The Functional Outcome of Staged Surgery for the Correction of Talipes Equinovarus

Between 1988 and 1995, 110 idiopathic clubfeet from a cohort of 120 recalcitrant feet in 86 patients requiring surgical treatment were studied. There were 61 male and 25 female patients. The mean age at surgery was 9.5 months. In 91 feet, the surgery consisted of an initial plantarmedial release, followed 2 weeks later by a posterolateral release. Nineteen feet required only a posterolateral release. Feet were categorised preoperatively and prospectively according to a system suggested by Dimeglio into four groups, and the rates of relapse and wound healing data were previously reported. This paper reports the functional outcome of this cohort of idiopathic clubfeet and the results are related to the preoperative grade, the patient's gender, the age at which the child first walked, and whether the deformity is unilateral or bilateral. The interim functional outcome is good in the majority of cases despite a high rate of relapse in the more severe deformities.

The purpose of this study was to analyse the functional outcome of surgical treatment for the recalcitrant idiopathic clubfoot. Many authors reported results previously, but the essential difficulty in interpreting data is the lack of preoperative classification. In this study, feet were classified preoperatively and prospectively, which permitted the outcome to be evaluated.
DISCUSSION

The relapse rates and wound healing data from this study were reported previously (26) and identified a 65.4% rate of relapse in the severe (grade 4) feet. The stimulus for this study was therefore to assess the function of these children. This functional outcome was related to the preoperative grade, the patient’s gender, the age at which the child first walked, and whether the deformity is unilateral or bilateral. The anatomical and functional results are compared with the radiographic reduction.

CONCLUSION

Since 1988, a two-stage surgical protocol has been adopted for the treatment of recalcitrant clubfoot deformity. All children presenting with talipes equinovarus undergo a programme of physiotherapy starting from birth that is initiated and supervised by the senior author (N.M.P.C.). Passive stretching and serial plaster casts are used in combination. Those patients with recalcitrant deformities undergo a two-stage surgical correction before the child starts walking, usually between 7 and 11 months of age. The range of motion and degree of stiffness of equinus, varus, and supination were recorded, and all feet were photographed. In addition, standardised radiographs were taken pre-and postoperatively, and measurements were made from the radiographs by one consultant radiologist. The following angles were used (27):

- Anteroposterior talocalcaneal
- Lateral talocalcaneal (plantarflexion and dorsiflexion)
- Talo-first metatarsal

Between 1988 and 1995, a cohort of 86 children with 120 primary clubfeet required surgery. There were 61 male and 25 female patients; 19 male and 11 female patients had bilateral deformities (Table 1). Ten feet in six children with teratologic deformity were excluded from the study for the following reasons: arthrogryposis, cerebral palsy, Larsen’s syndrome, spina bifida, or hemipelvic hypoplasia.

The mean age at surgery was 9.5 months for the index procedure and 35 months for revision surgery. Ninety-one of the 110 feet (82.7%) were available for follow-up at a mean of 5.7 years (range, 2.2–9.6 years).

Surgical procedure

The surgical procedure employed was described in detail by Carroll et al. (7) as a one-stage procedure. In this study, the plantar medial and posterolateral procedures were separated by an interval of 2 weeks and were performed through separate incisions as described in the index paper (26). Postoperatively serial above-knee plaster casts are applied for 3 months with a change under general anaesthesia at 6 weeks. Night splints are used for as long as the child will tolerate them and usually until the age of 2 years. An additional 19 feet required only a single posterolateral release and were included in this functional assessment. A two-stage strategy was prospectively adopted to reduce the incidence of wound complications (26).

Classification

Each foot was graded preoperatively into one of four groups using a system (Dimeglio, personal communication, 1988) that subsequently developed into the classification described by Dimeglio et al. (10) and is shown in Table 2. This classification was favoured because of its pragmatic approach.
Follow-up assessment

For the purposes of follow-up, the patients were examined in a dedicated research clinic by the junior author as an independent assessor. The feet were regraded using the same criteria for joint range of motion and degrees of stiffness as used in the preoperative classification. This system is straightforward and enables the effectiveness of surgery to be analysed by allowing direct comparisons to be made between the preoperative and follow-up assessment. At follow-up, grade 1 was considered to be a foot with full correction or slight residual deformity but >90% range of motion. The degree of stiffness of the foot is considered to be the most important criterion of the assessment and therefore feet with good anatomical correction but poor flexibility were always down graded according to the degree of stiffness. In addition, the appearance and functional outcome was analysed using simple gait analysis.

- Strike (heel, midfoot, toe)
- Intoe
- Activity (running, hopping, jumping)

RESULTS

Preoperative grade

The preoperative grades are grade 2 (27.3%), grade 3 (49.1%), and grade 4 (23.6%). No feet were from grade 1 as these postural feet do not require surgery.

All feet that required a posterolateral release only were grade 2. The forefoot had corrected adequately with manipulation and did not warrant a plantar-medial release.

Relapse

Any further surgical procedure after the initial procedure was considered to represent a relapse of deformity. The results for each of the preoperative grades are as follows: grade 2 (0.0%), grade 3 (20.4%), and grade 4 (65.4%).

Using the Cochrane-Armitage trend test, the increased proportion of relapses with increasing severity of preoperative grade is statistically significant ($p = 0.001$). Using the Mantel-Haenszel test significantly more females relapse than males ($p = 0.018$), but the proportion of relapses for patients with bilateral clubfeet is not significantly higher than for patients with a unilateral clubfoot ($p = 0.377$).

Mean walking age

The mean age at which the children started to walk independently was recorded for each preoperative grade, for gender, and for unilateral or bilateral deformity. Statistical analysis was performed using the Mann-Whitney U test.

- grade 4 (17 months; range, 12-26)
- grade 3 (15.6 months; range, 9.6-60)
- grade 2 (13 months; range, 9.6-19)

There was a trend but no statistical difference between preoperative grades with respect to walking age ($p = 0.228$)

- Unilateral deformities: females, 13.0 months; males, 14.4 months
- Bilateral deformities: females, 15.6 months; males, 16.8 months

There was no statistical difference between the sexes nor the number of deformities with respect to walking age ($p = 0.97$ and 0.397, respectively).

Postoperative classification

The outcome for each of the initial grades of deformity is shown in Fig. 1. No feet were found to be worse postoperatively compared with the preoperative grade. Grade 1 feet were identified in 96.3% of initial grade 2, 56.0% of initial grade 3, and 17.4% of initial grade 4 feet. Grade 2 feet were found in 22.0% of Initial grade 3 and 21.7% of initial grade 4 feet. Grade 3 feet were identified in 26.1% of initial grade 4 feet. Of the initial grades, 3.7% of grade 2, 22% of grade 3, and 34.8% of grade 4 were assessed to be the same grade at follow-up.
Functional assessment

The functional assessment is shown in Table 3 and confirms that the more severe the initial deformity, the less good the final grade. The gait assessment shows clearly that the strike phase of the gait cycle differs between the grades. As expected, the proportion of those who strike with the heel decreases from grade 2 to 4 and those who strike with a flat foot or toe walk are from grade 3 and 4. There is a significant difference in the wear pattern of the sole of the footwear between the grades with 22.7% abnormal wear in grade 2 and 75.0% in grade 4.

Calf circumference and shoe size

The difference in calf circumference and shoe size between the normal and abnormal side in children with unilateral deformity is shown to vary between the different groups. Grade 4 feet have a mean difference in shoe size of 2.3 compared to 1.9 for grade 3 and 1.0 for grade 2 feet. The difference in calf circumference is only 1.1 cm for grade 2 but 1.9 and 1.8 for grades 3 and 4, respectively. The Kruskal-Wallis test was used to analyse the data and shows that the difference between the shoe sizes of grade 2 feet compared to both grade 3 and 4 feet was statistically significant, but the difference between grade 3 and grade 4 was not: grade 2 compared to grade 3 ($p = 0.005$), grade 2 compared to grade 4 ($p = 0.003$), and grade 3 compared to grade 4 ($p = 0.269$).

For calf circumference, the difference between grades 2 and 3 is significant, but the difference between grades 2 and 4 only tends towards significance: grade 2 compared to grade 3 ($p = 0.003$), grade 2 compared to grade 4 ($p = 0.064$), and grade 3 compared to grade 4 ($p = 0.845$).
Forefoot deformity

There was a large number of feet that had persisting forefoot deformity, either metatarsus adductus or supination, but the majority was only mild. Table 4 shows the details for all the groups, but there were four (14.8%) moderate deformities of the forefoot in grade 2 feet, nine (21.9%) in grade 3, and six (26.1%) in grade 4 feet.

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### TABLE 4. The normal ranges for the angles measured on radiograph

<table>
<thead>
<tr>
<th>Angle</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>APTC</td>
<td>28°</td>
<td>38°</td>
<td>48°</td>
<td>58°</td>
</tr>
<tr>
<td>LTC</td>
<td>24°</td>
<td>34°</td>
<td>44°</td>
<td>54°</td>
</tr>
<tr>
<td>Max df</td>
<td>38°</td>
<td>48°</td>
<td>58°</td>
<td>68°</td>
</tr>
<tr>
<td>T1stMT</td>
<td>28°</td>
<td>38°</td>
<td>48°</td>
<td>58°</td>
</tr>
</tbody>
</table>

APTC, anteroposterior talocalcaneal angle; LTC, lateral talocalcaneal angle; Max df, maximum dorsiflexion; T1stMT, talo 1st metatarsal angle.

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Radiographs

Available for review was 72.3% of the radiographs. All films were measured by one consultant radiologist. The normal values used are shown in Table 4 and the results in Table 5. No allowance was made for measurements that were only a few degrees outside the normal values quoted. The talocalcaneal index (3) was calculated and the results are shown in Table 6.

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### TABLE 5. The results of the radiographic analysis

The figures in parentheses show the percentage number of films available for review in each group. See footnote to Table 4 for abbreviations.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Normal</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>APTC</td>
<td>28°, 38°, 48°, 58°</td>
<td>65%</td>
<td>42%</td>
<td>34%</td>
<td>26%</td>
</tr>
<tr>
<td>LTC</td>
<td>24°, 34°, 44°, 54°</td>
<td>70%</td>
<td>55%</td>
<td>40%</td>
<td>30%</td>
</tr>
<tr>
<td>Max df</td>
<td>38°, 48°, 58°, 68°</td>
<td>65%</td>
<td>42%</td>
<td>34%</td>
<td>26%</td>
</tr>
<tr>
<td>T1stMT</td>
<td>28°, 38°, 48°, 58°</td>
<td>65%</td>
<td>42%</td>
<td>34%</td>
<td>26%</td>
</tr>
</tbody>
</table>

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### TABLE 6. The talocalcaneal indices for each group

This is calculated by adding the APTC and LTC (in plantar flexion); >=40° is considered to be normal (3).

<table>
<thead>
<tr>
<th>Grade</th>
<th>Normal</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index</td>
<td>&lt;=40°</td>
<td>65%</td>
<td>42%</td>
<td>34%</td>
<td>26%</td>
</tr>
<tr>
<td>Relaps</td>
<td>&gt;=40°</td>
<td>35%</td>
<td>58%</td>
<td>66%</td>
<td>74%</td>
</tr>
</tbody>
</table>

Poor correlation was found between the anteroposterior talocalcaneal (APTC) angle and the clinical grade of the foot. In grade 1 feet, 55.9% of APTC angles were outside the normal range, whereas 60% in grade 4 were abnormal. The lateral talocalcaneal and talo-first metatarsal were more closely correlated, but even in grade 1 feet, the angles were outside the normal range in 35.3 and 38.2%, respectively. Of films reviewed, 80% in grades 3 and 4 showed abnormal values. The talocalcaneal index was <40° in 36.4% of grade 1, 45.4% of grade 2, and 57.5% of grade 3 feet but 60% of grade 4. In those cases that relapsed, 62.1% had an index >40°. The numbers in some of the groups are small, and therefore comparisons are limited.

**DISCUSSION**

The results presented in this paper show that grading feet according to severity is beneficial in analysing the results of surgery. The correction obtained for the more severely deformed feet is less good than that achieved for milder degrees of deformity, but the functional outcome is well maintained.

Statistical analysis showed that there is a significantly higher rate of relapse in females compared with males and with increasing grade of deformity preoperatively. The difference in calf circumference and shoe size between the normal and affected sides in children with unilateral deformities was statistically significant for grade 2 feet when compared with grades 3 and 4. Children with bilateral deformities were no more likely to relapse than those with unilateral deformities. In addition, we reported a number of persisting deformities of the forefoot. Most of these are mild and may not be...
significant but necessitate further study in the future. There is a statistical trend for the age of initial walking to increase
with increasing deformity. Surgery may therefore be delayed in severe cases until the foot is more mature but still
achieve a correction before the child walks.

The use of radiographs to assess outcome is controversial and the results presented confirm this. Even the grade 1
feet with excellent correction and functional outcome had abnormal APTC and talocalcaneal index in 35.1 and 36.4%,
respectively. Of those feet that relapsed, 62.4% had a normal talocalcaneal index, and therefore radiographs alone are
not reliable in predicting relapse.

This is an interim report as the mean age of our patients is only 5 years 9 months. We chose not to include the
functional assessment directly into a point scoring system as this may in fact cloud the picture. The results from this study
show that for those feet with persisting deformity, the function is usually remarkably good at this stage. The foot may
deteriorate as the foot matures, and the final outcome may not therefore be as good as predicted from a grade that
includes function at this interim stage. It is of course essential to record the functional assessment, but only when the
final outcome is completed at maturity can the true results of surgery be known.

This form of critical analysis is not possible if preoperative grading is not utilised. The effectiveness of surgery for the
treatment of clubfoot can only be assessed satisfactorily if the deformity is classified preoperatively. Only four authors
previously reported on the treatment of clubfoot with any form of preoperative assessment (2,9,15,23). We chose the
grading system that was initiated by Dimeglio (personal communication, 1988) and is used in conjunction with a method of
final evaluation to assess the outcome of surgical treatment (5). We adapted the initial grading system and used it to
grade feet at the follow-up examination so that a direct assessment can be made of the progress of an individual foot.

There are numerous other methods described to assess the results of clubfoot surgery (Table 7) (1,2,4,6,9,11–25). Many
of them are very detailed, involving angles, the measurement of which is difficult to perform accurately.
Examination of joint stiffness and function of specific muscles is also difficult in young children and when incorporated
into detailed scoring systems and increases the potential errors. The use of a pragmatic system of assessment does not
imply that the examination is less accurate but that the differentiation of patients into specific groups is easier and more
repeatable.

| Table 7. Methods described to assess the results of clubfoot surgery (Table continued) |

| Y, yes; N, no; Ex, excellent; G, good; F, fair; P, poor; U, unsatisfactory; m, months; y, years; w, weeks; POP, cast; ctev, talipes; SSG, split skin graft; f.u., follow-up |

The synopsis of results presented in Table 7 shows the diversity of methods used to assess the results of surgery. It
also demonstrates how complicated and unrewarding is the task of trying to draw significant comparisons between work of
differing authors. The crux of the problem is being able to identify preoperatively those cases with a poor prognosis. The

outcome of the differing approaches could then be evaluated to identify the most effective treatment.

CONCLUSION

This study showed that classification of clubfeet before and after surgery is essential to analyse outcome effectively. The outcome of treatment in idiopathic clubfeet is largely dependent on the degree of initial deformity. Despite radiographic evidence and clinical grading, the functional outcome appears good in the majority of cases. This may have implications for decision making in the treatment of relapsed clubfeet.

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REFERENCES


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