PRIMARY SUBTALAR ARTHRODESIS IN THE TREATMENT OF
SEVERE FRACTURES OF THE CALCANEUM

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Fractures of the calcaneum [os calcis, calcaneus] in which the posterior articular facet is depressed, comminuted, or both, notoriously lead to poor function. So poor is this in fact that Bankart (1942) wrote: "The results of treatment of crush fractures of the os calcis are rotten . . . It would seem that the best result that can be expected from a fracture of the os calcis involving the sub-astragaloid joint is a completely stiff but painless foot of a good shape, and with free movement of the ankle joint."

Different methods have been attempted and described in the search for better results. Open and closed methods are described, and the results have been so unsatisfactory that many fractures are deliberately left unreduced, and early movements begun.

Closed methods of treatment for this crush fracture depend upon the use of Steinmann or similar pins. Böhler (1931) employed single pin skeletal traction; Harris (1946) used three pins with the traction radiating from the foot to a circular support around it. Westhues (1934) attacked the fractured fragment directly, attempting elevation on the end of a pin. There are many other methods combining various procedures.

Open reduction was reported by Bell (1882) and Morestin (1902) but it appears to have found little favour until recent years. Lenormant, Wilmoth and Lecoeur (1929) described reduction of the fragments under direct vision, and Whittaker (1947) described a similar reduction but advised the use of metallic internal fixation for the unstable fragment. Palmer (1948) described open reduction in some detail. Being dissatisfied with the results of conservative treatment, he performed three subtalar arthrodeses at an early stage. These had all been moderately successful, but he was disturbed by the amount of soft-tissue stripping required in the lateral approach that he had used, and was concerned for the blood supply to the bone. He also found that the feet were left in a varus position after an adequate removal of cartilage. From these operations he found that the depressed fragment was sharply outlined, firm and stable: by applying traction to the heel he reduced what he called the forward deformity of the main fragment, and then elevated the depressed fragment of the posterior articular facet. This left a gap which he packed with iliac bone. He commented on the uselessness of simple traction in this particular deformity, because it could be seen at operation that the intact part of the facet of the calcaneum was pulled away from the talus, but nothing was done to correct the impaction of the smaller fragment.

In 1952 Essex-Lopresti described reduction by means of the Gissane spike under direct vision. He, too, appreciated that after disimpacting the fragment a considerable cavity was left, but he found that if the fragment was maintained in position by incorporating the elevating spike in plaster the cavity filled with new bone; a graft was not required in fresh fractures. There was developing meanwhile a more radical school of surgeons who believed that the joint was damaged past hope of useful function, and advocated arthrodesis. Van Stockum (1912) presented some successful subtalar arthrodeses in the treatment of this fracture. His paper attracted little attention despite the tremendous disability accompanying this injury, which was estimated in the 1920's as 2 per cent of all fractures, and of which Cotton and Henderson (1916) had said that any worker who sustained it was "done" so far as heavy work was concerned. An excellent report of the operative treatment was made in 1927 by Wilson, who described subtalar arthrodesis through a lateral approach which permitted eighteen of twenty patients to return to their old jobs in seven months. In the remaining
two cases one patient had Buerger's disease, and in the other the operation had failed because of a technical error. Wilson again reported on this procedure in 1933, having followed thirty-three out of forty patients. Twenty-four had good results and six fair. He made the comment which is no less true to-day than it was in 1933: "This is an operation only for the surgeon experienced in this region."

Conn (1935) wrote that the lack of success in conservative treatment, when fusion had been confined to the subtalar joint, was due to depression of the sustentaculum tali. Although believing in and recommending arthrodesis after a preliminary five weeks of traction, he thought that a triple arthrodesis was essential. He restated this belief in 1943 when discussing Gallie's paper, and stated that the reciprocal function of the posterior tarsal and mid-tarsal joints demanded that, when one had been fused, the other must also be fused. Gallie (1943) described a posterior approach to the joint and gave, among other indications for fusion, the presence of arthritic irregularity. In the same year, and for much the same reasons, Armstrong (1943) described the use of a cortical bone graft passed from the superior surface of the neck of the talus down and back through the calcaneum. This seems to be mechanically unsound because the graft is passed along the axis of movement instead of at right angles to it (Hall 1959). Dick (1953) wrote strongly in favour of early arthrodesis to save the patient time and needless pain. He reported ten patients who had all returned to work in less than seven months after the injury. After these reports of excellent results obtained from an early arthrodesis as a primary treatment of the severe fracture, Lindsay and Dewar's paper (1958) came as a complete reversal of the previous statistics. After examining a series of 144 fractured heels they concluded that of the group treated by early arthrodesis only 60 per cent had a good clinical result compared with 76 per cent of a similar group treated conservatively.

Severe fractures of the calcaneum, with joint comminution and depression, have for some years been treated in St Joseph's Hospital by early arthrodesis limited to the subtalar joint. In this paper the results of this treatment will be discussed.

TREATMENT

After the initial radiographs an immediate decision is made on the treatment necessary. Operation is performed on all joints showing gross depression or comminution; usually within a week of the injury. In some cases operation is delayed because of skin blisters, and other patients may be admitted to hospital after a period of rest and elevation elsewhere. The following is an account of the procedure at present employed. Two teams of surgeons work using separate instruments and nurses. The patient is prone. One surgeon takes the bone graft from the posterior superior iliac spine, while the other works on the foot. One Steinmann pin is inserted into the posterior inferior part of the calcaneum and another into the shaft of the lower tibia. With the Roger Anderson distraction apparatus it is possible to separate these pins and open the damaged joint. A procedure similar to this but for definitive treatment was described by Shaar and Kreuz (1943). The method described by Gallie is then followed with some minor alterations. The same posterior approach, lateral to the tendo calcaneus, is used. Distraction of the joint by the Roger Anderson apparatus helps the exposure and increases the working space. It also permits, facilitates and maintains accurate correction of any varus or valgus deformity. Some attempt at correction of the articular surfaces is made in order to approximate the greatest surface area, but this is not a meticulous restoration as in Palmer's operation. Articular cartilage is gouged away from the posterior joint surfaces and a trough one inch deep and half an inch wide is cut across the two bones. This trough is packed with cortical strips of iliac bone, and a considerable quantity of cancellous bone is packed in and around it. While distraction is maintained the lateral expansion is corrected manually. The distraction is then released, the wound is closed, and a below-knee plaster incorporating the pins is applied. The pins are left in place in order to maintain the correction of the upward displacement of the posterior end of the calcaneum, and to prevent varus or
valgus deformity. The patient is allowed up gradually from the seventh day after operation; the pins are removed and the plaster is changed after four weeks. A walking plaster is applied at the end of the second month, and if the patient is walking well and the radiographs are satisfactory immobilisation is discontinued at the end of the third month: active exercises and full weight bearing are then encouraged.

MATERIAL

Periods of observation vary from twenty-one months to ten years. The patients have been under the care of four members of the staff of St Joseph's Hospital. During this period forty-four patients with severe crush fractures of the calcaneum have been treated, representing fifty primary arthrodeses because some patients had bilateral fractures. Four patients were women. Of these forty-four patients two have died, thirteen were not traced, and twenty-nine were examined by the authors. Three of these twenty-nine patients had a bilateral arthrodesis. Twenty-seven patients were covered by Workmen's Compensation Board Insurance. Many others belonged to insurance schemes that paid such varying parts of their lost wages that it was not possible to assess the patients on this basis. It is considered that this must be so with many reported series of fractures and that a distorted picture is given when too definite a distinction is made between insured and non-insured patients.

RESULTS

Results are not easily assessed on a basis comparable with other series. The patient's opinion is not unreservedly reliable: for example—"I am terribly grateful to the doctor who put the broken bones in my feet together. I can only walk one block." However, if he is a heavy labourer and he has returned to work without difficulty the operation must be regarded as successful, as it must be also in a man whose work is less strenuous but who has not given up any of his normal activities. Many patients find it hard to separate the activities which they had to give up on account of their fracture from those in which they were losing interest as age advanced.

Assessment—The classification of Maxfield and McDermott (1955) has been used so that some comparison may be made between the results of this procedure and of that described by Palmer. These categories are: excellent—no pain and no limitation; very good—no serious interference, but minor complaints; fair—activity restricted by pain; poor. Thus the patients with "excellent" results have returned to their full previous employment and perform a

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<td>Fair</td>
<td>6 (19·3 per cent)</td>
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<tr>
<td>Very good</td>
<td>18 (58·0 per cent)</td>
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<tr>
<td>Poor</td>
<td>2 (6·6 per cent)</td>
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normal day's work. They have no limitation of their social lives, and no pain in the injured feet. Those with "very good" results have returned to their full previous employment, but have some ache or do not lead quite as active a social life as previously, but are without major restriction of their activities. There may be some criticism of the inclusion of patients in this group who have had to give up any activity, but to put a patient in a lesser category when he is capable of a full day's heavy work on his feet, often on irregular ground and without major complaint, would not give a true picture of the result. The group called "fair" includes
those patients who have modified their work, some who have to rest during it and others who have had to find a lighter occupation. It includes also those who have a major restriction of their social life, but who remain employed in their normal occupation. “Poor” is used for a group of unsatisfactory results to be described individually.

Of the thirty-two arthrodeses one has been excluded because of a later injury. The results are shown in Table I.

Return to work—Of the twenty-nine patients examined, twenty-five returned to their full previous employment. Details of the four who failed to do so are given below.

Case 1—A man aged thirty-five years, who had previously been employed in sheet metal work involving a good deal of ladder work, gave this up to drive a truck because “I wouldn’t trust my feet.” He had had an unsuccessful triple arthrodesis for congenital equino-varus deformity of the other foot, with gross residual varus, and had also an artificial eye. His decision to change his occupation is not surprising.

Case 2—A man aged twenty-three years had been employed as a labourer on the freight tracks at the time of his injury. The railway company would not re-employ him and he has since been trained as a spot welder.

Case 3—A man aged thirty-one years returned to his previous work as a labourer in a mattress factory. He gradually found himself unable to do this work, not because of pain in the heel but because of swelling and generalised pain in the leg. The cause was obscure. It may have been due to a deep thrombosis resulting from the accident or operation, but no connection could be established.

Case 4—A man aged forty years who was employed as a window cleaner. This was the most disastrous case of the series. The patient developed pin track infections in both the calcaneum and tibia, and eventually had a below-knee amputation.

Modification of work was found necessary in the following two patients.

Case 5—A man aged fifty-two years is employed as a painter in the same job he had before his injury. He had sustained bilateral fractures, but only one side was operated upon immediately. He now has to take frequent rests during the working day. He says the need for resting is caused by the foot on which operation was delayed and not the one that was operated upon immediately.

Case 6—A man who was employed as a lathe operator is the grateful patient who can walk one block. He sustained his fracture at the age of sixty-four and had returned to his previous work within four and a half months. Because of an ailing wife and a “tired” feeling he retired after six months. He later sustained an injury to the ankle on the same side and has, on that account, not been included in the statistics.

Time of return to full employment—Of the twenty-nine patients examined the time of return to work is not known by two of them. The amputee (Case 4) and the patient who had a subsequent injury (Case 6) are excluded.

The longest period off work was nineteen months, the shortest two months. The average time off full employment was 6-4 months from the time of injury.

Ache and pain—An exact distinction between these two complaints is not easily given briefly, but in most cases the patients had no doubt in separating them. It was found that about 25 per cent were completely free of either complaint, 50 per cent had some ache, and 25 per cent had some pain at times though not necessarily sufficient to interfere with their activities.

Tenderness—It was clearly established that the successful patient who had avoided complications was completely without tenderness. Lateral sub-malleolar tenderness was particularly sought, and was found in five cases. Two of these had a failure of bony ankylosis, two had had post-operative infections that had subsided, and the fifth had marked degenerative changes of the ankle joint. Many of the patients without this tenderness had a typical bony prominence beneath the lateral malleolus, which Lindsay and Dewar (1958) reported to have had no radiographic correlation with the complaint.

Function of tendo calcaneus—This was assessed principally on the patient’s ability to rise up and hop on his toes. Without exception it was found that this was a satisfactory test in that
the patient either had no hesitation in its performance or was obviously unable to do it. The same patients who had lateral sub-malleolar pain had loss of tendo calcaneus function, whereas the other patients without tenderness had no loss of function. No correlation was found between the degree of correction of the elevation of the posterior end of the calcaneum and tendo calcaneus function.

**Alteration of sensation**—There has been a suggestion that pain after injury to the subtalar joint may be relieved by neurectomy (Nyakas and Kiss 1954, Sallick and Blum 1948). It has also been suggested that injury to the sural nerve during the exposure might result in less subsequent pain. In this group six patients had sural nerve injury as shown by anaesthesia or hypoesthesia, and none of these was without some ache. There seems to be no justification for this assumption.

**Residual deformity**—Some broadening of the heel was found in every case. Valgus was present in nine feet, and the one patient who had quite marked valgus had the best subjective result of the entire series. One patient had some slight varus, and he was the only one to complain of a "tired" feeling along the plantar surface of the foot.

**Age**—The series is small, but of the nine patients over fifty (one sixty-four, not Case 6), two had had excellent results, six very good and one fair. This controverts the argument employed against this procedure in the older patients that the foot is already stiff and further immobilisation will only diminish its eventual range of movement and its function (Essex-Lopresti 1952).

**Failure of fusion**—This occurred in three cases or 9-4 per cent. One foot has since been operated upon successfully.

**Loss of joint movement**—An accurate estimation of this could only be made radiographically, and this was not done. The average loss of ankle movement was 10–25 per cent and of mid-tarsal movement 25–50 per cent. Although the mid-tarsal movement is considerably reduced it seems worth while, despite Conn’s (1943) argument, to preserve even 50 per cent of movement, and there was nothing to suggest that this movement was more limited in those who had been operated upon ten years ago than those operated upon more recently.

**Infection**—There were four infections—a rate of 12-5 per cent. The most serious occurred in a patient of unstable temperament who fell when drunk and disturbed the position of the Steinmann pins and did not report for treatment until the plaster was foul with pus. He was eventually transferred at his own request to the Veterans’ Hospital, where he remained under the care of the same surgeon. Due largely to his lack of cooperation and frequent disappearances from the hospital, for which he was eventually barred from treatment, conservative treatment failed and a below-knee amputation was performed eighteen months after the injury. He represents a type of patient in whom the pins should be removed at the conclusion of the operation.

Of the other infections, two cleared rapidly but necessitated prolongation of immobilisation, and the third caused a non-union which has subsequently been operated upon successfully.

**DISCUSSION**

The treatment of comminuted fractures of the posterior articular facet of the calcaneum by an early arthrodensis is shown by the figures of various authors to be at least capable of good results. Wilson (1933) had 73 per cent good results in patients who returned mostly to heavy work, and 9-1 per cent poor results. Gallie (1943) reported fifty patients with good results. Harris (1946), using the same method of fusion, had thirty-four out of thirty-five patients back to work in six months. Geckeler (1950), using the posterior approach for the less deformed fractures and the lateral approach for the more deformed ones, had his twenty-seven patients back to work in six months, 70 per cent in full work and 30 per cent in light work. Dick (1953) reported that all of the ten patients followed had returned to work within six and a half
months. In the series reported here, within an average time of six and a half months 93 per cent had returned to full gainful employment and 81 per cent had returned to the same job they had had at the time of their injury. Thus the statement of Lindsay and Dewar (1958) requires examination. They divided their results into categories of good and poor only, and therefore the poor results are of more significance than the good ones. In the group that they described as treated by early arthrodesis 51 per cent had poor results as compared with 29 per cent poor results in a similar group treated conservatively. The implication is that whereas conservative treatment leaves much to be desired an early arthrodesis will only increase the likelihood of a poor result. Obviously these conclusions are incompatible with those of Wilson (1927, 1933), Gallie (1943), Harris (1946), Dick (1953), and of this paper; examination of the causes for this incompatibility might be fruitful. The term "early" has been used in this paper to describe the performance of the operation as the primary intention in the treatment of the fracture, and the patients reported have been limited to those operated on within thirty days of the injury. Dick waited until the swelling had subsided after rest, pressure bandaging and elevation. Conn treated his patients in traction for five weeks, and Wilson for not more than two. Harris, after manipulating the fracture, made his decision regarding operation from the radiographs, and the operation was performed soon thereafter. Lindsay and Dewar included all patients operated upon within twelve months of the injury, and although those patients who were operated upon early will be included in this group some who had varying periods of other treatment must also be included in it. The distinction between one month and one year is believed to be of great importance in the treatment of this fracture. It has

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<td><strong>Comparison of End Results Following Palmer or Gallie Operation</strong></td>
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<td>Excellent</td>
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been the experience of those who treated the fracture conservatively that the earlier movements were begun the better the result. Stiffness has been one of the major features of the unsatisfactory results, and it was partly with this in mind that primary fusion has been recommended. The period of immobilisation by spasm or plaster is in many cases lessened and the patient rapidly regains movement after the removal of the post-operative plaster. Dick (1953) did not use plaster at all for this reason but encouraged movement from the beginning. Edmunds (1955) after Palmer's operation reduced its use to four weeks. One of the patients in this series who suffered bilateral fractures, both of which were operated upon and were immobilised in plaster for only ten weeks, very picturesquely described his rigid "flipper" feet until one day he was fortunate enough to stumble on the sidewalk; he suffered severe pain, but has walked normally ever since. A further advantage is that in operating on the fresh fracture the surgeon is able to correct any varus or valgus deformity, which is much more difficult to accomplish when the heel has united in a deformed position. The normal successful uncomplicated primary arthrodesis is not followed by lateral sub-malleolar pain so typical of this injury, and since Lindsay and Dewar have shown that this complaint is not cured by a late arthrodesis one
might conclude that it is the alterations in the soft tissues in the region of the subtalar joint that accompany the deformity that are responsible for this pain. If, therefore, a late arthrodesis is not going to be as satisfactory as an early one the surgeon may not run with the hare and hunt with the hounds but is forced to declare himself at the outset as being for or against operative treatment. This attitude is exemplified in Smith's (1956) recommendation that surgical intervention is contra-indicated for eighteen months by "slow continued functional improvement in the foot in a patient who can engage in reasonable physical activities." As this fracture is usually sustained by the manual worker "reasonable physical activity" means remaining unemployed. A choice is thus made between a probable return to full heavy labour within six and a half months, and a period of unemployment possibly of eighteen months, to be followed by an operation with the same subsequent period of convalescence as if it had been performed at the outset, but with less chance of success.

The classification of Maxfield and McDermott (1955) was used in order that some comparison could be made between the results of this method and that of Palmer (Table II).

Although proportionately about twice as many excellent results have followed the Palmer procedure as the Gallie it will be seen that if the very good and excellent groups are added together the results of the two procedures are not very dissimilar.

**SUMMARY**

1. The history of open operations on fractures of the calcaneum is reviewed.
2. A report is given of the results of treatment of comminuted and depressed fractures of the calcaneum by primary arthrodesis by a modified Gallie procedure.
3. Of twenty-nine patients, twenty-seven returned to full employment within an average of 6-4 months. Twenty-five of these returned to their previous jobs.
4. Poor tendo calcaneus function and lateral sub-malleolar pain were found to be closely allied; both complaints were absent in the usually successful case and occurred only where there had been some complication.
5. It is contended that subtalar arthrodesis is a successful method of treatment for this fracture, but that the operation should be performed soon after the injury in order that the deformity may be corrected.

We would like to thank Dr G. Williams and Dr G. McDonald for permission to include cases of theirs in this report. We would also like to express our appreciation of the considerable help received from Miss Edna Simmonds in tracing the patients.

**REFERENCES**

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