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FRACTURES OF TIBIAL CONDYLES

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Despite the frequent occurrence of fractures of the tibial condyles, the principles of their treatment are still debated. Disagreement concerning the significance of anatomical reduction divides the surgeons into adherents of conservative therapy and advocates of surgery. The purpose of the present investigation was to analyse the factors influencing the end results and assess the indications for various therapies on this basis.

MATERIAL AND METHODS

During the period 1962–1967, 291 patients with tibial condylar fractures were treated at the Department of Orthopaedics and Traumatology, University Central Hospital, Helsinki. At the time of this study 33 of these patients had died and the addresses of 61 patients were unknown. The hospital records of these two groups of patients, however, permitted the conclusion that there was no difference between them and the remainder. This report is concerned only with the remaining 197 patients, 90 males and 107 females, who were clinically and radiologically followed up. Their mean age at the time of injury was 52 years. The interval between injury and follow-up ranged from 2–9 years, the average being 4.5 years.

The causes of injury appear in Table 1. Traffic accidents were the cause in over half the cases. The injured were pedestrians almost as often as occupants or drivers of various vehicles.

The fractures were classified as sugggested by Hohl & Luck (1956) (Figure 1). Fractures involving the articular surface but lacking more than 3 mm displacement as shown by radiography were thus termed undisplaced fractures (36 patients). The depth of the depression was measured either from the remaining intact articular surface or from a line drawn as an extension of the other tibial condyle to the point of maximum depression. The displaced fractures were divided into (1) the local depression type (89 patients), with comminution of the articular surface; (2) the total depression type (22 patients) with depression of the entire intact articulating surface of the condyle; (3) the split type (19 patients), in which lateral displacement without depression was the presenting feature; and (4) the bicondylar type

(31 patients). The lateral condyle was involved in 128 cases of monocondylar fracture, the medial condyle in 38.

The methods of treatment appear in Table 2.

Table 1. Causes of injury in tibial condyle fractures.

Causes of injury	Total
Traffic accidents	
Injuries to car occupants	22
Car injuries to pedestrians	41
Motorcycle or bicycle injuries to driver	32
Motorcycle or bicycle injuries to pedistrians	7
Fall, twist or both	93
Unknown	2
Total	197

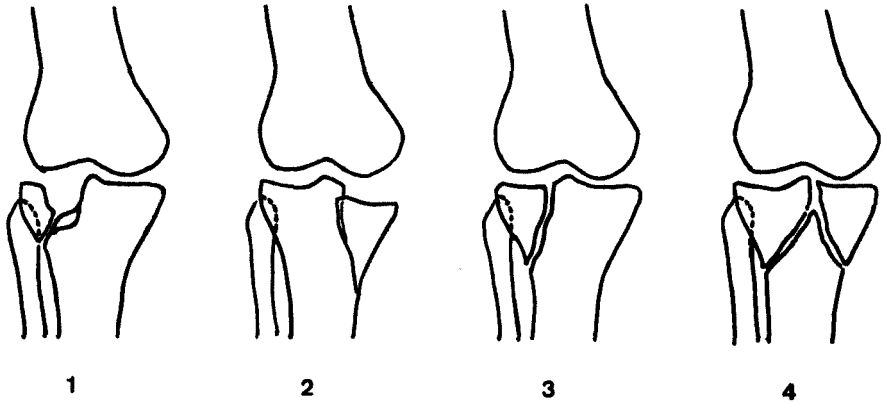

Figure 1. 1. The local depression type. 2. The total depression type. 3. The split type. 4. The bicondylar type.

Conservative Treatment

Over half the patients (53 per cent) were conservatively treated. Early mobilization was used in some cases, but the majority were treated by immobilization in a plaster cast. In some of the patients reduction of the fracture by manipulation was the first measure attempted.

Operative Treatment

Most of the patients with dislocated fractures (91, or 70 per cent) were operatively treated. The majority (70 patients) were operated on 1–3 days from the accident, the remainder (21 patients) 4–11 days from injury. The limb was exsanguinated

during operation. The fracture was exposed by an incision which also permitted exploration of the joint. A ruptured meniscus (44/91 patients) was excised, whereas a meniscus partly torn from its marginal attachment and a meniscus that had been detached to permit better visualization of the fracture were fixed with sutures. The depressed fragments of the articular surface were elevated. The cavity thus created in the spongy bone was packed with heterogenous Kiel bone (37 patients) or autogenous bone (18 patients) taken from the iliac crest or femoral condyle. The fracture was usually (64/91 patients, or 70 per cent) fixed with Ackerman's (through and through) bolt. A screw was used in 8 cases and in 19 no internal fixation was done, restoration of the articular surface being the only procedure carried out. In connection with operation of the fracture, torn ligaments of the knee were primarily sutured in 24 patients. The medial collateral ligament was torn in 16 cases, the lateral collateral ligament in 2 and the cruciate ligaments in 13. In one case early amputation was done owing to a vascular lesion. The postoperative treatment consisted of active exercise in traction in 12 cases and immobilization in a plaster cast in 79/91 (90 per cent). Postoperative wound infection developed in 3 cases, in one leading to osteitis, which healed after trepanation performed five weeks after the primary operation. Postoperative venous thrombosis developed in 5 patients, in one resulting in permanent disability. No postoperative deaths occurred.

Table 2. Present series of 197 fractures of the tibial condyle classified by types of the fracture and method of treatment.

Method of treatment	Monocondylar fractures				Bicondylar fractures	Total
	Undisplaced	Local depression	Total depression	Split		
Cast immobilization without reduction	36	26	3	3	7	75
Closed reduction followed by cast	–	9	1	4	9	23
Yearly mobilization without operation	–	4	1	1	1	7
Open reduction followed by cast	–	43	14	9	13	79
Open reduction followed by early mobilization in traction	–	7	2	2	1	12
Primary amputation	–	–	1	–	–	1
Total	36	89	22	19	31	197

The average duration of plaster immobilization was 9.4 weeks in both the conservatively and surgically treated cases. The average time of non-weight bearing was 11.7 weeks in both groups.

RESULTS

The functional and anatomical end results were separately rated as acceptable or unacceptable. A result was considered functionally acceptable if the patient was able to do work corresponding to his occupation or age, if there was full extension of the knee with flexion of at least 90° and the knee subjectively stable, and if the patient only experienced transient pain occasionally in connection with exertion. A result was considered anatomically acceptable if the articular surface was dislocated by a maximum of 3 mm, varus/valgus was under 10°, and there was no or only minimal arthrosis. The ratio of anatomically acceptable results was 123/197 (62 per cent); 77 were treated conservatively and 46 operatively. The ratio of functionally acceptable results was 147/197 (75 per cent); 91 were treated conservatively and 56 operatively. An extension deficiency of 5–10° remained in 21 patients (11 per cent), and 8 (4 per cent) showed an extension deficiency of at least 20°. Ankylosis developed spontaneously in two knees and arthrodesis was performed on one knee. A limitation of flexion by a maximum of 20° was noted in 37 patients (19 per cent), a limitation by 30–40° in 15 patients (8 per cent) and limitation by over 50° in 4 (2 per cent). Slight arthrosis was present in 39 patients (20 per cent), moderate arthrosis in 35 (18 per cent) and marked arthrosis in 28 (14 per cent), whereas no arthrosis was discovered in 95 patients (48 per cent). Among 36 patients with primarily undislocated fractures, 31 showed no arthrosis, 4 showed slight arthrosis and one moderate arthrosis. In the 161 patients with primary dislocation the development of arthrosis was compared to the results attained by reduction (see below). Good reduction was associated with minimal late arthrosis in 28 cases, with moderate arthrosis in 17 and with marked arthrosis in 15. No arthrosis developed in 55 of the satisfactorily reduced cases. When the result of reduction was poor (widening or depression of the articular surface by at least 5 mm and/or valgus/varus over 10°), no arthrosis resulted in 8 cases, moderate arthrosis in 17 and marked arthrosis in 13. Residual valgus was observed in 41 knees (20 per cent), residual varus in 7 (3.5 per cent). No varus deformity was over 10°. The valgus deformities were a maximum of 10° in 34 cases and 20–30° in 7.

The treatment of the menisci in connection with operation seemed to have no effect on the end results.

When the cancellous bone defect was filled with a bone graft, the kind of graft had no effect on the overall results. However, when the

primary defect was large (10 mm at least), the Kiel bone seemed to be less resistant to compression than autogenous bone (Wilppula & Bakalim 1972 a).

Forty patients showed insufficiency of the ligaments of the knee at follow-up. The insufficiency was mostly slight, but in 9 cases it was considered to be the main cause of a functionally unacceptable result (Wilppula & Bakalim 1972 b).

The position of the fracture was impaired during the observation time in 27 patients. In this group the average duration of non-weight bearing was 11.5 weeks. The treatment was operative in 23 cases, conservative in 4.

There was no correlation between the functional end results and the age of the patients or the duration of immobilization, although healing was more rapid in those patients who were mobilized early.

The relationship between the end results and the different types of fracture and the different methods of treatment appears in Tables 3–10.

Table 3. Results in undisplaced fractures

Method of treatment	Anatomical results acceptable	Functional results acceptable	Total
Cast immobilization	36	35	36

Undisplaced Fractures (Table 3)

All of the 36 patients with undisplaced fractures were conservatively treated by cast immobilization. The anatomical result was acceptable in all cases and the functional result was unacceptable in only one.

Local Depression Fractures (Table 4)

In 50 surgically treated patients the depth of the primary depression averaged 8.5 mm. In 39 conservatively treated cases the primary depression was an average of 5 mm. The original position of the fracture or the position attained by reduction deteriorated in 17 cases. Of these patients 3 had been conservatively treated, 14 operatively.

The relationship between the results of reduction and the functional end results is shown in Table 5. When the depth of the depression was under 5 mm after reduction or attempted reduction, a significantly ($X^2 = 5.4$) better result was obtained than in those cases where reduction had been less successful. The tendency was the same in the con-

servatively and operatively treated groups. The data for the two groups are pooled in the table.

Table 4. Results in local depression fractures treated by various methods.

Method of treatment	Anatomical results acceptable	Functional results acceptable	Total
Conservative treatment			
Cast immobilization	18	27	35
Early mobilization	3	3	4
Operative treatment			
Cast immobilization	22	24	43
Early mobilization in traction	5	5	7
Total	48	59	89

Table 5. Functional results compared to accuracy of reduction in local depression fractures.

Depression after reduction	Functional results		Total
	Acceptable	Unacceptable	
0–4 mm	47	15	62
5 mm	13	14	27
Total	60	29	89

Table 6. Results in total depression fractures treated by various methods.

Method of treatment	Anatomical results acceptable	Functional results acceptable	Total
Conservative treatment			
Cast immobilization	4	4	4
Early mobilization	1	1	1
Operative treatment			
Cast immobilization	6	7	14
Early mobilization in traction	–	1	2
Primary amputation	–	–	1
Total	11	13	22

Table 7. Functional results compared to accuracy of reduction in total depression fractures.

Depression after reduction	Functional results		Total
	Acceptable	Unacceptable	
0–4 mm	12	6	18
5 mm	1	2	3
Total	13	8	21

Table 8. Results in split fractures treated by various methods.

Method of treatment	Anatomical results acceptable	Functional results acceptable	Total
Conservative treatment			
Cast immobilization	6	7	7
Early mobilization	1	1	1
Operative treatment			
Cast immobilization	7	9	9
Early mobilization in traction	2	2	2
Total	16	19	19

Total Depression Fractures (Table 6)

In this group 16/22 patients were surgically treated. The depth of the depression averaged 9.7 mm. A vascular lesion necessitated early amputation in one case. Among the 5 conservatively treated patients, 4 had a primary depression of 3.5 mm and one had a deeper depression. The position of the fracture deteriorated during the observation time in 5 patients, 4 of whom had been operatively treated, one conservatively.

The relationship between the results of reduction and the functional end results appears in Table 7. A good result of reduction (depression under 5 mm) correlated with an acceptable end result.

Split Fractures (Table 8)

Of 19 patients 11 were operatively treated. The functional end result was acceptable in all. The 8 conservatively treated patients also had acceptable functional results in spite of residual widening of the fracture line by 3–7 mm in 5 cases.

Bicondylar Fractures (Table 9)

The apparently better results of conservative treatment of this type of fracture may be due to the relatively greater frequency of slight primary dislocation (depression or widening under 5 mm) in the conservatively treated patients (12/17) compared to the surgically treated patients (2/14).

The result of reduction was considered to be good if the depression or widening was under 5 mm and valgus/varus angulation under 10°. As may be seen in Table 10, the correlation was striking between a good result of reduction and an acceptable functional end result.

The alignment was impaired during the time of observation in 5 operatively treated patients.

Table 9. Results in bicondylar y- and t-fractures treated by various methods.

Method of treatment	Anatomical results acceptable	Functional results acceptable	Total
Conservative treatment			
Cast immobilization	8	12	16
Early mobilization	–	1	1
Operative treatment			
Cast immobilization	4	8	13
Early mobilization in traction	–	–	1
Total	12	21	31

Table 10. Functional results compared to accuracy of reduction in bicondylar y- and t-fractures.

Result of reduction	Functional results		Total
	Acceptable	Unacceptable	
Good	15	2	17
Poor	6	8	14
Total	21	10	31

DISCUSSION

The significance of anatomical restoration of the articular surface is still a matter of debate. Hohl & Luck (1956) showed experimentally

that the area of the defect in the tibial articular surface was gradually replaced with cartilaginous tissue. Similar observations have been made in human beings in connection with arthrography (Dovey & Heerfordt 1970) and with arthrotomy (Maisel & Cornell 1948, Reibel & Wade 1962). The above-mentioned authors emphasized the favourable effect of mobilization of the joint. Early activation also prevented the formation of intra-articular adhesions (Hohl & Luck 1956). These observations speak in favour of Apley's (1956) argument for recommending conservative treatment: "moulding movement is the best way to achieve the greatest congruity of the joint surfaces!" Conservative treatment, in which early mobilization of the knee is a leading principle, has many adherents (e.g. De Morgues & Chaix 1964, Barrington & Dewar 1965, Poulsen & Tophøj 1969).

Not all investigators, however, rely on the healing forces of nature alone, but think that in any event the worst deformities of the joint surface ought to be repaired. Operative reduction has thus been considered indicated if condylar depression or widening of the fracture line exceeds ¼ inch (Gylling & Lindholm 1953, Wolf & White 1963), if the depth of the depression is over 10 mm (Hohl & Luck 1956, Porter 1970, Lucht & Pilgaard 1971) or a minimum of 5 mm (Palmer 1951, Hohl 1967), or if the depression is 3–4 mm (Perey 1952). Other authors have emphasized the importance of exact reduction in general (Jakobsen 1953, Solonen 1963, Fryjordet 1967).

As regards the clinical material of the present retrospective study, the tendency seems to have been to treat the worst fractures surgically and less badly dislocated cases conservatively. Hence, the number of comparable cases was not large enough to permit evaluation of the relative merits of the different methods of treatment. But we assessed the effect of the alignment achieved by reduction or attempted on the end results. The best functional results were attained in undislocated and split-type fractures lacking a depression. Moreover, a significant correlation was observed between a good result of reduction and a good functional end result in fractures of the local and total depression types as well as in bicondylar fractures. A similar correlation was discovered between the results of reduction and the development of late arthrosis. On the basis of these observations we recommend anatomical restoration of the articular surface whenever possible. As a rule this is not feasible without operation. However, if the original depression of the joint surface is slight (under 5 mm), the position of the fracture may often be accepted and the patient may be conservatively treated. The

operation as such did not seem to have any detrimental effects, and a further advantage of surgery is the possibility of simultaneously repairing soft tissue injuries. Ligamentous insufficiency was the main cause of an unacceptable result in 4.5 per cent of cases in the present series, and we consider primary repair of totally ruptured ligaments to be desirable in connection with the treatment of tibial condylar fractures (Wilppula & Bakalim 1972 b). However, it is useless to suggest any fixed rules as to the kind of dislocation requiring operative treatment, since the individual needs of the patient and his possibilities of receiving efficient after-treatment must be taken into account (Hohl 1967).

The trend in the treatment of tibial condylar fractures is clearly in favour of early mobilization (e.g. Charnley 1967, Reibel & Wade 1962, Solonen 1963, De Morgues & Chaix 1964, Barrington & Dewar 1965, Fryjordet 1967, Porter 1970, Rasmussen 1971, Lucht & Pilgaard 1971), although the meaning of this phrase as used by different authors varies from mobilization started after a few days to after several months. A relatively long period of immobilization, 2 months, has also been recommended (Chuinard 1964). Although our clinic has also gone in for a reduction of the period of immobilization, the average duration was still relatively long (9.4 weeks) in the present series. Despite this the end results were very good, and no significant effect of the duration of immobilization on the results could be demonstrated. As a general impression it may, however, be stated that early mobilization seemed to accelerate the restoration of a normal range of movement of the knee (Solonen 1963). A relatively long period of immobilization seems to be compensated by efficient, controlled after-treatment. Manipulation under anaesthesia has proved useful in cases where the return of full mobility of the knee came to a standstill (Chuinard 1964).

As regards the duration of non-weight bearing in tibial condylar fractures, there is a high degree of consensus in the literature. Most authors have recommended 10–12 weeks' non-weight bearing (e.g. Palmer 1939, Jakobsen 1953, Jensenius, Jensen & Nielsen 1961, Reibel & Wade 1962, Solonen 1963, Jonasch 1965, Fryjordet 1967, Rasmussen 1971). The average duration of non-weight bearing in the present series, 11.7 weeks, is in agreement with this general trend. Hohl (1967) suggested non-weight bearing for as much as 6 months. In the present series redepression occurred in 27 cases. This seems to suggest that a prolonged period of non-weight bearing may be indicated in some cases.

SUMMARY

A series of 197 patients with tibial condylar fractures was retrospectively studied. The treatment was conservative in 53 per cent. Of the dislocated fractures 79 per cent were operatively treated. There was a strong correlation between a good result of reduction and a good functional end result. Operative reduction is recommended. Ligamentous tears often occur in conjunction with tibial condylar fractures, and it is suggested that these lesions be primarily treated by surgery. A relatively long period of immobilization does not necessarily exclude a good end result, provided that mobilizing after-treatment is controlled.

REFERENCES

Apley, A. G. (1956) Fractures of the lateral tibial condyle treated by skeletal traction and early mobilisation. *J. Bone Jt Surg.* **38**-B, 699.

Barrington, T. W. & Dewar, F. P. (1965) Tibial plateau fractures. *Canad. J. Surg.* **8**, 146.

Charnley, J. (1963) *The closed treatment of common fractures.* 3rd ed. E. & S. Livingstone Ltd., Edinburgh and London.

Chuinard, E. G. (1964) Fractures of the condyles of the tibia. *Clin. Orthop.* **37**, 115.

De Morgues, G. & Chaix, D. (1964) Treatment of fractures of tibial plateaus. *Year book of orthopaedics traumatic & plastic surgery* (1964–65), p. 178. Year Book Medical Publ. Inc., Chicago.

Dovey, H. & Heerfordt, J. (1970) Tibiakondylfrakturer. En efterundersøgelse af 200 tilfælde. *Nord. Med.* **83**, 830.

Fryjordet, A., Jr. (1967) Operative treatment of tibial condyle fractures. *Acta chir. scand.* **133**, 17.

Gylling, U. & Lindholm, R. (1953) Fractures of the tibial condyle. *Annal. Chir. Gynaec. Fenn.* **42**, 229.

Hohl, M. (1967) Tibial condylar fractures. *J. Bone Jt Surg.* **49**-A, 1455.

Hohl, M. & Luck, J. V. (1956) Fractures of the tibial condyle. *J. Bone Jt Surg.* **38**-A, 1001.

Jakobsen, A. (1953) Operative treatment of lateral tibial condyle fractures. *Acta orthop. scand.* **23**, 34.

Jensenius, H., Jensen, I. & Nielsen, F. K. (1961) Tibiakondylfrakturer med saerligt henblik på operativ behandling. *Nord. Med.* **66**, 1573.

Jonasch, E. (1965) Einfache Methode zur Behandlung der unikondylären Scienbainkopfbrüche. *Arch. orthop. Unfall-Chir.* **57**, 5.

Lucht, U. & Pilgaard, S. (1971) Fractures of the tibial condyles. *Acta orthop. scand.* **42**, 366.

Maisel, B. & Cornell, N. W. (1948) Conservative treatment of fractures of the tibial condyles. *Surgery* **23**, 591.

Palmer, I. (1939) Compression fractures of the lateral tibial condyle and their treatment. *J. Bone Jt Surg.* **21**, 674.

Palmer, I. (1951) Fractures of the upper and of the tibia. *J. Bone Jt Surg.* **33**-B, 160.

Percy, O. (1952) Depression fractures of the lateral tibial condyle. *Acta chir. scand.* **103**, 154.

Porter, B. B. (1970) Crush fractures of the lateral tibial table. *J. Bone Jt Surg.* **52**-B, 676.

Poulsen, J. O. & Tophøj, K. (1969) Konservativ behandling af tibiakondylfrakturer. *Nord. Med.* **82**, 1243.

Rasmussen, P. S. (1971) *A functional approach to evaluation and treatment of tibial condylar fractures.* Elanders Boktryckeri, Gothenburg.

Reibel, D. B. & Wade, P. A. (1962) Fractures of the tibial plateau. *J. Trauma* **2**, 337.

Solonen, K. A. (1963) Fractures of the tibial condyles. *Acta orthop. scand.*, Suppl. 63.

Wilppula, E. & Bakalim, G. (1972 a) Kiel bone in the surgical treatment of tibial condylar fractures. *Acta orthop. scand.* **43**, 62.

Wilppula, E. & Bakalim, G. (1972 b) Ligamentous tear concomitant with tibial condylar fractures. *Acta orthop. scand.* **43**, 292.

Wolf, M. D., White, E. H. (1963) Depressed fractures of the tibial plateau. *Surg. Gynec. Obstet.* **116**, 457.

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