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HAHN'S OPERATION FOR PSEUDARTHROSIS AFTER OSTEOMYELITIS OF THE TIBIA IN CHILDREN

A Report of Three Cases

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Three children with pseudarthrosis of the tibia after osteomyelitis and extensive sequestration of the diaphysis were operated according to Hahn with transfer of the fibula to the proximal part of the tibia at ages 2–9 years. Because of damage to the distal growth plate, secondary to the infectious process, epiphyseodesis of the proximal ends of the tibia and fibula on the unaffected side was necessary to reduce the length discrepancy. Restored continuity of the tibial diaphysis resulted in restored longitudinal growth proximally and in increased diaphyseal width. In all three cases the operation resulted in good weight-bearing limbs with only slight residual disability at adult age. Hahn's original method is simpler and in children may result in a limb which is closer to normal than the modifications of his method.

Key words: fibular transplantation; osteomyelitis; pseudarthrosis; tibia

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Since Hahn in 1884 reported the first case in which a pseudarthrosis of the tibia was successfully treated by transfer of the fibula, many authors have described similar cases treated by different modifications of the method. However, few have reported long-term results. The purpose of this communication is to demonstrate the results in three children in whom post-osteomyelitic pseudarthrosis of the tibia was successfully treated by Hahn's original method and regular follow-up examinations were possible until the patients became adult.

CASE REPORTS

Case 1

A boy aged 6 months was admitted on June 17, 1959 to a general hospital with acute abdominal symptoms. Septicaemia was suspected and Sigmamycin® was administered parenterally. Four days after admission, swelling of the left leg was noticed. Two days later, an abscess in the proximal part of the leg was opened and 10 days after that another abscess in the distal part was incised. *Staphylococcus aureus* was cultured. Treatment with different antibiotics and immobilization of the left leg were continued.

The boy was first seen in the Orthopaedic Hospital of the Invalid Foundation on Oct. 21, 1959 (Figure 1). Of the main part of the left tibial diaphysis only some sequestra remained and there was no marked involucrum. The lower end of the fibular diaphysis was also affected. Sequestra were removed from the tibia in Nov. 1959 and Feb. 1960. In Sept. 1960, the signs of infection had subsided. There was a large defect and a pseudarthrosis in the tibial diaphysis (Figures 2 and 6 A). On Sept. 28, 1960 the diaphysis of the left fibula was transferred into the remaining proximal part of the tibia, principally according to the original method described by Hahn (1884). The distal fragment of the tibia was fixed to the fibular diaphysis with a screw (Figure 3).

The limb was immobilized for 6 months, after which there was solid union. The transferred fibular diaphysis merged into the tibia and a new fibular diaphysis

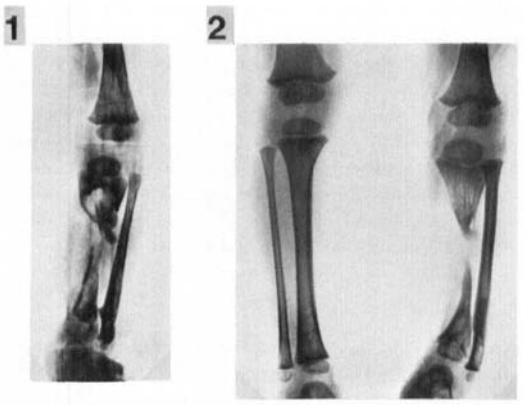

Figure 1. Case 1. Radiograph of left leg. Age 10 months. Large defect and sequestra of left tibia 4 months after onset of osteomyelitis.

Figure 2. Case 1. Radiograph of both legs. Age 1 year and 9 months. Large defect of left tibial diaphysis. Proximal subluxation of head of left fibula. Growth disturbance in distal end of tibia. State before Hahn's operation.

formed from the periosteum (Figure 4). At the age of 11 years the left leg was 4 cm shorter than the right and epiphyseodesis of the proximal ends of the right tibia and fibula was performed. At the age of 15½ years

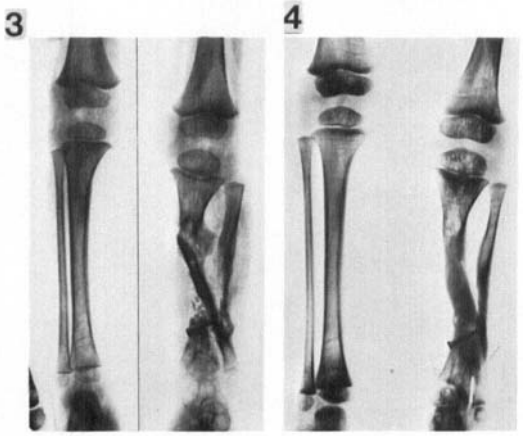

Figure 3. Case 1. Radiograph of both legs. Age 2 years. State 1½ months after transfer of the left fibula according to Hahn's method. Formation of a new fibular diaphysis from periosteal sleeve left in place had started.

Figure 4. Case 1. Radiograph of both legs. Age 2 years and 11 months. Tibio-fibular synostosis below the middle third of the leg. Otherwise, both diaphyses reformed. Slight growth disturbance in distal end of tibia.

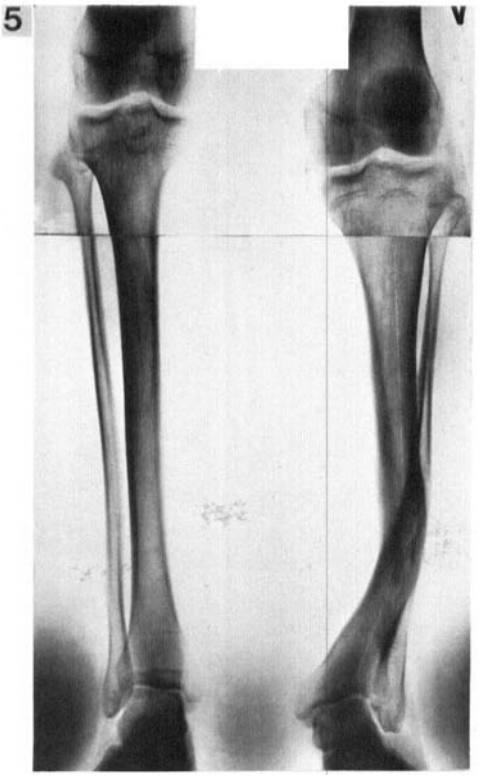

Figure 5. Case 1. Radiograph of both legs. Age 15½ years. Growth finished. Bowing into varus of tibial diaphysis. Valgus in ankle joint after growth disturbance in distal tibia. No functional disability.

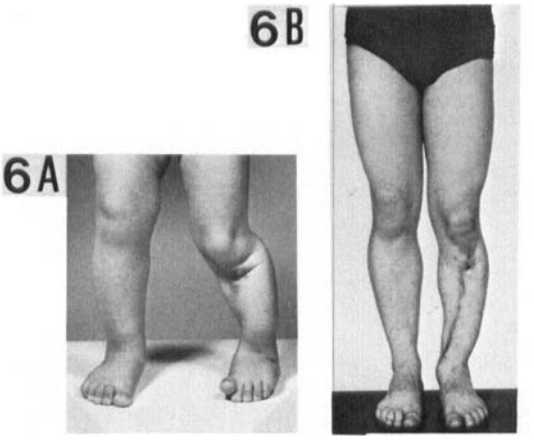

Figure 6. Case 1. Photographs. A, *Age 1 year and 9 months. State before Hahn's operation.* B. *Age 20 years.*

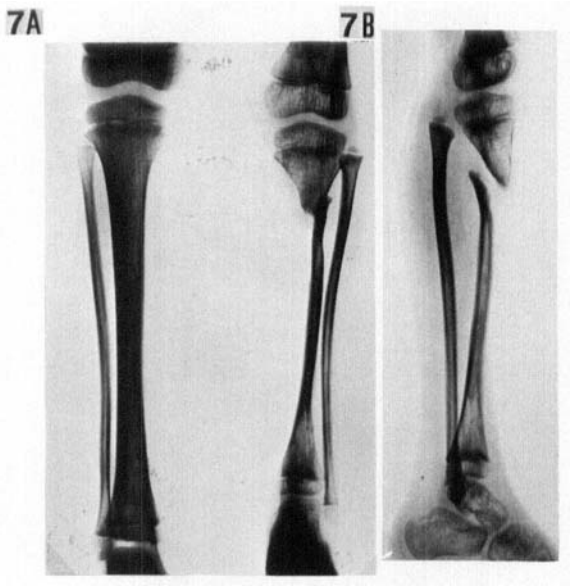

Figure 7. Case 2. Radiographs before Hahn's operation. Age 8 years. A. *Anteroposterior radiograph of both legs. Tibial diaphysis extremely thin, pseudarthrosis in its proximal part. Proximal subluxation of the head of the fibula.* B. *Lateral radiograph of left leg. The shape of the distal tibial epiphysis proved that the central part of the distal growth plate had been affected by the disease (cf. Figure 9).*

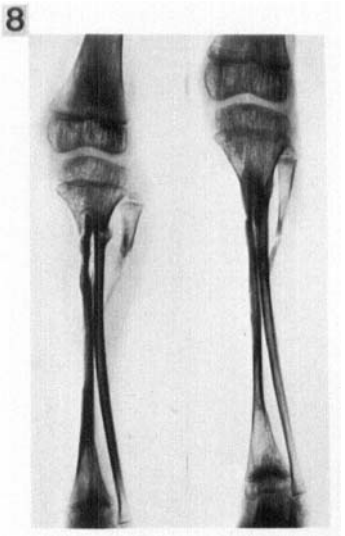

Figure 8. Case 2. Anteroposterior radiographs of left leg. Left: *2 months after transfer of the fibula to the proximal end of tibia. A sliding graft from the tibial diaphysis had been plugged into the proximal part of the tibia beneath the fibular diaphysis. The proximal part of the fibular diaphysis had started to reform from the periosteum left in place.* Right: *8 months after operation.*

growth of the legs was finished (Figure 5). The left leg was 2 cm shorter than the right. There was some bowing into varus of the tibia at the site of tibio-fibular synostosis and some valgus in the ankle joint as a result of the affection of the distal tibial growth plate secondary to the infectious process. Clinically, the deformity was less apparent (Figure 6 B) and the function of the left lower limb was undisturbed. At the last follow-up examination at the age of 20 years, the boy was voluntarily doing his military service in the Finnish army.

Case 2

An 8-year-old boy was first seen in the Orthopaedic Hospital of the Invalid Foundation on March 13, 1962 (Figures 7 and 10 A). There was a pseudarthrosis in the proximal third of the left tibia and the tibial diaphysis was extremely thin. The left leg was 5 cm shorter than the right. At the age of 3½ years he had an infected stab wound in his left leg followed by osteomyelitis of the left tibia. The boy was treated in a county hospital. Staphylococci were cultured from an abscess in the leg. There was total sequestration of the tibial diaphysis. From 1957 to 1959 the limb was immobilized in plaster and from 1959 to 1962 the boy used a brace on the left lower limb.

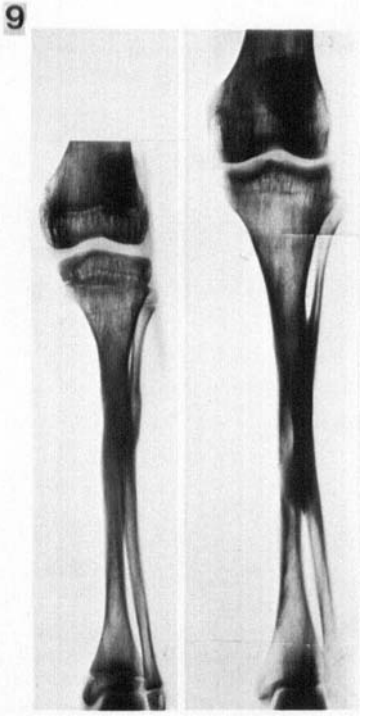

Figure 9. Case 2. Anteroposterior radiographs of left leg. Left: *Age 11 years. Synostosis of tibia and fibula.* Right: *Age 19 years. Synostosis of the diaphyses was the only pathological sign.*

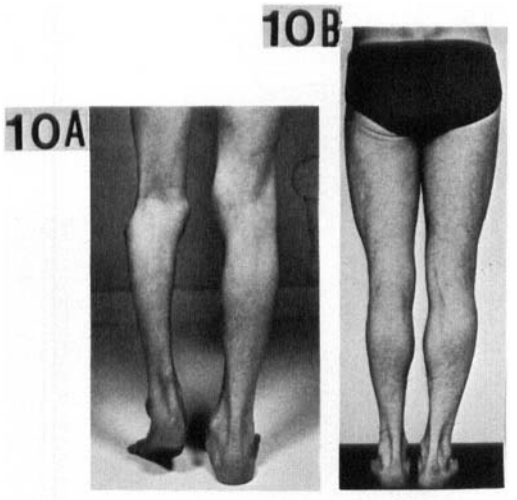

Figure 10. Case 2. Photographs. A. *At age 8 years, before Hahn's operation.* B. *At age 25 years.*

Figure 11. Case 3. Anteroposterior radiographs of both legs. Age 8 years and 8 months. Pseudarthrosis between proximal and middle third of tibial diaphysis. Distal tibial epiphysis fused to the talus but distal growth plate open.

On March 28, 1962 the left fibula was transferred to the proximal part of the tibia, according to Hahn's method. Five months after the operation, spongy bone was transplanted to the site of the pseudarthrosis and 3 months later the tibia was clinically solid. The operated limb grew rapidly (Figure 8). At the age of 12 years, the shortening of the left leg was 4½ cm and epiphyseodesis of the proximal ends of the right tibia and fibula was carried out. Two years later, epiphyseodesis of the distal end of the right femur was performed. The radiographic signs of growth disturbance in the distal end of the left tibia, as seen in Figure 8, disappeared (Figure 9, left). At the age of 19 years, the left leg was 1½ cm shorter than the right (Figure 9, right). At the last follow-up examination at the age of 25 years (Figure 10 B), the mobility of the left lower limb was normal and there was no functional disability.

Case 3

A boy was admitted to the Orthopaedic Hospital of the Invalid Foundation on Feb. 7, 1961, at the age of 8½ years. Between the proximal and the middle third of the left tibia there was a pseudarthrosis (Figure 11). The tibial diaphysis was thin and the distal tibial epiphysis was fused to the talus. *Staphylococcus aureus* was cultured from a fistula at the left ankle.

At the age of 7 years, in Nov. 1959, there was an abscess in the gluteal region which was followed by osteomyelitis of the left tibia. The boy was treated in a general hospital and antibiotics were administered from the day of onset of pain in the leg. There was total sequestration of the tibial diaphysis and sequestrectomy was performed in October 1960. In 1961, a brace was prescribed.

In Feb. 1962 (Figure 12), a small fistula at the ankle remained. On April 5, 1962, the left fibula was transferred to the proximal fragment of the tibia according to

Figure 12. Case 3. Anteroposterior radiograph of left leg. Age 9 years and 8 months. State before Hahn's operation.

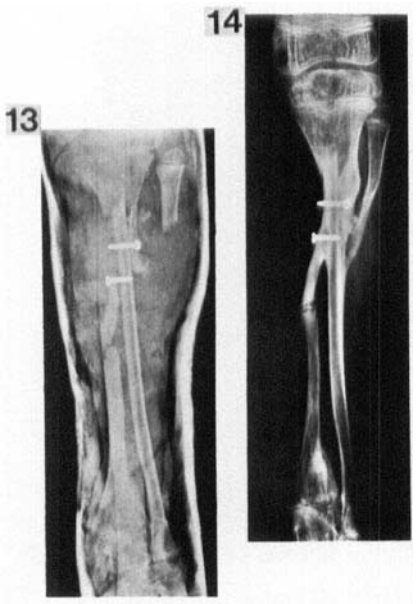

Figure 13. Case 3. Anteroposterior radiograph of left leg in plaster immediately after Hahn's operation. Age 9 years and 10 months. The proximal tibial fragment was fixed to the fibular diaphysis by means of a screw. The distal tibial fragment was osteotomized 5 cm from its proximal end and fixed to the fibula by another screw.

Figure 14. Case 3. Anteroposterior radiograph of left leg 9 months after Hahn's operation. Fibula fused to the tibia. Pseudarthrosis of the tibia at the osteotomy site. The leg was stable.

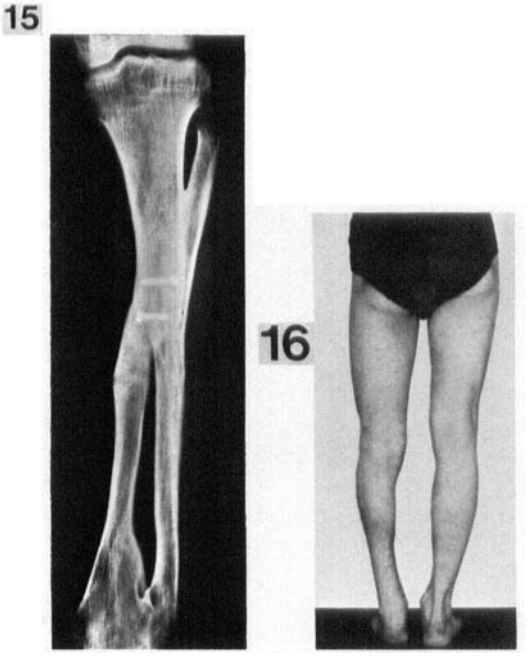

Figure 15. Case 3. Anteroposterior radiograph of left leg. Age 26 years. Pseudarthrosis at osteotomy site healed. Tibia and fibula fused to the talus.

Figure 16. Case 3. Photograph. Age 26 years.

the method of Hahn (Figure 13). Weight bearing without protecting plaster was allowed 5½ months after the operation. Five months later, there was still a pseudarthrosis at the site of osteotomy of the distal fragment of the tibial diaphysis, but the fibula had fused to the tibia (Figure 14). At the age of 13 years, the left leg was 3 cm shorter than the right and epiphyseodesis of the proximal ends of the right tibia and fibula was carried out. The last follow-up examination was made when the patient was 26 years old (Figures 15 and 16). There was a 3½ cm shortening of the left leg. When the left heel was raised 2 cm by the shoe, no limp could be noticed. There was a synostosis between the tibia and the fibula in the middle part of the leg. At the ankle, both the tibia and the fibula were fused to the talus. The function of the left knee was normal.

Operative procedure

In all three cases reported above, the main steps of the operation as described by Hahn in 1884 were carried out. The following measures were common to all three operations: A longitudinal incision, including excision of scars, was made over the anterior aspect of the tibial diaphysis. The scar tissue connecting the proximal and the distal portion of the tibia was excised and bone was removed from the end of the proximal portion in order to open the marrow cavity enough to make room for the fibular diaphysis. Following the anterior aspect of the interosseous membrane in the lateral direction, the fibular diaphysis was reached. Along the medial border of the fibula the periosteum of the diaphysis was split longitudinally and by blunt preparation the bone was released from its periosteum. The fibular diaphysis was divided at or a little proximal to the level of the tibial pseudarthrosis. The distal part of the fibula was brought medially and its proximal end was plugged into the marrow cavity of the proximal part of the tibia. Bone chips obtained during trimming of the bone ends were packed into the places where bony fusion was aimed at. The soft tissues were closed without drainage and a padded and split plaster cast was applied. Hahn's operation was performed at the ages of 1 year and 10 months, 8 years and 9 years, respectively.

Depending on differences in the pathological anatomy in the three cases, there were some differences in the operative technique:

Case 1. In order to obtain fusion between the distal portion of the tibia and the fibular diaphysis, the marrow cavities of both bones were opened wide at the

level of the proximal end of the distal tibial fragment. This was fixed to the fibular diaphysis by means of a screw (Figure 3).

Case 2. Close contact between the proximal and the distal portions of the tibia was obtained by means of a 6-cm-long sliding graft taken from the proximal end of the distal tibial portion. The graft consisted of about half of the width of the very slender diaphysis and it was plugged into the marrow cavity of the proximal fragment beside the fibula (Figure 8).

Case 3. Contact between the fibular diaphysis and the proximal portion of the tibia was secured by a screw. In order to provoke fusion between the distal portion of the tibia and the fibular diaphysis, the tibial diaphysis was osteotomized about 5 cm distal to the level of the pseudarthrosis and the proximal end of the distal portion of the tibia was turned against the fibula and fixed to it by means of a screw (Figure 13).

RESULTS

The results are evident from the case reports and from the figures. The most remarkable consequences of the restored continuity of the tibial diaphysis in all three cases were the restored growth in the proximal end of the tibia and the gradual increase in diameter of the tibial and fibular diaphyses. In all three cases the operation resulted in a good weight-bearing limb and residual disability was slight in cases 1 and 3 and minimal in case 2. In the middle part of the operated limbs a synostosis of the tibial and the fibular diaphyses persisted. Before the transfer of the fibula the head of this bone was markedly prominent (Figures 2, 6 A, 7 A, 10 A and 11). However, this phenomenon disappeared and was not present when growth was finished (Figures 5, 6 B, 9, 10 B, 15 and 16). The distal growth plate was affected by the infectious process in all three cases, and led to a marked growth disturbance in case 1. In case 2, marked radiographic changes were seen in the distal end of the tibia at the age of 6–8 years (Figures 7 and 8), but these changes later disappeared (Figure 9). The course in case 2 shows that a normally functioning leg without any joint deformities can be expected after Hahn's operation for tibial pseudarthrosis in a child.

In all three cases, epiphyseodesis of the proximal ends of the tibia and fibula of the unaffected leg reduced the final discrepancy of leg length to an acceptable amount.

DISCUSSION

The timing of sequestrectomy on diaphyses of long bones in children has been discussed by many authors. Before the era of antibiotics, the life-saving role of diaphysectomy and sequestrectomy was thoroughly discussed (Mitchell 1928, Platt 1928) but today antibiotics enable us to recommend delayed sequestrectomy (Fowles et al. 1979). In 1968, Griffiths recommended delay of sequestrectomy "in the hope that an involucrum will develop". This principle is even more important when the femur is concerned (Langenskiöld 1982). Ferrand et al. (1966) and Pinon & Martini (1981) pointed out that pseudarthrosis after osteomyelitis may be provoked by too early and too radical surgery. In our cases 1 and 2, sequestrectomy was performed 5 months and in case 3 1 year after onset of the disease. Radiographic findings do not support the idea that further delay or less radical surgery would have prevented pseudarthrosis in these cases.

The successful treatment of infection in osteomyelitis in children today is mainly a question of time. However, when destruction of important parts of the skeleton has occurred there is often urgent need for reconstructive surgery. Boyd et al. (1961) pointed out that all pseudarthroses of long bones in children are difficult to cure and imply a risk of ultimate amputation. In a bone with a pseudarthrosis, growth is slowed down and therefore reconstruction should not be delayed too long. Methods involving minimal risks for failure should be used.

Transfer of the fibula for pseudarthrosis of the tibia after osteomyelitis, first described by Hahn (1884), has been modified by several authors (Huntington 1905, Stone 1907, MacAusland & Wood 1912, Brandes 1913, Stracker 1926, Girdlestone & Foley 1933, Wilson 1941, Milch 1950, Bosworth et al. 1966 and Ferrand et al. 1966). Huntington (1905) transferred both ends of the fibular diaphysis to the tibia and several other authors have followed this principle (Agiza 1981). According to our experience, the use of Hahn's original method seemed to be simpler and to carry less risk for complications than the modifications. In our cases the proximal part of the

diaphysis of the fibula was easily approached by preparation from the medial part of the leg through the area of tibial pseudarthrosis and along the interosseous membrane. The subperiosteal release of the fibular diaphysis implicates minimal risk for damage to the peroneal nerve and leaves the periosteal sleeve to regenerate the proximal part of the diaphysis. Several authors have reported complications from paralysis of the peroneal nerve when the fibula has been approached from the lateral side in order to transfer it to the tibia.

Osteotomy of the distal fragment of the tibia and attaching it to the fibula, a measure used in case 3, has earlier been used by Bettman (1929).

Some authors (Brandes 1913, Oldenburg 1962) have pointed out that the original method of Hahn could produce a change in the position of the lateral malleolus in relation to the ankle joint, thus causing trouble in this joint. The course in case 2 (Figure 9) points to this risk being ruled out when Hahn's operation is performed many years before the end of the patient's growth period.

In 1979, Bielawski et al. and in 1981, Papineau et al. suggested transplantation of cancellous bone when pseudarthrosis of a tubular bone threatens as a sequel of osteomyelitis. This solution is an alternative to delaying sequestrectomy in order to wait for a stable involucrum. However, when the tibia is involved and infection has subsided, Hahn's operation may be a safer method than just free transplantation of bone.

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