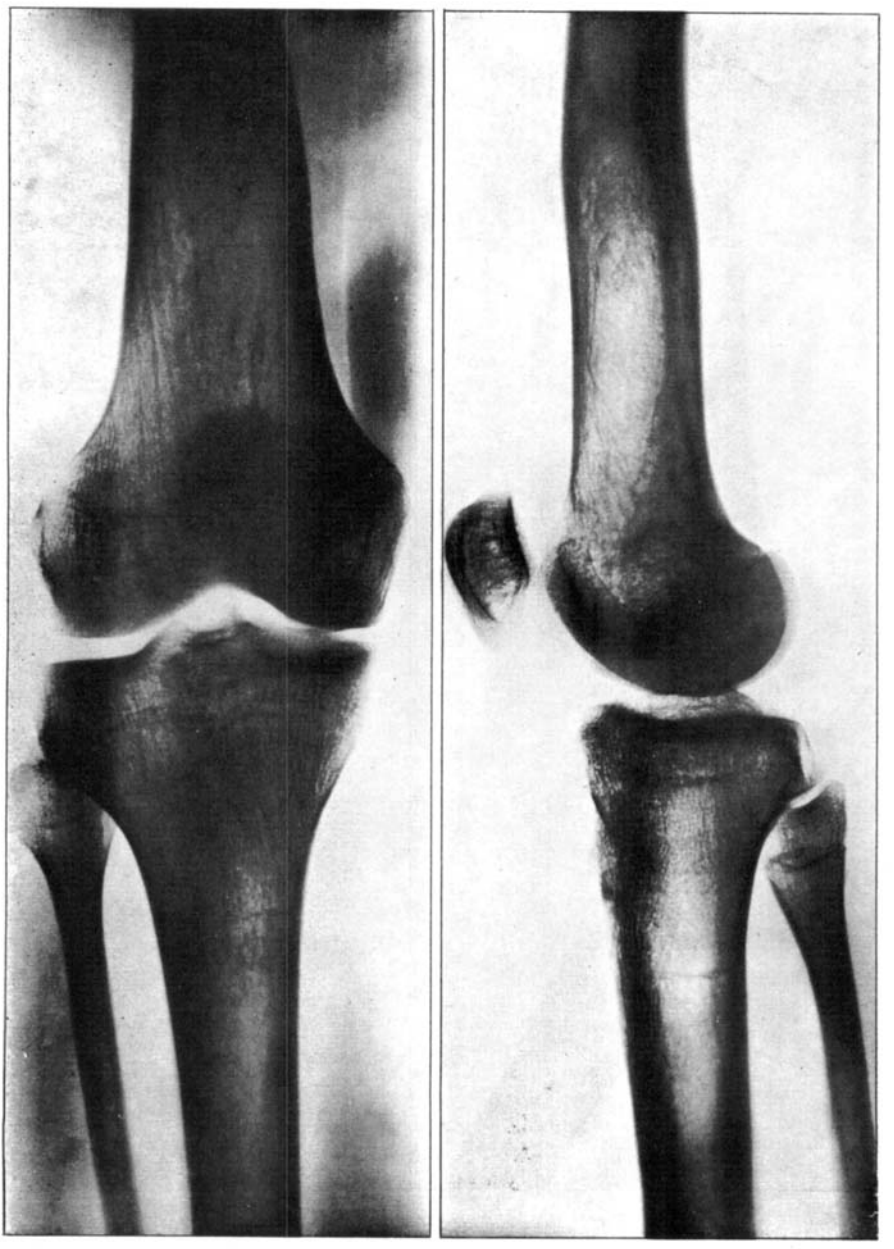


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Figure 6. Case 1. A and B. The right knee region at the age of nineteen years.

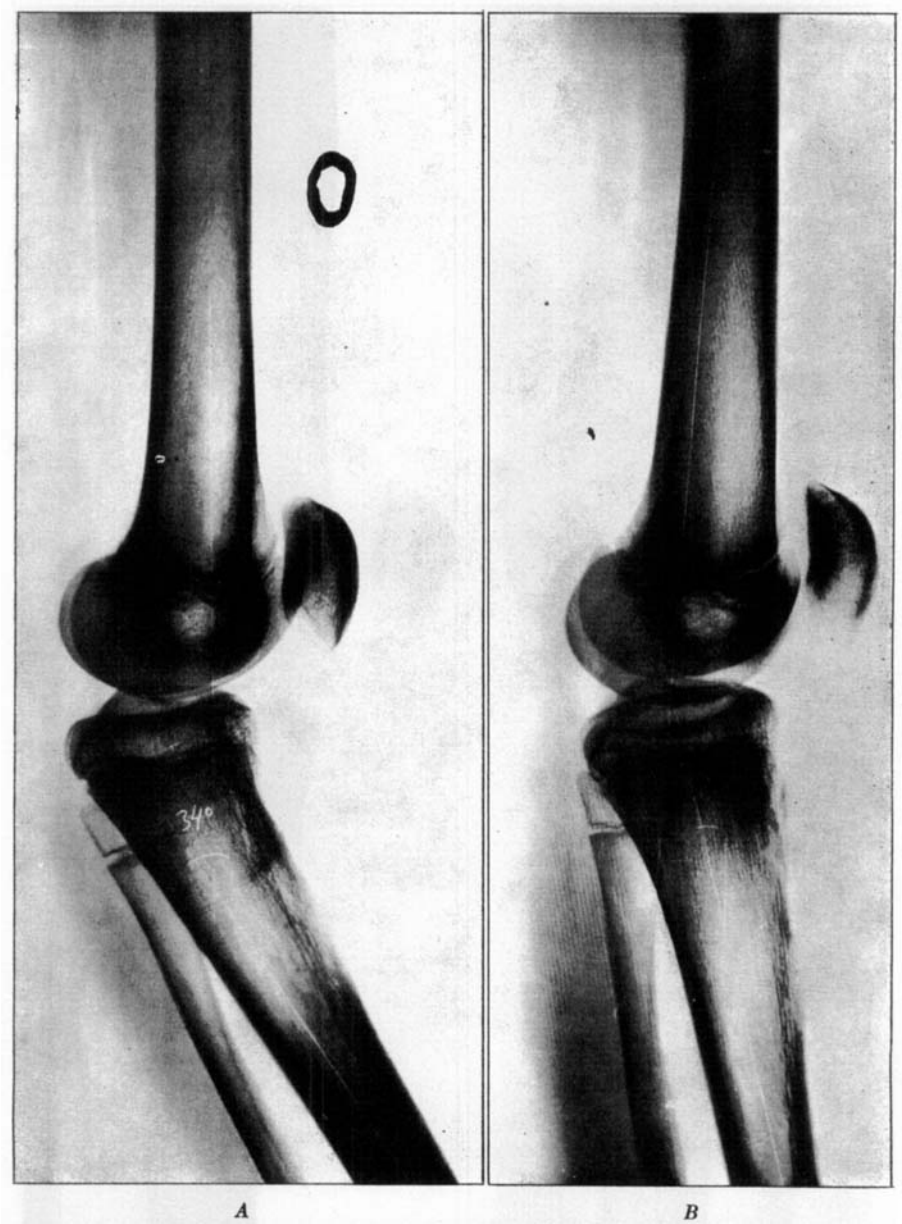
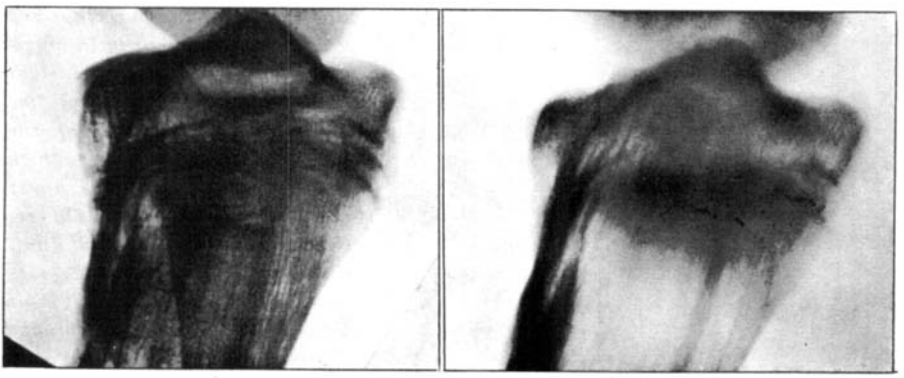


Figure 7. Case 2. Age fifteen years. Skeletal age fourteen years. Side-view radiographs of both knees in maximal hyperextension. Recurvatum deformity in the upper end of the right tibia. A. Right leg. B. Left leg.



A B

Figure 8. Case 2. Age fifteen years. A. Plain radiograph taken tangentially to the bony bridge connecting the anterior part of the upper tibial epiphysis with the metaphysis. B. Tomograph corresponding to A.

method of choice in young children and when the important distal end of the femur is concerned. In children over nine years of age, epiphyseodesis of the growing part of the damaged epiphyseal plate has proved adequate in the upper end of the tibia (*Langenskiöld & Riska*).

The great risk of causing additional damage to an epiphyseal cartilage or to its blood supply has probably prevented most orthopaedic surgeons from trying to restore normal growth in partially closed growth zones. However, some experimental work (*Johnson & Southwick, Friedenberg, Key & Ford)* and the cases described above suggest that operative elimination of premature closure of a circumscribed area of an epiphyseal cartilage could be possible. In 1949 *Langenskiöld & Edgren* showed that X-ray injury to limited portions of an epiphyseal plate did not provoke partial closure of the plate. Apparently the injured portion of cartilage prevented fusion of the epiphysis to the metaphysis.

The type of recurvatum deformity caused by partial closure in the anterior part of the tibia was extensively reviewed by *Peltesohn* in 1933. In recent years cases have been described by *Stirling* (1952), *Kellock* (1958), *Fielding, Liebler & Tambakis* (1960) and *Morton & Starr* (1964). In this group of cases the closure of the plate appears close to the periphery and is thus easily approachable by surgical intervention. In case 2 described above, implantation of fat prevented the reformation of the bony bridge for a long enough time to allow correction of the deformity by growth. According to the experiments of

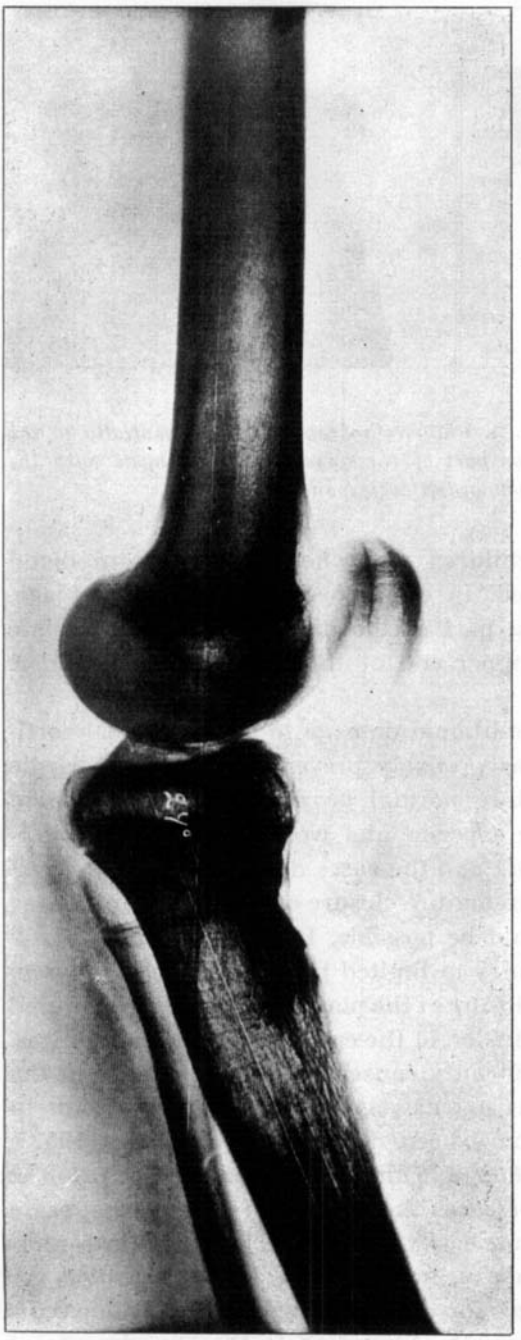


Figure 9. Case 2. Age sixteen and a half years. Side view in maximal hypertension of the right knee region one year and five months after resection of the bony bridge impeding growth in the anterior part of the upper tibial epiphyseal plate. The recurvatum deformity had diminished by about ten degrees (compare with Figure 7 A). Four other side-view radiographs taken in slightly different projections with the X-ray tube situated slightly anteriorly and posteriorly compared to Figure 7 A and Figure 9, showed variations of recurvatum within two degrees.

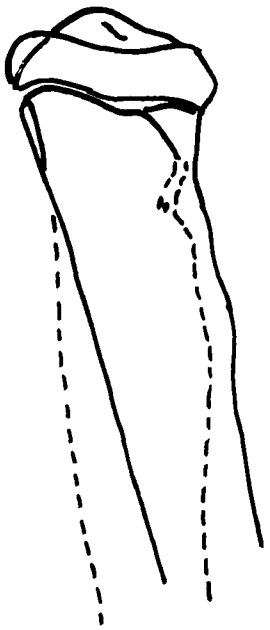


Figure 10. *Figure 11.*

Figure 10. Case 2. Side view tomograph of the upper end of the tibia two and a half months after operation. No signs of reformation of the bony bridge (compare with Figure 8 B).

Figure 11. Case 2. Contour drawings of the upper end of the tibia as seen in Figure 7 A and Figure 9.

Langenskiöld & Edgren and to those of *Heikel* concerning epiphyseal transplantation, dead cartilage might be another material suitable for interposition between the epiphysis and the metaphysis. Whether bony bridges in the inner parts of an epiphyseal plate would be accessible by surgical intervention from the side of the metaphysis without provoking additional growth disturbing factors is a question which needs further experimental research.

SUMMARY

In a boy aged ten and a half years, partial closure had appeared in the antero-medial part of the distal epiphyseal plate of the femur

within two years after trauma. Recurvatum and varus deformity of the knee and a three centimeter shortening of the affected bone were present. After supracondylar osteotomy and correction of the deformity, the bony bridge disappeared and the bone grew normally until maturity.

In another boy, resection of a bony bridge between the anterior part of the upper tibial epiphysis and the metaphysis at the skeletal age of fourteen years led to a ten-degree correction by growth before maturity.

There seem to be possibilities of creating operative methods for the elimination of epiphyseal closure in circumscribed areas.

RESUME

Chez un garçon âgé de 10 ans et demi, une fermeture partielle de la partie antéro-médiane de la plaque épiphysaire du fémur s'est manifestée dans les deux ans qui ont suivi un trauma. La déformation en recurvatum et varus du genou et un raccourcissement de 3 cm de l'os ont été constatés. Après ostéotomie supracondylaire et correction de la déformité, le pont osseux disparut et la croissance de l'os s'effectua normalement jusqu' à maturité.

Chez un autre garçon, la résection d'un pont osseux entre la partie antérieure de l'épiphyse tibiale supérieure et la métaphyse, à l'âge de 14 ans, a abouti à une correction de dix degrés par la croissance avant maturité.

Il semble qu'il soit possible de trouver des méthodes opératoires pour empêcher la fermeture épiphysaire dans des parties circonscrites.

ZUSAMMENFASSUNG

Bei einem Knaben im Alter von zehn und ein halb Jahren fand eine partielle Schliessung im antero-lateralen Teil der distal Epiphysenfuge des Femurs statt innerhalb zwei Jahren nach einem Trauma. Eine Recurvatum- und Varusdeformität des Knies und eine Verkürzung von drei centimetern wurden festgestellt. Nach einer suprakondylären Osteotomie und Korrektion der Deformität verschwand die knöcherne Brücke und das Femur ist normal gewachsen bis zur Maturität.

Bei einem anderen Knaben leitete eine Resektion einer knöchernen Brücke zwischen dem vorderen Teil des Epiphysenkerns und der Metaphyse des oberen Endes der Tibia im Alter von vierzehn Jahren

zu einer Korrektion einer Recurvatumdeformität vor dem Ende des Wachstums.

Es scheint als ob es Möglichkeiten gäbe operative Methoden zu entwickeln, mit denen ein vorzeitiger Schluss eines begrentzten Gebietes einer Epiphysenfuge eliminiert werden kann.

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