THE ANKLE JOINT IN RELATION TO ARTHRODESIS OF THE FOOT IN POLIOMYELITIS

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Seventy-five years have passed since subtalar arthrodesis was first performed, by Albert of Vienna (1882), to counteract lateral instability in the paralytic club foot, but to Davis (1892) is due the main credit for developing the operation as an established procedure. Soon afterwards Whitman (1901) devised "astragalectomy" [excision of the talus] for calcaneus deformities, an operation which aimed to correct the deformity and to improve the balance of the foot by displacing it backwards upon the bones of the leg. These two principles of subtalar fusion and posterior displacement were incorporated in the operation of triple arthrodesis, which was developed by Ryerson (1923) and Hoke (1921) in America and by Dunn (1922) in England, and further modified by Campbell (1923) and Lambrinudi (1927) to control downward movement in the antero-posterior plane. In one or other of its forms, the triple arthrodesis has remained the standard operation for stabilising the foot in poliomyelitis.

The main purpose of this paper is to consider the late results of these operations in relation to their effect upon the ankle joint and to determine the extent of 1) lateral instability, 2) restriction of antero-posterior movement, and 3) clinical or radiographic evidence of osteoarthritis. These are the late complications which might be expected. A second purpose is to study the results of fusing the ankle as well as the tarsus (pantalar arthrodesis) in cases of flail foot (Steindler 1923). Complete paralysis of the muscles controlling the foot is usually associated with severe weakness throughout the lower limb: surgical reconstruction of the flail foot must therefore be related to the limb as a whole and to extension of the knee in particular.

MODE OF INVESTIGATION

The investigation was related to a series of patients who, more than ten years ago, had undergone arthrodesis of the foot for poliomyelitis at the Princess Elizabeth Orthopaedic Hospital, Exeter, or at the Mount Gold Hospital, Plymouth. As many of the patients as were accessible were re-examined. Information concerning patients who were abroad or in distant parts of the country was obtained from relatives or by correspondence. These cases have not been included in the review, but they raised the proportion of operations traced from 58 per cent to 74 per cent, a figure which is statistically acceptable. The details are given in Table I.

<table>
<thead>
<tr>
<th>TABLE 1</th>
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<tbody>
<tr>
<td>CLINICAL MATERIAL</td>
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<tr>
<td>Feet operated upon</td>
</tr>
<tr>
<td>103</td>
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Of the sixty feet seen, thirty-three were examined in out-patient clinics and twenty-seven by domiciliary visits. Radiographs were taken if lateral instability or stiffness of the ankle was found.

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Age at operation—Forty-six patients were aged between ten and sixteen years at the time of operation; in the whole series the youngest was aged eight years and the oldest fifty-three years. Length of follow-up—Figure 1 shows the length of follow-up—that is, the number of years since the date of operation.

Nature of operation—The types of operation reviewed are listed in Table II. Most of the triple arthrodeses were of the Dunn type. Twenty-seven operations were associated with tendon transfers. On every occasion the subtalar joint was widely opened and the foot fully inverted. The pantalar operations were performed in one stage.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Number</th>
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<tbody>
<tr>
<td>Subtalar arthrodesis</td>
<td>4</td>
</tr>
<tr>
<td>Triple arthrodesis</td>
<td>42</td>
</tr>
<tr>
<td>Campbell’s bone-block</td>
<td>2</td>
</tr>
<tr>
<td>Lambrinudi’s arthrodesis</td>
<td>4</td>
</tr>
<tr>
<td>Pantalar arthrodesis</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>60</strong></td>
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RESULTS AND DISCUSSION

All the patients showed evidence clinically of sound subtalar fusion. Some residual deformity persisted after one-third of all operations, and in 8 per cent the residual deformity was marked. In every case this represented inadequate correction of the original deformity, and in no instance had “over-correction” occurred.

Lateral instability—In three patients persistent deformity gave rise to instability which was clinically apparent and required an appliance for its control.
Eight feet arthrodesed in good position (15 per cent of the total, if the pantalar operations are excluded) showed some compensatory increase in lateral movement of the talus within the tibio-fibular mortise, but no patient complained either of pain or of instability. Radiographs showed some rounding of the margins of the talus, but it was noted that the operation films, when available, showed that these structural changes preceded the tarsal fusion and therefore that they did not result from it (Figs. 2 and 3).

**Restriction of movement**—Limitation of movement in the antero-posterior plane is one of the objects of Lambrinudi’s operation and of Campbell’s posterior bone-block. In this series it was apparent that many of the triple arthrodeses of the Dunn type showed some loss of movement compared with the normal ankle, but this was never a cause for complaint.

**Osteoarthritis**—The single case of advanced osteoarthritis, albeit symptomless, occurred in a woman who was operated upon at the age of forty-six, when her ankle was already subluxated and arthritic. One patient showed minor degenerative changes radiographically. He had undergone a triple arthrodesis with Campbell’s bone-block twenty-one years before, and had some persistent valgus deformity with clinical instability.

**The Flail Foot**

The problem of the flail foot should be considered in relation to the lower limb as a whole. When control of the knee is good, a triple arthrodesis confers adequate stability of the foot and at the same time allows passive movement at the ankle. If the quadriceps is weak, some degree of equinus of the foot assists extension of the knee and a small range of ankle movement is helpful. If the quadriceps is paralysed the fusion should include the ankle joint in order further to assist the stability of the knee in extension.

Steindler (1935), basing his work on that of von Baeyer, was probably the first to show how the equinus position of the foot helps in extending the knee. The reasons for this are not always clearly understood and it will be helpful to restate them here (Figs. 4 to 6). If all the muscles below the hip are paralysed, extension of the knee is secured by the centre of gravity of the body acting in front of the plane of the knee joint, provided 1) that the gluteus maximus is strong enough to prevent the knee from going forward by increased flexion in the hip; and 2) that the tibia is not allowed to come forward through a dorsiflexion
movement of the ankle. Any effective power in the soleus will maintain the foot in equinus; acting from the periphery as the fixed point, when the foot is on the ground, contraction of this muscle will carry the tibia backwards and thus extend the knee (Fig. 5). If there is no effective power in the calf, the action of gravity in extending the knee is aided by fixation of the ankle in slight equinus (Fig. 6). Pantalar arthrodesis combines this purpose with control of lateral movement in the tarsus. A small degree of genu recurvatum further assists stability in extension, but when operation is undertaken on the growing child allowance must be made for the tendency for this to increase.

Seventeen cases of flail foot were studied, in eight of which the patient had been treated by triple arthrodesis. In three cases in which there was adequate control of the knee the results were satisfactory, but of the other five, with associated paralysis of the quadriceps, all but one showed a flexion contracture of the knee, requiring an appliance for its control.

One patient had been treated by triple arthrodesis and fusion of the knee. His stability enabled him to undertake ladder work in a naval dockyard, but the limb was unwieldy and a knee-jointed appliance would probably have been more satisfactory.

The remaining eight patients, six of them with paralysed quadriceps, had undergone pantalar arthrodesis. The average length of follow-up was nineteen years. All the results were satisfactory. In those patients without quadriceps control, sound fusion had been achieved with the foot plantigrade and in slight equinus, so that the knee was encouraged to extend passively as the heel came to the ground, a mechanism which was assisted by a small degree of genu recurvatum. Four of these patients walked confidently without the aid of appliances.

CONCLUSIONS

Tarsal fusion for poliomyelitis is performed predominantly upon young people. It is therefore important to know whether it will stand the test of time, and, in particular, whether the neighbouring joint of the ankle is able to bear the increased strain thrown upon it.

From the cases reviewed it seems reasonable to conclude that degenerative changes in the ankle joint do not ensue during the twenty years after operation. Provided that varus
or valgus deformity is adequately corrected, a compensatory increase in the lateral mobility of the ankle is not accompanied by pain or clinical instability, and some reduction in anteroposterior movement may not be undesirable.

Capener (1956) noted the lack of association of poliomyelitis and osteoarthritis of a related joint, even when grossly unstable: this observation demonstrates the essential part played by muscular forces in the causation of osteoarthritis. While these facts are well recognised, the particular point of this paper is to stress that fixation of a given joint in the lower extremity does not have a harmful effect on the one above, especially the ankle in relation to the foot. In this series the number of patients with a pantalar fusion in the presence of a paralysed quadriceps are few, but their ability to control the knee in extension is in striking contrast to those whose ankle joint was not included in the fusion. It was also noticeable that slight genu recurvatum was much to be preferred to a flexion contracture.

SUMMARY

1. Sixty feet operated upon either by triple or pantalar tarsal fusion for instability after poliomyelitis were re-examined ten to twenty-four years later.
2. After triple fusion with preservation of the ankle joint there was a striking absence of late osteoarthritis of the ankle, and only a low incidence of troublesome lateral instability of the ankle. The results were generally good provided the patient had reasonable power of extension of the knee.
3. Triple arthrodesis for completely flail foot in patients without active muscle control of the knee was often disappointing, so far as the limb as a whole was concerned, because of a persistent flexion deformity of the knee which usually necessitated the wearing of an appliance.
4. The results of pantalar arthrodesis for the flail foot were satisfactory. When this operation was performed (with the foot in slight equinus) in patients who lacked active extension of the knee it helped to stabilise the knee in walking by encouraging hyperextension.

I wish to thank Mr Norman Capener, under whose care most of these patients had been, for his guidance in the preparation of this paper. Many of the patients reviewed, although living in the Exeter area, were treated at the Mount Gold Hospital, Plymouth.

REFERENCES

Whitman, R. (1901): The Operative Treatment of Paralytic Talipes of the Calcaneus Type. American Journal of the Medical Sciences, 122, 593.

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