G. ODELBERG-JOHNSON, VARBERG:

ON SO-CALLED GRAFT FRACTURES AFTER ALBEE'S OPERATION

Albee's spinal operation aims at fixing a certain portion of the spine rendered deficient through disease or injury. As is well known this is done by inserting into the split spinal processes an autoplastic bone graft usually taken with its periosteum from the tibia. The graft unites with the spinal processes and forms a bony bridge between these. In such manner a firm posterior brace is obtained for the weakened spine.

In the course of the last five years, Albee's operation has been performed at Apelviken in more than 250 cases of tuberculous spondylitis of the thoracic, lumbar and lumbo-sacral spine. As to the indications for operation and the technique we have followed in the main the lines suggested by *Waldenström*. Thus, the operation has been carried out: 1) only after the patient's general condition has been rendered satisfactory through treatment on general lines, 2) when clinical and roentgenological signs have made it evident that the diseased process has subsided or become stationary, 3) after the best possible correction in plasterbed by Finck's method of a gibbus if present. As a rule we have made use of a straight tibial graft, with the periosteum directed dorsally or toward one or either side. In several cases where it was impossible to obtain entire correction of the gibbus we made use of an arc-shaped graft laid in with the periosteum laterally. In one case with a large gibbus the graft was fractured sub-periosteally at the operation and inserted into the spinal processes, so as to cause the fractured ends to overlap at the maximum point of the gibbus. The graft has generally been fixed to two healthy vertebræ above and one

healthy vertebra below those affected. In some cases we have used shorter grafts.

According to current opinion most of an autoplastic free bone graft undergoes necrosis, the periosteum and endosteum partly surviving. Vessels and connective tissue extend and grow into the transplant and gradually absorb the necrotic bone. Simultaneously we get an invasion of osteoblasts forming new bone. If the transplant is in good contact with living bone and periosteum and subjected to stress, it soon becomes firmly united. By gradual absorption and apposition of new bone the graft becomes organized and rebuilt for its new task. The reformation of a bone graft in dogs takes from 4 to 8 months, in man a far longer time, probably 18 months to 2 years. Already after 2—3 weeks the graft is generally found united to surrounding bone. The rebuilding, with absorption and new bone formation, can be followed by roentgenograms from different stages of the healing process.

The commonest complication after Albee's operation that we have had to deal with has been the so-called »graft fracture« (Waldenström). This complication has been described by several authors. With graft fracture we mean in this relation a defect of the bone graft, clinically and roentgenologically demonstrable, often with an altered position of its fragments. In 28 patients we have had 30 graft fractures kept under observation for a longer or shorter period of time. The majority of fractures were diagnosed 5—6 months after the Albee operation, none earlier than 2 months afterwards. In many cases the diagnosis was made much later. In one patient the fracture seemed to have arisen without known cause in an entirely rebuilt graft 1 year and 11 months after the Albee operation, in another patient 1 year and 7 months, and in a third patient 14 months after the operation.

The patients complain of pains in the back and the sides. The spine, formerly stabile, again shows signs of instability. Pains have appeared in upright position but disappeared in supine position. Locally there has been swelling and tenderness over the seat of fracture. We have been unable to find on clinical

examination any mobility between the fragments of the transplant except in one case, where respiratory movements between the fragments could be observed at the second operation. In several cases the gibbus, corrected in plaster bed, partly reappeared after fracture of the graft. In five cases the operation scar healed by second intention after the Albee operation; in some of these the transplant underwent partial sequestration. We cannot speak here of simple fracture of the graft, but the clinical and roentgenological signs accord with those observed in an ordinary fracture of the graft. The periosteal new bone formation becomes more active, however, the end result being often a coarse bony plate between the spinal processes.

In all the cases the graft fracture remained undetected until the patient left his bed about two months after the Albee operation and began to subject his spine, hitherto reclined in a plaster bed, to stress. In one case a female patient was free from symptoms for 21 months after the Albee operation. She then fell in a staircase hitting her back against a step, and developed pains and instability of the back. On examination a fracture of the graft was found at the injured place.

In a skiagram, the graft fracture appears as a defect throughout the transplant, visible in lateral as well as in anteroposterior projection. The fragments often form an angle open ventrally or laterally. The outlines of the defect, at first sharp, gradually become blurred. Little by little, periosteal deposits begin to form on its dorsal, ventral and lateral aspects. These gradually increase, finally forming a bridge across the defect. In some cases the periosteal bone has first formed a bridge across the defect; the latter having then been filled up with dense bony substance, probably endosteal bone; the site of the fracture is only evident by a swelling. In a couple of cases of graft fracture situated in the periphery, signs of more active bone formation are lacking despite a long time of observation. In these cases the spinal processes of the destroyed vertebral bodies are firmly united by a powerful bony bridge.

Twenty patients were treated on conservative lines in plaster bed for from 3 to 6 months, followed by a supporting corset.

In 3 cases recovery was complete, with a roentgen appearance as described above. In most of the remaining cases there are signs of a more or less advanced periosteal callus formation.

In 8 cases operation was performed, one or several transplants being inserted parallel with and in good contact with the old one, thus bridging the defect. In 6 cases the new graft gives evidence of complete or progressing union, in the rest the time of observation has been too short to make possible a final judgment of the result. At the operation, the graft fracture is evident in the shape of a narrow, light-coloured, soft band in the dark-red spongiosa. Histological examination was carried out in 4 cases. In the bone defect was thus found not only hard connective tissue with a transition to cartilage, but also true hyaline cartilage with chondrogenous new bone formation. In several of the cases there was at the operation obvious periosteal callus formation; in one there was found a firm osseous union between two spinous processes immediately at the ventral aspect of the defect in the transplant. It is therefore clear that graft fractures have an obvious tendency to unite, whether the treatment be of conservative or operative nature. The union proceeds as in union with callus formation in the case of a simple fracture. The abundant presence of cartilage and chondroid tissue is very like the appearance of the fracture of an extremity where the fragments have not been fully fixed during the process of union.

In many patients the spondylitis remains stationary in spite of the graft fracture. Symptoms have disappeared fairly soon; in many patients, however, the time of observation has been too short. In one of the patients treated by operation, a girl, aged 8, there is a coarse bony bridge between five spinous processes, and of the graft fracture there is not a trace. From the two vertebræ originally affected the process has, four years after the onset of the disease, encroached upon the peduncles and the posterior half of the vertebral bodies of the two vertebræ immediately above. Another patient shows, eighteen months after the new graft inlay, a defect also through the latter, at the site of the old fracture. Concurrently with this there are signs

of fresh spondylitis in another part of the spine, beside active tuberculosis.

Menard's investigations have shown that a tissue defect in the pillar made up of vertebral bodies and intervertebral discs superimposed on one another in the thoracic and lumbar spine is compensated by a greater or lesser degree of inflexion. The vertebral bodies above and below the defect approach each other in order to fill up the gap in the spinal column. It this way the body is always striving to re-establish the lost stability of the spinal column.

In the case of tuberculous destruction of the vertebral bodies, the remainder of the affected bodies become compressed on inflexion. The healthy vertebral bodies above and below the destruction will approach each other and sink down into the tuberculous granulation tissue. As a result of pressure on the atrophic spongiosa and caries arising from the tuberculous granulation tissue the destructive process in the bone goes on attacking also sound bony tissue and healthy vertebral bodies. The original inflexion increases with progressive bone destruction. In this way the gibbus may grow for a long time.

By overcoming vertical stress by reclining in supine position, the mechanical factor for progress of the spondylitis is *partly* inhibited. The contractures of the back muscles can only be made to disappear by prolonged reclination. This reclination stops a progressive inflexion and brings about, through reduction of the gibbus, a more favorable shape of the spinal column, functionally and cosmetically. Alteration in shape and reduction of the gibbus are partly attained through the formation of lordosis immediately above and below the gibbus, which is thereby caused to fall in. Prolonged pressure causes atrophy, with alteration in the shape of the spinal processes and vertebral arches. Collapsed remainders of vertebral bodies which do not show signs of osseous or fibrous union may be forced apart by redression so as to diminish the angle of inflexion.

The Albee operation such as it is carried out at Apelviken aims at fixing and retaining the shape of the spine obtained through redression. The bone graft inserted into the spinous

processes is thus meant to fix not only the paragibbous lordoses but also to retain the corrected inflexion in those cases where a gap has again arisen in the vertebral column. If in the last event the spine is again subjected to stress, the gap again tends to close, with re-formation of the original inflexion. The transplant united into the spinous processes is thereby subjected to stress under flexion. In several of the cases under observation with graft fractures, the redression in plaster bed led to separation of the vertebral fragments collapsed before treatment, which can be seen in skiagrams taken at the time of the Albee operation. In subsequent pictures it can be seen how the fragments of the vertebral bodies have again fallen in. The graft has sustained a fracture, its fragments often forming an angle open ventrally. In one or two cases with asymmetrical destruction of the vertebral bodies, an angle, open laterally, arose between the fragments of the transplant. In several other cases the redression did not cause diastasis between the most badly affected vertebral bodies, but instead a well-marked lordosis with abnormally wide intervertebral spaces above and below it. It may be seen here how the stress has caused the redression to become partly lost and how the graft has sustained a fracture in connection with it. In two cases the fracture is located between the spinous processes of the most severely affected vertebræ, in most cases immediately above or below the spinous processes of such vertebræ. In one case there are two simultaneous fractures with the angle open laterally. On one patient Albee's operation was performed after redression in plaster bed, the two most badly affected vertebral bodies being separated. When the patient returned to upright position, the graft sustained a fracture and the vertebral bodies fell together. After another redression at which the vertebral bodies were separated, a fresh graft was inserted side by side with the old one covering the defect. One could also later detect bony union of the latter inlay. Eighteen months after the second operation, the destruction of the remaining parts of the vertebral bodies had increased, the two vertebræ most affected had again collapsed, and one can now see a through and through defect at the same place as before, involving both the grafts.

In some cases the graft has been fractured near one or other of its ends. The tendency to union is obviously less here. In one case a large portion of the peripheral fragment of the graft had been absorbed twelve months after the fracture, on its central part there was slight periosteal deposits. The cause of such a process would seem to be that the vertebræ and intervertebral discs corresponding to the peripheral parts of the graft remain unchanged. When the diseased vertebræ have formed into one block, the patient gets rid of his pain, and the contracture of the back muscles subsides. The sound vertebræ above and below the seat of spondylitis endeavor to regain their normal mobility. The rebuilt transplant cannot in the long run prevent these efforts. The free mobility occasioned by the fracture prevents subsequent callus formation and union.

Gibbus formation in tuberculous spondylitis is a process through which the organism endeavors to restore to the spine its stability lost through destruction of the vertebræ, the final aim being the formation of a block between the affected vertebræ. This natural process of healing is counteracted by redression. When patients after redression and an Albee operation get on their feet again about 2 months after the operation, the back endeavors to regain its gibbus. This can only be partly prevented by the patient's supporting corset. The transplant, now united to the spinous processes, will then be subjected to stress under flexion, which will be greater in the case of a large vertebral defect than when such defect is a minor one. By this time the transplant is necrotic, partly pervaded by newly formed vessels and surrounded by newly formed periosteal bone. Its strength is materially reduced. If the graft is unable to offer sufficient resistance to the above described tendency to inflexion, fracture occurs. In several cases that have come under my observation, the position has been retained in spite of the vertebral defect arisen at the redression, and the transplant has been organised and rebuilt without fracture. The gap in the vertebral column has been filled up of newly-formed bone. In another case, — spondylitis of the thoracic spine, that had been operated on in an early stage in another hospital, — the vertebral destruction continued and an enormous gibbus formed. The graft has stood

the strain but has bent with the gibbus. Such a course of event is not unusual in children.

Whether the fracture occurs abruptly, at a sudden increase of the stress, or whether it is preceded by a gradual loosening of the bone structure is impossible to say. In a couple of cases of fracture occurring almost 2 years after the Albee operation when the transplant had largely reformed, the patients felt a sudden pain at that point of the back where the fracture was detected shortly afterwards.

From what has been said above it seems to me that early graft fractures, at least, occur on the subsidence of the position attained by reclination in the plaster bed. This takes place when the spine is subjected to vertical stress, and can only be partly prevented by the wearing of a supporting corset. The position of reclination is reduced either through reduction of the paragibbous lordoses or by the falling together of the vertebral fragments, previously forced apart by the reclining position. Both these processes cause the bone graft united with the spinous processes to become subjected to vertical stress under flexion, which in many cases it is unable to withstand. A development such as this is particularly aided by the faulty position so often observed, with an angle between the fragments of the graft open ventrally.

Similar faulty position between the graft fragments lends support to the view that also some of the late graft fractures have a like origin, in many cases due to continued destruction of vertebral bodies, with gradually increasing tendency to inflexion.

DISCUSSION:

Robert Hanson, Varberg:

In the matter of fixation with corset, each case must be dealt with individually. As a rule, when a patient is discharged, fitted with a leather corset, instructions are given that he must present himself after one year for after-examination. If it is then found that there is no trouble of any kind, he is allowed to try to lay aside the corset. As a rule, the result has been successful.

We have had one case which was operated on for »graft fracture«, and in which fracture occurred a second time. This second arch fracture must have been due to progression of the patient's lung tuberculosis and to advancing destruction of the bodies of the vertebræ, with resulting increased strain on the arch.

In these, as in other cases of surgical tuberculosis, it is a question of individualising. In dealing with a clientele like the one here it is not only the body, but also the mind, that has to be taken care of. If the patients should have to lie in plaster bed for two years after the operation, they would become miserable. The psychic factor plays a great rôle. Besides, the social conditions must be thought of; therefore we must try to get them on their legs as quickly as possible. The risk of »graft fractures« I take upon me. Nature is very kind to us physicians. When an arch fracture does occur, it is most often in a place where no fixation is needed — either above or below the diseased vertebral bodies.

In cases of lumbar spondylitis, where the portions of two vertebral bodies opposite one another are involved, I have begun to use Galland's method of fixing the spinous processes to those two bodies by means of a bridge, so that the arch is saved from getting broken above or below. As the human frame has no need of the bits above the diseased vertebral bodies, nature lets them disappear. We must remember that there is a constant reconstruction going on in the framework of the body, in order to meet the demands of its functioning.

Patrik Haglund, Stockholm:

In connexion with the discussion that followed *Odelberg-Johnson*'s extremely interesting paper, it appears to me that emphasis should be laid on the necessity of individualising. One cannot possibly treat orthopedic cases according to the almanac. It is, I think, the clinical examination of the patient that must decide when one can venture to allow him to leave his bed, or to finish the corset-treatment. In general, it is, of course, a very easy thing for the orthopedist to obtain a good idea of the state

of the individual patient in the case of insufficiencies or destructions. I should also like to support most warmly what *Waldenström* has said concerning the necessity of restricting the lying in bed to the shortest permissible limits, and of not keeping the patient in bed merely because there is always the risk, on allowing a spondylitic patient to get up, that this may have been done too soon. If the patient is carefully observed, such risky imprudences will seldom be committed.

H. E. Hansson, Simrishamn:

The exhaustive account given by the speaker has given us a good picture of the so-called »graft-fracture«. I should like to enquire, however, whether, in the material at the lecturer's disposal, no case has been observed that might be interpreted as acute transformation of the bone, accompanied by a so-called »Umbauzon«, in consequence of the localisation of the fracture coinciding with the foci where such alterations are to be expected. Such »Umbauzonen« are namely sometimes observed within newly formed osseous tissue in cases of pseudoarthrosis.

Robert Hanson, Varberg:

As regards the treatment here, the patients have, as *Odelberg-Johnson* said, lain in plaster bed for two months after operation, and have then been allowed to get up in plaster jacket with a window cut in it as described by *Waldenström* and padded with cotton. Four months after the operation, cast has been made for leather- or celluloid corset.

I must express my disagreement with *Odelberg-Johnson* when he says that redressment is pernicious. I do not think so, and therefore continue to use it. Do we not often see how patients with spondylitis, suffering from considerable pain and cramps in the muscles of the back, are relieved of their pains by redressment in plaster bed? In my opinion, redressment in plaster bed is quite as justified as stretching treatment in tubercular coxitis. A different thing is, of course, that the redressment must not be carried too far; for in that case we should probably, after an Albee's operation, get more arch frac-

tures than we would otherwise. The strain becomes too great; if the lordosis is exaggerated, the arch will simply not be able to bear it; except perhaps in the lumbar region.

In his »Pathologische Physiologie der Wirbelsäule« (1932), *Walter Mueller* describes two cases of »Umbauzon« in the spinous processes of patients with tubercular spondylitis. In those cases the bones underwent a metaplasia to connective tissue when the pull became too great, and the same is probably what happens in the case of the so-called graft fractures.

G. Odelberg-Johnson, Varberg:

It would seem of importance to subject the transplant to stress in upright position already during the early part of the rebuilding stage. Its spongiosa will thereby from the start be subjected to a suitable stress, which will help in creating a functionally proper spongious structure.

The term »graft fracture« indicates that it is generally a question of fracture in a wholly or partly necrotic bony tissue under the process of reconstruction. A »graft fracture« is not to be compared with a fracture of a healthy bone of a limb. »Umbauzonen« are described by *Looser* in rachitis and osteomalacia. They correspond histologically to a gradual rebuilding of fibrous bone-marrow and irregular endosteal bone. Periosteal irritation is exceedingly slight. The usual clinical symptoms and signs of fracture are missing. *Looser* makes a clear distinction between »Umbauzone« and infraction. In my cases there have been malposition, false mobility and local tenderness. In addition nearly all the cases show union with the formation of periosteal callus. In all probability endosteal new bone formation occurs in several cases and, histologically, enchondral new bone has been found in the callus.

SVEN JOHANSSON, GOTHENBURG:

ON OPERATIVE TREATMENT OF FRACTURA COLLI FEMORIS

(Published in this journal Vol. III, fasc. 3—4).

S. Orell, Styrsö:

It has been my privilege to see Dr. *Johansson* operate on a case of collum fracture with the use of this method, and I was impressed by the sureness with which it enables one to work; probably because it is simple, in spite — or perhaps precicely on account — of its fine technical points. The use of the mandrin or guiding wire, and the manner of its arrangement before the spike is inserted, is a good technical way of dealing with the problem.

What interests me the most at present, however, is the question as to how the bone heals after the operation. This we know from experience depends in a great measure on the reposition, and perhaps even more on the subsequent fixation. In Dr. *Johansson*'s case we see that the reposition is very good, but not exact; the spike sucks itself into the spongiosa, and is difficult to extract, even several months after the operation.

That the reposition ought to be good — preferably quite exact — will soon be evident if one studies the healing of the bones in cases where epiphyseal bone transplantation has been made. I have recently published a case of this kind (*S. Orell:* »Osteoplastic cuneiform Osteotomy in the Treatment of Ankylosis. Report of two Cases«. Journal of Bone and Joint Surgery, vol. XIV, no. 3, pp. 643—654; July 1932). In the transplanted wedge-shaped piece of bone, which had been boiled for ten minutes in a physiological NaCl solution and then fitted exactly into place, one finds, after 4 or 5 months, zones of resorption, but very little resorption out toward the resection surfaces in the fresh, living bone, where the osseous structure is good right up to the line of resection. After 3—4 months, the corners of the resected ends begin to become somewhat rounded and transformed; and in the months immediately following, the transplanted piece little by little begins to show signs of fresh osseous structure; first in the lower part of the wedge, where the vascular supply is most easily restored. In those places where the transplanted bone is high, the zones of density remain for a long time; but little by little they probably change into more

compact-like strata, which then afterwards very slowly become transformed according to the demands of the mechanical strain. I have followed this healing of the bone with roentgenographs for 800 days after the operation.

In Dr. *Johansson*'s case there is, after several months, no positive sign of fresh bone formation, no positive new-formed osseous structure. There is, however, a distinct rounding off of the corners of the resected bone ends, and the osseous structure is very well preserved right up to the line of fracture. Zones of resorption extending to the latter are few, or hardly noticeable; which seems to me to indicate that the fracture is healing, and the fracture ends well nourished. It is also very interesting to notice that the rust-free spike does not seem to irritate the bone substance, causing it to disintegrate and become resorbed.

In Dr. *Johansson*'s technic it is probable, since the reposition is not exact and the osseous reaction indicates healing of the bone, that the compression of the fracture with mallet and instrument after reposition is an important feature. Of course, the reposition must be made after the extension has been discontinued; for otherwise the attempt at compression might lead to the very opposite result; namely, a diastasis between the ends of the fracture. It is evident, even, that the chance of succeeding with the compression should be all the greater the sooner it is made after the fracture has occurred, so that there will not yet have been time for the development of any organic tissue between the ends of the fracture. It will be interesting to see how the he healing is going to proceed ulteriorly.

How long the bone spike should be left in place is something which experience must show. If it does not cause any irritation or disintegration of the osseous substance worth speaking about, it is safer to have it remaining a long time than too short. If the healing of the bone, in Dr. *Johansson*'s case, is so far advanced as the roentgenographs seem to indicate, it seems that the duration of the treament, and especially the patient's confinement to bed, might be shortened little by little.

G. Odelberg-Johnson, Varberg:

As is well known it was pointed out already by *Kocher* that an internal fracture of the neck of the femur is a combination of flexion and compression fracture. The compression always gives rise to loss of substance through crushing of the thin cortex and spongiosa. It is therefore impossible to reduce the fracture exactly so as to retain the original shape *simultaneously* with getting a broad contact between the fragments. The loss of substance is usually localised to the dorsal part of the neck. After reduction of the fragments so as to obtain a broad contact between the surfaces, the central axes of the head and neck thus form, in most cases, an angle open backwards. This backward angle can be seen in one of Dr. *Johansson*'s pictures shown here of a fractured neck reduced and nailed.

I would further draw attention to the special type of internal fracture of the neck, where a spike, 2—3 cm long, of the anterior internal compact part of the neck belongs to the proximal fragment (demonstration of specimen). In such cases it is particularly difficult to attain a satisfactory position after reduction.

In internal fractures of the neck, absorption of the bony tissue of the fracture surfaces is often very marked. Through bone absorption it may happen that reduced fractures fixed in Whitman's plaster which show a good position from the start become displaced in the plaster. In many cases bony union is hindered by this displacement.

The firm fixation by Smith-Petersen's nail seems to retain the reduced fragments in an excellent manner. The firm fixation and the possibility of early weight-bearing probably help to lessen the above mentioned bone absorption, thus hastening the bone union.

Robert Hanson, Varberg:

The paper to which we have just been listening was most interesting, not only from a practical, but to me also from a theoretical point of view. I have never been able to understand that the healing of the bone in the case of a medial collum fracture should take place in a different way from that of any

other fracture. If both the endosteum and the periosteum can grow together again after a medial fracture of the collum femoris, what probably no one will deny, it would be rather remarkable if the defectuosity on the posterior side could not be filled out with new bone. From the roentgenopraphs Dr. *Johansson* showed us it also seems that such a filling out takes place. That a medial collum fracture should invariably result in the collum getting an open angle posteriorly, owing to the loss of osseous substance, has to me always seemed an unlikely idea, when one sees the size of the defectuosities in bones that can be built over or fill out with bone tissue, for instance after an osteotomy or after other fractures. What causes the formation of the open angle toward the back is probably faulty reposition and fixation. That it is impossible to obtain exact fixation in a plaster bandage should be easy to understand. By Dr. *Johansson*'s method, on the other hand, it seems that both an ideal reposition and exact fixation can be obtained, and thus the posteriorly open angle probably be avoided.