CRUSH FRACTURES OF THE LATERAL TIBIAL TABLE

Factors Influencing the Prognosis

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The treatment of fractures of the lateral tibial condyle is still the subject of controversy. Some surgeons favour non-operative treatment in virtually all cases, believing it to be a safe method giving good results (Cotton 1936, Bick 1941, Fairbank 1955, Apley 1956). Others operate for all but minor fractures (Cubbins, Conley, Callahan and Scuderi 1934; Palmer 1939; von Bahr 1945; Knight 1945). The latter argue that it is impossible to obtain a satisfactory reduction by non-operative means, and believe that conservative treatment leaves the end-result to chance (Palmer 1951).

Fractures of the condyles of the tibia are so varied that this is a major difficulty in comparing the results of different forms of treatment. It is necessary to classify them so that one may, so far as possible, compare like with like. Some of these classifications are too detailed to provide groups of sufficient size for comparison, particularly when an attempt is also made to grade the apparent severity of the fracture. It has, therefore, been found useful to divide fractures of the tibial tables into three broad types (Fig. 1): 1) split fractures; 2) \(\lambda\)-shaped or bicondylar fractures; and 3) crush fractures. A similar classification was used by Bradford, Kilfoyle, Kelleher and Magill (1950), Palmer (1951), Slee (1955) and others.

![Types of tibial table fracture. (The crush fracture of the lateral tibial condyle is the type discussed in the present paper.)](image)

The first type, the split fracture, is not common and probably never occurs in a pure form without some element of depression, for pieces of articular cortex are usually found crushed in the depths of the split (Fig. 2). Because there is a large fragment with intact articular cartilage, one might expect the prognosis to be good if this is replaced in its normal position. Only two patients in the present study were considered to have fractures in this category; they were treated by open reduction and screw fixation with results classified as acceptable. These cases are not included in the subsequent discussion.

The second type of fracture is the \(\lambda\)-shaped or bicondylar fracture. Sometimes the articular surfaces appear to be intact, but one or other may be depressed. Often the medial condyle is

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pushed down without apparent damage to the articular surface, but in the case of the lateral condyle there is frequently crushing of the central part (Fig. 3). Such fractures are by no means uncommon, but have not been included in this series unless the fracture entering the medial tibial cortex was an undisplaced crack accompanying a depressed fracture of the lateral tibial condyle. It was then classed as a crush fracture.

Figure 2—Split fracture of lateral tibial condyle showing fragments of articular cortex depressed into the depths of the split; such fragments may prevent closed reduction. Figure 3—Bicondylar fracture; the articular surface of the medial condyle is intact, as is often the case.

Figure 4—Crush fracture of the lateral tibial condyle with severe depression of the articular surface and a lateral fragment comprising only a thin shell of cortex. Figure 5—Crush fracture with large lateral fragment including a good articular surface; it may be seen that there is little difference between this and the split fracture (Fig. 2). Such injuries are hard to categorise.

In crush fractures, the third type, there is usually a lateral cortical fragment remaining at the original joint level, though it is often displaced outwards. This lateral fragment varies in size from a mere shell of cortex (Fig. 4), to a large piece of bone with intact articular cartilage (Fig. 5), and the "split" fracture should probably be considered as representing the latter end of this spectrum. A variant of the crush fracture is the marginal fracture (Fig. 6), in which
there is less damage to the articular surface but sometimes an associated tear of the medial ligament (Solonen 1963). Another variant, the so-called "sliding" fracture, in which the whole condyle is pushed down without injury to the articular surface, has not been seen in our series. It is probably virtually confined to the medial condyle, where there is no counter-pressure such as is provided by the head of the fibula (the anvil to the hammer of the lateral femoral condyle).

The crush fracture of the lateral tibial table is the commonest type and this paper is a study of the long-term results of treatment of such fractures. The purpose of the study was to determine the factors which influence the results and the indications, if any, for open reduction.

Severity of fracture—Objective grading of the severity of the fractures is possible by measuring the depth of the depression on the initial radiographs. The measurement taken is the greatest depth to which the articular cortex has been depressed below the normal level of the lateral tibial plateau, some of which is usually intact (Fig. 7). It can generally be made within an error of two or three millimetres provided the radiographs are of good quality, and the distance from tube to film is constant. It represents the depth to which the lateral femoral condyle has been forced into the upper end of the tibia.

CLINICAL STUDY

Clinical records and radiographs were available for 137 patients who sustained 138 crush fractures of the lateral tibial table during the years 1956-66 and who were treated in the orthopaedic departments of either the Western Infirmary or the Southern General Hospital, Glasgow.

There were sixty-five males and seventy-two females; one female patient sustained injuries to different knees on separate occasions. The ages of the patients are shown in Figure 8, which
indicates the predominance of women in the sixth and seventh decades and the more even distribution in males.

The causes of the injuries are shown in Table 1. It is noticeable that falls, which usually occurred in the house, accounted for the overwhelming majority of fractures in women.

It was possible to assess sixty-eight knees at follow-up. Of the other seventy patients, thirty-four had changed their addresses and were not traceable, ten were known to have died and seven to have emigrated: no response was obtained from the remaining nineteen patients, but examination of their case records did not suggest that they were an unrepresentative group.

Only the sixty-seven patients (with sixty-eight fractures) who attended for clinical and radiological examination are considered hereafter. Particular note was taken of symptoms,
TABLE II
CLASSIFICATION OF RESULTS—METHOD OF ASSESSMENT

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Excellent</th>
<th>Feels like a normal joint</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Good</td>
<td>“Barometric” or other mild occasional aching which does not interfere with ordinary activity; feeling of slight weakness</td>
</tr>
<tr>
<td></td>
<td>Fair</td>
<td>Discomfort on ordinary activity; knee feels weak</td>
</tr>
<tr>
<td></td>
<td>Poor</td>
<td>Severe daily aching</td>
</tr>
<tr>
<td>Function</td>
<td>Excellent</td>
<td>Full extension, flexion of 120 degrees or more, and no abnormal abduction rocking</td>
</tr>
<tr>
<td></td>
<td>Good</td>
<td>Extension to within 5 degrees of full, flexion to 90 degrees or more, and no abnormal lateral mobility</td>
</tr>
<tr>
<td></td>
<td>Fair</td>
<td>Extension to within 10 degrees of full and flexion to 75 degrees or more; excessive lateral mobility</td>
</tr>
<tr>
<td></td>
<td>Poor</td>
<td>Worse than fair</td>
</tr>
<tr>
<td>Appearance</td>
<td>Excellent</td>
<td>Knee of normal appearance—no abnormal valgus or fixed flexion deformity</td>
</tr>
<tr>
<td></td>
<td>Good</td>
<td>Slight swelling around joint or slight valgus deformity</td>
</tr>
<tr>
<td></td>
<td>Fair</td>
<td>Noticeable swelling or valgus deformity</td>
</tr>
<tr>
<td></td>
<td>Poor</td>
<td>Marked swelling or ugly valgus deformity</td>
</tr>
</tbody>
</table>

TABLE III
RADIOGRAPHIC APPEARANCES AT FOLLOW-UP

| Excellent | Restoration of displacement within 3 millimetres; no degenerative joint change |
| Good      | Restoration of displacement within 3 millimetres; minimal degenerative joint change |
| Fair      | Restoration of displacement within 10 millimetres; moderate degenerative joint change |
| Poor      | Worse than fair |

the appearance of the knee, its stability and the range of joint movement. All the patients were examined personally.

In twenty-nine of the fractures the depression of the lateral tibial articular surface was less than 10 millimetres, in twenty-one it was 10–14 millimetres, and in eighteen it exceeded 14 millimetres.

Three years was regarded as the shortest time after injury at which the results could be assessed (von Bahr 1945). Twelve years was the longest follow-up; the average was six years. Method of assessment—Assessment of the results at follow-up examination was based on the suggestions of Hohl and Luck (1956), who used two grades, “anatomical” and “functional”, associating appearance with radiographic changes, and symptoms with stability and range of movement. However, it clarifies matters to have three criteria, namely symptoms, function and appearance (Table II), and to separate these from the radiographic appearances (Table III), which are of less importance to the patient though possibly having a bearing on the eventual outcome. To simplify the interpretation, excellent and good results have been regarded as “acceptable” and fair and poor results as “unacceptable”.

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METHODS OF TREATMENT AND RESULTS AT FOLLOW-UP

FRACTURES WITH DEPRESSION OF LESS THAN 10 MILLIMETRES

These fractures were treated mainly by active exercises, with avoidance of weight-bearing for four to six weeks. A few knees were treated by immobilisation in plaster for up to six weeks. Several were treated in simple traction for a few weeks. Two were treated by open reduction.

Results—In twenty-eight out of twenty-nine the result was “acceptable” according to all three criteria (most falling into the excellent group). The single patient with an unacceptable result, who had persistent pain and stiffness of the knee, had been treated in plaster for five and a half weeks.

FRACTURES WITH DEPRESSION OF 10 MILLIMETRES OR MORE

Of the thirty-nine crush fractures with depression of 10 millimetres or more, nineteen were treated conservatively and twenty by operation. The proportions of moderately severe and more severe fractures were approximately the same in each group (Table IV). The treatment chosen varied with individual surgeons; no doubt cases were selected for the method of treatment but in retrospect the basis of selection was not clear, and in some instances conservative treatment was adopted because the degree of depression of the articular surface was underestimated.

Conservative treatment consisted in active exercises, either free or in traction, or immobilisation in plaster for an average of four weeks. A few fractures were manipulated as a first stage in their treatment.

Operative treatment varied somewhat from case to case but in general followed the lines described by Palmer (1939) and by Barr (1940). A “lazy S” incision was made over the anterolateral aspect of the knee joint and upper end of the tibia, and the fracture exposed with minimal soft-tissue dissection. So that the articular surface of the tibial condyle might clearly be seen, the lateral meniscus was always excised. Either through the fracture site after retraction of a lateral cortical fragment, or from below, with an elevator inserted through a small cortical window, the depressed fragments of articular surface were fully elevated. The cavity thus created below the elevated surface was packed with bone usually taken from the iliac crest. It was found that radiographic examination was valuable at this point to confirm that complete elevation had been obtained. This may be difficult to ascertain visually. Various types of internal fixation were used to reattach the lateral cortical fragment and to hold the reduction: in earlier cases screws were commonly employed (Figs. 9 and 10), but of late the transverse bolt was used more often (Fig. 11). After operation the knee was usually immobilised in plaster for four weeks and never for more than six. In some recent cases, knee movements were started immediately. No case of wound infection was recorded.

TABLE IV

<table>
<thead>
<tr>
<th>Depression</th>
<th>Number of fractures</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Closed treatment</td>
<td>Operation</td>
<td></td>
</tr>
<tr>
<td>10–14 millimetres</td>
<td>10</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Over 14 millimetres</td>
<td>9</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>
FIG. 9
Radiographs taken before and after open reduction showing excellent reposition of the depressed part of the articular surface. Bone grafts were inserted beneath the elevated portion before insertion of a screw to retain the position of the lateral cortical fragment.

FIG. 10
Radiographs before and after operation showing failure to reconstitute the articular surface; in this case the surface was not supported by bone grafts after elevation. Clinically the end-result was unacceptable.

FIG. 11
Severely depressed crush fracture of the lateral tibial condyle treated by elevation of the depressed surface, iliac bone grafting and bolt fixation.
The average time before weight-bearing was allowed was seven weeks in both the conservatively treated group and those treated by open reduction. All patients received intensive physiotherapy.

**Results** (Tables V and VI)—Of the nineteen patients treated without open reduction the results in ten were unacceptable in one or more of the three criteria (in two patients in appearance only). The ten unsatisfactory results comprised five of the ten patients with depression of the articular fragments of 10–14 millimetres and five of the nine patients with more severe depression. Not surprisingly, the radiological appearance at follow-up was “unacceptable” in all nineteen cases.

The results in four of the twenty patients treated by operation were unacceptable in at least one respect (in one case in appearance only). Three of these four unacceptable results occurred when the depression of the articular surface of the lateral tibial condyle exceeded 14 millimetres. In all four cases the operation was unsatisfactory in that there was inadequate reposition of the fragments as judged by the radiographs taken immediately after operation.

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**TABLE V**

**Results of Treatment in Crush Fractures with Articular Surface Depressed by 10 Millimetres or More Treated by Closed Methods**

<table>
<thead>
<tr>
<th>Depression</th>
<th>Acceptable</th>
<th>Unacceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>10–14 mm</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Over 14 mm</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>10</td>
</tr>
</tbody>
</table>

**TABLE VI**

**Results of Treatment in Crush Fractures with Articular Surface Depressed by 10 Millimetres or More Treated by Operation**

<table>
<thead>
<tr>
<th>Depression</th>
<th>Acceptable</th>
<th>Unacceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>10–14 mm</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Over 14 mm</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
<td>4</td>
</tr>
</tbody>
</table>

**TABLE VII**

**Results of Treatment Related to Depth of Depression**

<table>
<thead>
<tr>
<th>Depth</th>
<th>Acceptable</th>
<th>Unacceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 10 mm</td>
<td>28</td>
<td>1</td>
</tr>
<tr>
<td>10–14 mm</td>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td>More than 14 mm</td>
<td>10</td>
<td>8</td>
</tr>
</tbody>
</table>
To give two extreme examples, two radiographs after operation with the corresponding initial positions are shown, in one case (Fig. 9) with very good reposition and in the other (Fig. 10) almost complete failure. At follow-up the radiological appearance was judged to be acceptable in ten patients and all of these ten had acceptable clinical results.

When all the crush fractures, however they were treated, are considered it is apparent that the prognosis is directly related to the depth of the depression; the results in cases with mild depression were almost uniformly good, whereas only just over half of the patients in whom the depression exceeded 14 millimetres had an acceptable result (Table VII).

**OTHER FACTORS INFLUENCING THE RESULT**

*Area of condyle depressed*—The proportion of the articular surface involved in the depression does not admit to measurement in the way that the depth of depression does, but it can be roughly assessed by the comparative radiological density of the part of the tibial table which is left undisplaced, as illustrated in Figure 12. If the cases with depression of 10 millimetres or more in depth are divided into those with a large and those with a smaller area of depression, one finds that the results are poorer in the patients in whom more of the tibial condyle has been involved (Table VIII). Seven out of nine patients with a large area of depression of over 14 millimetres in depth had unacceptable end-results.

When the method of treatment is taken into account (Tables IX and X), it is clear that operation gave the best results when the depressed area was not extensive, although it also appeared to show some advantage in the cases with a large depressed area.

*Age and sex*—The sex of the patient did not appear to have any bearing on the results of treatment, neither did age, as was also noted by Palmer (1951), Slee (1955), Hohl and Luck (1956) and Reibel and Wade (1962). In von Bahr's (1945) series, older patients appeared to do less well.

*Delay in operation*—There was no evidence that, in those patients treated surgically, delay in operation of a few days influenced the result.

**DAMAGE TO LIGAMENTS**

In a series of experimentally produced tibial plateau fractures in cadaveric limbs, Kennedy and Bailey (1968) showed a low incidence of ligamentous injury. In clinical studies, Bick (1941)
and Reibel and Wade (1962) noted that any early instability due to soft-tissue injury was usually only a temporary phenomenon, whereas Solonen (1963) considered that laxity of the ligaments was a frequent cause of an unsatisfactory late result. Roberts (1968) found unstable knees at follow-up in five out of nine patients in whom a ruptured medial ligament had been demonstrated but not repaired.

In the present series no patient had symptoms which were considered to be caused by instability of the knee. A sensation of slight "give" on the lateral aspect of the joint on adduction stress was detected at follow-up examination in almost all the patients, but never

**TABLES VIII TO X**

**RESULTS OF TREATMENT RELATED TO AREA OF DEPRESSION**

**TABLE VIII**

All patients with depression of 10 millimetres or more in depth

<table>
<thead>
<tr>
<th>Area</th>
<th>Result</th>
<th>Acceptable</th>
<th>Unacceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small or moderate</td>
<td>19</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Large</td>
<td>6</td>
<td>11</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE IX**

Cases treated by open reduction

<table>
<thead>
<tr>
<th>Area</th>
<th>Result</th>
<th>Acceptable</th>
<th>Unacceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small or moderate</td>
<td>12</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Large</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE X**

Cases treated by closed methods

<table>
<thead>
<tr>
<th>Area</th>
<th>Result</th>
<th>Acceptable</th>
<th>Unacceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small or moderate</td>
<td>7</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Large</td>
<td>2</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

amounted to definite instability. It was presumed to be caused by failure of the soft tissues to adapt fully to the altered bony anatomy.

In six patients there was detectable laxity of the anterior cruciate ligament; in all except one the laxity was minimal. Rupture of this ligament was not recorded primarily.

In six patients injury to the medial ligament was suspected at the time of injury and confirmed by stress radiographs (Martin 1960). The ligament was repaired in five of these cases. In only one patient was there detectable, though slight, laxity of the ligament at review and this was a patient in whom no rupture had been noted initially. Often the integrity of the medial ligament at the time of injury was not clearly stated in the case records.
MENISCI

At review no patient complained of symptoms which were thought to be attributable to damage to the menisci, either in the patients treated by operation or those treated conservatively, some of whom must presumably have had torn or displaced cartilages. This agrees with the findings of Cotton (1936), Barr (1940), Palmer (1951), Slee (1955) and Reibel and Wade (1962). In cases treated by open reduction, the lateral meniscus was excised routinely to aid exposure of the articular surface, even when there was no evidence of tearing or depression of the meniscus. Various authors (Cubbins, Conley and Seiffert 1929; von Bahr 1945; Solonen 1963) have suggested that it is preferable to preserve the meniscus as a protection for the injured articular surface, and advocate repair of minor tears and resuture of a meniscus which has been reflected to gain exposure.

DISCUSSION

The finding that the long-term results are directly related to the initial depth of depression does not support the view of Fairbank (1955) who considered that severely displaced fractures carried little worse prognosis than those with a mild displacement.

With the more severe depressions (10 millimetres or more) a good reposition of the depressed articular surface produced a uniformly satisfactory result. If the reposition was poor, either following an unsuccessful operation or because no reconstitution was attempted, the results were much less certain, with about an equal chance of being acceptable or unacceptable. The fact that some good functional results were obtained even in the presence of less than perfect reconstitution agrees with the findings of von Bahr (1945). Solonen (1963) showed that a good anatomical result, demonstrable radiographically, was an almost certain guarantee of a good functional result; the present series confirms this.

Prolonged plaster fixation of the knee was avoided. The evil effects that may be produced by immobilisation of the joint after injury were clearly demonstrated by Haldeman (1938) and by Hohl and Luck (1956). There can be no doubt that early movement is essential, especially after open reduction of an articular fracture.

None of the patients interviewed complained of symptoms starting some years after the injury. A fracture into a joint is generally considered to be a common cause of so-called “secondary osteoarthrosis”, and one would imagine that a comminuted fracture involving the weight-bearing surface of a large lower limb joint would be ideally placed to produce such changes. It therefore seems surprising that osteoarthrosis did not appear to be a feature at follow-up, either clinically or radiologically. It was unusual to see generalised degenerative changes in the knee joint at the follow-up radiological examination, although there was commonly irregularity of the lateral tibial articular cortex. Possibly the period of follow-up (average six years) was not long enough for the onset of secondary arthrosis to be detected. Perhaps other factors, as yet unknown, operate in addition to the irregularity of the joint surface (Dingle 1962, Dintenfass 1963). It is possible that those patients with a good functional result at the present time, but who have poor reduction of the articular surface, will be more liable to develop painful arthrosis in the future.

SUMMARY

1. Sixty-eight crush fractures of the articular surface of the lateral tibial condyle have been analysed.
2. Follow-up examination at a minimum of three years after injury was carried out in all cases.
3. The only factors which appeared to influence the results were the extent of the original depression, and if this was severe, the degree of restoration obtained by the treatment. Prolonged plaster fixation was avoided.
4. At review, no patient complained of symptoms which were attributable to damage to ligaments or menisci and no patient had symptoms of late onset.
5. The results suggest that there is nothing to be gained by open reduction if the lateral condyle is depressed by less than 10 millimetres, as conservative treatment gives good results. If the depression is more severe, however, a good result can only be assured if the articular surface is successfully reconstituted, but this is sometimes difficult to achieve. It is not possible to reconstitute the surface by non-operative means.

I wish to express my thanks to the orthopaedic surgeons at the Western Infirmary and the Southern General Hospital for allowing me to report on their cases. I am most grateful to the Medical Illustration Department of the Western Infirmary for preparing the figures and to various secretaries of the orthopaedic departments for their assistance. Particular thanks are due to Professor Roland Barnes for his helpful criticism and advice in the preparation of this paper.

REFERENCES


