ARTHRODESIS OF THE METATARSO-PHALANGEAL JOINT
OF THE GREAT TOE

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It is probable that in Britain the most common treatment for hallux valgus is the Keller operation. Whereas gratifying results may be obtained, there is nevertheless a considerable percentage of failures, particularly in those feet with metatarsalgia and subluxation or dislocation of the lateral toes (Bonney and Macnab 1954, Holden 1954). In consequence many modifications of this operation have been designed (Stamm 1957).

Arthrodesis of the metatarso-phalangeal joint has never found great favour. At Guy's Hospital, London, and at St Bartholomew's Hospital, Rochester, arthrodesis has been widely used, and this report is based on a review of operations performed there in the last ten years. For comparison, the results of the Keller procedure are also briefly presented.

OPERATIONS

Arthrodesis—Two methods have been employed and the principal feature of each will be described.

Peg and socket arthrodesis—Through a dorsi-medial incision with, if necessary, excision of an ellipse of skin over the bunion, the interior of the proximal phalanx is removed with awls and a burr of the Marin type (Fig. 1). The metatarsal head is then shaped to a peg, which is inserted into the hollowed-out phalanx. Stability is ensured by a screw passed through the phalanx and across the metatarsal as shown in Figure 2. A wool and crêpe dressing is applied and the patient remains in bed for three to ten days, after which he walks in a plaster slipper for four to six weeks.

Excision of cartilage with screw fixation—The exposure is as already described. The cartilage and subchondral bone are removed from the base of the phalanx and from the metatarsal head with a gouge, and the exostosis is removed with an osteotome. A hole is then bored
from the side of the phalanx to its base, the point of emergence being near the medial border. The hole is enlarged until it will admit a screw which is driven straight down the shaft of the metatarsal, exerting an element of compression (Fig. 3). The post-operative management is the same.

![Fig. 3](image)

**Keller’s operation**—The operative details are too well known to need description. Three points are, however, worthy of emphasis. First, an attempt is made to maintain continuity between the metatarsal and the phalangeal fragment by resecting the collateral ligaments off the phalanx subperiosteally. Second, only the proximal third of the phalanx is resected. These two details aim to provide a functioning toe under muscle control as opposed to a non-functioning space filler to which patients generally object. Third, a Brock’s pin is inserted into the toe pulp and traction is applied for about two weeks. After three or four days the patient is allowed to be up and about.

**MATERIAL**

**Arthrodesis**—This group comprised two series, one of thirty-four patients subjected to arthrodesis by the peg and socket method and one of seventy-four patients treated by excision of the joint surfaces and screw fixation (total 108 patients) (Table I). The second series was investigated in detail, with 98 per cent follow-up. As the results in the two series were comparable they will be considered together.

**TABLE I**

**THE NUMBER OF PATIENTS AND THE OPERATIONS PERFORMED**

<table>
<thead>
<tr>
<th>Method</th>
<th>Number of patients</th>
<th>Hallux valgus</th>
<th>Hallux rigidus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arthrodesis by peg and socket</td>
<td>34</td>
<td>49</td>
<td>5</td>
</tr>
<tr>
<td>Arthrodesis by excision of cartilage</td>
<td>74</td>
<td>87</td>
<td>17</td>
</tr>
<tr>
<td>Keller’s operation</td>
<td>56</td>
<td>71</td>
<td>13</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>164</strong></td>
<td><strong>207</strong></td>
<td><strong>35</strong></td>
</tr>
</tbody>
</table>

**Keller’s operation**—This group comprised fifty-six patients (Table I).

The age of the patient and the length of follow-up in all groups are shown in Figures 4 and 5. As one might expect, the patients were mostly in the fourth, fifth and sixth decades. More than half the patients have been followed up for more than five years.

**ANALYSIS OF RESULTS**

**Period of disability after operation**—It is difficult to determine accurately the duration of disability in a largely non-employed female population, and the criterion used was the length of time until the patient could wear normal walking shoes. After arthrodesis 59 per cent of the patients were wearing normal shoes within three months of operation. In a small percentage the length of time was considerably increased (Table II).

The period of disability after the Keller operation was almost the same. In each case I felt that patients had received inadequate information on the post-operative progress that
might be anticipated. Most had believed that on removal of the sutures or plaster of Paris they would have a normal functioning foot: many patients still bring a close-fitting shoe with them on the day that the plaster is to be removed.

**Fusion rate after arthrodesis**—Sound bony fusion was obtained in 87 per cent of feet with both the methods of fusion described, but three cases treated by excision of the joint and screw fixation required a second operation. There were twenty-one feet with fibrous ankylosis,

![Graph](image)

**FIG. 4**
Age distribution of patients.

![Graph](image)

**FIG. 5**
Length of follow-up.

but only seven of these were a source of complaint, two because of pain in the ankylosis and two because of recurrence of deformity. The other three had had a painful fibrous ankylosis converted to a Keller's arthroplasty with poor results.

If re-fusion is necessary it is easier to perform when the primary fusion has been by the second method described. It is then only necessary for the surfaces to be freshened and once more screwed together. The peg and socket method is more difficult to revise because it is often undesirable to shorten the toe further and a graft may be necessary. Failure of
fusion in the peg and socket method is often due to fracture of the metatarsal shaft just proximal to its insertion into the socket of the phalanx. This fracture is due to removal of too much of the cortex of the metatarsal head when shaping it, combined with failure to insert the metatarsal head deeply enough into the phalangeal socket.

Removal of the fixation screw was necessary in sixteen cases on account of local pain, tenderness or sepsis.

### Table II

**Length of Time Before Wearing Normal Shoes**

<table>
<thead>
<tr>
<th>Time after operation</th>
<th>Arthrodesis (per cent)</th>
<th>Keller's operation (per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1 month</td>
<td>—</td>
<td>21</td>
</tr>
<tr>
<td>Less than 2 months</td>
<td>37</td>
<td>20</td>
</tr>
<tr>
<td>Less than 3 months</td>
<td>22</td>
<td>20</td>
</tr>
<tr>
<td>Less than 6 months</td>
<td>28</td>
<td>30</td>
</tr>
<tr>
<td>Less than 12 months</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>More than 12 months</td>
<td>3</td>
<td>—</td>
</tr>
<tr>
<td>Surgical shoe</td>
<td>3</td>
<td>—</td>
</tr>
</tbody>
</table>

### Table III

**Success/Failure Rate**

<table>
<thead>
<tr>
<th>Method</th>
<th>Number of patients</th>
<th>Indication for operation</th>
<th>Results</th>
<th>Success rate (per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arthrodesis</td>
<td>108</td>
<td>Hallux rigidus</td>
<td>Satisfied . 14</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dissatisfied . 0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hallux valgus</td>
<td>Satisfied with reservation . 11</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dissatisfied . 15</td>
<td></td>
</tr>
<tr>
<td>Keller's operation</td>
<td>56</td>
<td>Hallux rigidus</td>
<td>Satisfied . 10</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dissatisfied . 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hallux valgus</td>
<td>Satisfied . 32</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dissatisfied . 13</td>
<td></td>
</tr>
</tbody>
</table>

**Grading of results**—In the case of arthrodesis three groups were defined: 1) successful—functionally and cosmetically a good foot with relief of presenting complaints including metatarsalgia; 2) satisfactory with reservations—functionally a good foot but with residual deformity, failure to relieve metatarsalgia, interphalangeal discomfort or minor shoe difficulties; 3) failure—marked interphalangeal pain, aggravation or onset of metatarsalgia or failure to relieve it, and shoe difficulties. In the case of Keller's arthroplasty, two groups were defined: 1) successful—functionally a good foot, little or no pain, relief of presenting symptoms; and 2) failure—recurrence of the bunion with return of marked symptoms, development or aggravation of metatarsalgia, or marked pain in the toe. These results are shown in Table III. It will be seen that 86 per cent of the cases of arthrodesis fall into category...
FIG. 6
The best position of fusion. Early degenerative changes in the interphalangeal joint of the great toe are shown.

DISCUSSION

ANGLE OF FUSION

From measurement and analysis of a large number of operated and unoperated feet it appears that the phalanx should be fused at an angle of about 30 degrees to the metatarsal bone and in a few degrees of valgus so that it lies comfortably alongside the second toe but does not crowd the other toes (Fig. 6). Surprisingly, the foot may accommodate quite wide variations from this without symptoms but on occasions difficult problems may be created as will be seen in the following paragraphs.

FAILURE AFTER ARTHRODESIS

Analysis of the failures is instructive because it also answers some of the criticisms of this procedure.

Pain in the interphalangeal joint of the great toe—Why do patients get pain in the interphalangeal joint? Is it because the joint initially has a poor range of movement? Does it loosen up with use, or does its range diminish? Do certain or all angles of fusion throw excess strain on this joint? Do degenerative changes develop because of the extra strain? If the pain is severe what should be done? These are the questions which are often asked when the operation of arthrodesis is discussed and the following is an attempt to answer them.
First, what is the normal range of movement in the interphalangeal joint? Both in the feet operated upon and in those that were not, approximately 75 per cent had an interphalangeal range of dorsiflexion of less than 20 degrees. From the function of the terminal segment of the toe this is what one might expect. The action of the toe is to grip the ground and to take some of the weight; any dorsiflexion is, so to speak, gratuitous. There is no suggestion from comparing pre-operative and post-operative movement that the range of interphalangeal movement increases after arthrodesis.

Out of 156 feet twenty-six had pain—an incidence of 15 per cent; but in only seven of these was it a cause of dissatisfaction or failure (in five a cause of failure, in two a cause of "satisfaction with reservations ").

The range of dorsiflexion at the interphalangeal joint in those patients complaining of pain was, if anything, slightly better than in the series as a whole. In the presence of a good range of interphalangeal movement attempts may be made to use this joint as a substitute for the metatarso-phalangeal joint and this might be a reason for pain.

Again in those twenty-six who had pain, the angle at which fusion was carried out was measured. This varied widely so that one cannot say that fusion in moderate dorsiflexion with a good range of interphalangeal movement will guarantee freedom from interphalangeal pain; nor can one say that poor interphalangeal movement and a low angle of dorsiflexion will certainly be associated with pain, although it often is. Almost certainly this absence of a significant pattern is due to the fact that symptoms are bound up with the function of the forefoot as a whole.

In a number of patients who had interphalangeal pain there was radiological evidence of degenerative change (Fig. 6). Whether these changes will be progressive is not possible to assess; none the less it may be significant. This raises the question of incidence of interphalangeal osteoarthritis in the arthrodesed toes. Thirty-two feet had radiological evidence of osteoarthritis, and a further eleven had possible osteoarthritis in the interphalangeal joint. Against this, only six of thirty-nine normal feet showed evidence of osteoarthritis. This does not prove that arthrodesis precipitated osteoarthritis, as it may be part of the original hallux valgus; none the less a high percentage of patients with pain in the interphalangeal joint have, in fact, mild degenerative changes.

How should such degenerative changes be treated if they become a source of troublesome pain? Fortunately this has not arisen and may never do so. There are two possibilities, either a pseudarthrosis of the interphalangeal joint or fusion of this joint in a position of dorsiflexion.

In most patients who have had an arthrodesis there is a pronounced callous on the inferomedial aspect of the interphalangeal joint and when pain is present it is generally located at this point.

Metatarsalgia or pain in the forefoot—In two patients failure to obtain relief of metatarsalgia was a cause of failure, and in a further six failure to obtain relief marred an otherwise satisfactory result.

What effect does this operation have on metatarsalgia both with and without dislocated toes? Of 156 feet, thirty-five had metatarsalgia and twenty-two (63 per cent) were relieved of pain. Sixteen feet had metatarsalgia with subluxation or dislocation of the second toe; these were treated in the main by excision of the metatarsal head, ten obtaining relief.

The reason for metatarsalgia is often obscure. It may be due to maldistribution of weight across the metatarsal heads consequent upon muscle and ligamentous failure, but in part it is certainly due to malfunction of the toes, probably resulting in prolongation of the metatarsal phase of weight bearing while walking. Metatarsalgia forming part of a specific syndrome such as Morton's metatarsalgia, or pain in Freiberg's disease, is not of course relevant in this discussion.

After operation, relief of metatarsalgia is principally due to an overall improvement in the function of the forefoot with the great toe again taking its share of weight. The adductor
hallucis muscle which once again is provided with a stable origin, may also be able to act more efficiently. Failure to obtain relief is probably due to a point of no return being reached with regard to forefoot function. As a third of patients fail to obtain relief or occasionally have metatarsalgia aggravated, it is unwise to advise arthrodesis for painless hallux valgus associated with metatarsalgia, without warning the patient of the chance of failure.

In patients with subluxation or dislocation of the second metatarsophalangeal joint, excision of the metatarsal head was carried out. Patients with subluxation or dislocation are troubled in one of three ways: pain on the dorsum of the toe because of its position relative to the shoe; pain in the subluxed joint, movements of which, particularly attempted plantar-flexion, are painful; and pain beneath the metatarsal head, usually associated with a callous. If symptoms are confined to the two former, simple excision of the base of the proximal phalanx may in some instances prove satisfactory.

When there is pain beneath the second metatarsal head, excision of the metatarsal head may relieve symptoms providing it is accompanied by stabilisation of the great toe. However, it may fail and in these cases the complaint is generally of pain beneath the next adjoining metatarsal head. In view of these factors it has become the practice of recent years to amputate the second toe, and so far in a small number of cases this seems to be a satisfactory procedure. If there is subluxation or dislocation of more than one toe a Fowler (1959) type procedure should be carried out.

In the Keller procedure relief of metatarsalgia was obtained in only 50 per cent of cases. No relief was obtained in two subluxations treated by excision of the second metatarsal head.

Thus we may say that in the presence of metatarsalgia or second toe dislocation arthrodesis is to be preferred to the Keller procedure.

**Difficulties with shoes**—These fall into three categories. First, those due to fusion of the phalanx in line with the metatarsal bone with regard to varus and valgus. This by transferring the broadest part of the foot distally leads to considerable difficulty except in the softest of shoes (Fig. 7), a difficulty which can only be rectified by corrective osteotomy. Second, if the toe is fused in too much dorsiflexion the interphalangeal joint or the tip of the toe may press into the upper of the shoe and rub a pressure sore. Third, if the angle of fusion is low, difficulty may be experienced in getting the foot into the shoe, particularly when the shoe has a small heel. These difficulties can be avoided if care is taken in obtaining a satisfactory position of arthrodesis.

**Cosmetic complaints**—Complaints about the appearance of the toes were due to failure to obtain fusion with subsequent relapse into valgus.

**Incorrect fusion angle**—Fusion in an excessive degree of dorsiflexion causes two difficulties: with footwear as mentioned above, and the production of a feeling of insecurity or of falling backwards. A number of these patients found that they were happier wearing high-heeled shoes.

Fusion in an excess of plantar-flexion gives the feeling that the toe is digging into the ground.

Fusion in too much valgus will result in crowding of the outer toes and occasionally in subluxation or dislocation of the second or third toe. A callous may also develop over the interphalangeal joint of the fifth toe. It is important to bear in mind the degree of interphalangeal hallux valgus of the great toe as this is often quite considerable and if unnoticed will result in pressure effects on the second toe.
Fusion in a rotated position may lead to the development of an ingrowing toe nail from pressure on the nail fold.

FAILURES AFTER KELLER'S OPERATION

Recurrence of the previous deformity was the most common reason for failure, and it is not really possible to guard against this completely. However, by careful technique the patient may be left with some degree of control over the toe which helps to diminish the likelihood of recurrence. Shortness and retraction of the great toe generally gave rise to symptoms by uncovering the second toe, with resultant corns on the tip of the second toe or development of a hammer or mallet toe. In some instances the shortness of the great toe produced a feeling of insecurity or instability. Pain in the pseudarthrosis was generally associated with a fibrous ankylosis and I cannot say whether or not this was due to failure to remove sufficient bone from the base of the proximal phalanx. In this connection it is interesting to speculate as to the value of traction in the immediate post-operative period.

In general the failures were those inherent in any pseudarthrosis: poor control, shortening, recurrence of deformity and occasional pain. Movement, on the other hand, remained fairly satisfactory.

CONCLUSIONS

The impression obtained in the follow-up clinics has been that arthrodesis is a satisfactory procedure both functionally and cosmetically. The results are more consistently better than Keller's operation particularly in the severe cases with forefoot pain and dislocation of the second toe. This impression has been substantiated by the follow-up presented. The results have been reviewed in the long term and the higher percentage of successes means that this operation will continue to be the procedure of choice in the operative treatment of hallux valgus. Its principal contra-indications are in patients specifically wanting mobility as they wish to wear high-heeled shoes, and patients with a very stiff interphalangeal joint. There is no doubt that in the hands of one person the success rate would be higher as some of the failures are due to inexperienced surgeons.

SUMMARY

1. A long term review of arthrodesis in the management of hallux valgus and rigidus is presented.
2. This is briefly compared with Keller's operation.
3. Eighty-five per cent of patients had a satisfactory result.
4. The reasons for failure and the errors in operative technique are discussed.

I would like to thank Mr. J. S. Batchelor, Mr. P. G. Epps and Mr. T. T. Stamm for continuing interest and encouragement and for kindly allowing me to examine their patients. I am also indebted to Mrs. E. K. Cook, secretary, the Radiological Department, and Mr. A. H. Jackson and the late Mr. G. Tomlinson, all of St. Bartholomew's Hospital, Rochester. A preliminary part of this work was carried out with Mr. B. Brock whose help I acknowledge. Figure 1 was kindly supplied by the LondonSplint Company Ltd.

REFERENCES