CALLUS FORMATION AND THE RATE OF HEALING OF FEMORAL FRACTURES IN PATIENTS WITH HEAD INJURIES

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Callus formation and the rate of union of nailed fractures of the femur has been determined in 22 patients with associated head injuries and compared with that in a group of patients with similarly treated fractures but without head injuries. The comparison confirms the widely held view that, in patients with head injuries, fractures frequently heal with excessive callus and at a faster rate than normal.

Orthopaedic dictum teaches that fractures of long bones, when associated with head injuries, frequently heal with excessive callus and at a faster rate than normal. The evidence, however, is flimsy and based on small series of patients treated in different ways and never with an adequate control series (Calandriello 1964). The dictum remains unsubstantiated and, indeed, Garland failed to confirm increased callus formation or more rapid healing of fractures of the tibia and femur in patients with head injuries (Garland and Toder 1980; Garland, Rothi and Waters 1982). These series, however, had no controls, nor did they quantify the callus.

The conservative treatment of fractures in patients with head injuries is made more difficult for both medical and nursing staff by the fact that patients are often unable to co-operate. Excessive callus in these patients may then be due to lack of control of the limb and excessive movement at the fracture, and only indirectly to the head injury. In order to eliminate these variables, we decided to study fractures of the shaft of the femur treated by AO nailing and to measure and compare the extent of callus production and the rate of healing in patients with or without associated head injury.

PATIENTS AND METHODS

The series reviewed comprised 22 consecutive patients admitted to the Royal Perth Hospital with head injuries and fractures of the shaft of the femur treated with AO intramedullary nails (Group I). One patient had bilateral femoral fractures and 13 had multiple injuries. The severity of the head injury was graded: mild – in a coma for less than 3 hours; moderate – a coma lasting 3 hours to 3 days; or severe – a coma lasting more than 3 days. Fourteen of the 22 patients had a severe head injury, the period of coma varying from 3 to 41 days (average 15 days).

Twenty-two consecutive patients without head injury but with similar femoral fractures treated with AO intramedullary nails formed the control group (Group II) and 11 of these patients had additional severe orthopaedic injuries.

The fractures in both groups were all diaphyseal with displacement of the whole diameter. The degree of comminution was graded: Grade I – minor, with one or two small fragments; Grade II – moderate, with three or four small fragments or a large displaced butterfly fragment; or Grade III – with severe comminution.

In the majority of patients the AO nailing was performed using a closed technique but in seven of the 23 fractures in the head injury group the fracture was openly reduced before fixation; in Group II only two patients required open reduction. The time lapse from injury to nailing was recorded.

An attempt was made to establish the rigidity of fixation in terms of the size of the nail used and the diameter of the medullary cavity at the level of the fracture. In all cases the medullary cavity was reamed to take a large nail at the narrowest part of the medullary cavity but excessive reaming was not performed; therefore, in fractures below the mid-shaft of the femur, the fixation was deemed not to be rigid owing to the poor fit of the nail within the medullary canal at this level.

The volume of callus produced was calculated using the formula:

$$2\pi r_1(r_2 - r_1)l$$

where r_1 is the radius of the bone and r_2 the radius of bone plus callus and l is the length of the callus (Fig. 1). This assumes the callus forms as a cylinder which is not

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strictly correct but does provide a quantifiable estimate of the volume of callus produced.

The time to union was difficult to establish. Because of the internal fixation, clinical assessment was clearly not possible and reliance was therefore placed on the radiological assessment of union.

RESULTS

The details of the patients and the results are shown in Table I (see page 524).

Apart from the presence or absence of a head injury, the two groups were dissimilar in other respects. In the group with head injuries (Group I), only nine patients had their fractures fixed soon after admission; the delay before nailing in the remaining 11 varied from 4 to 28 days. In Group II there was a delay (of 5 to 14 days) in

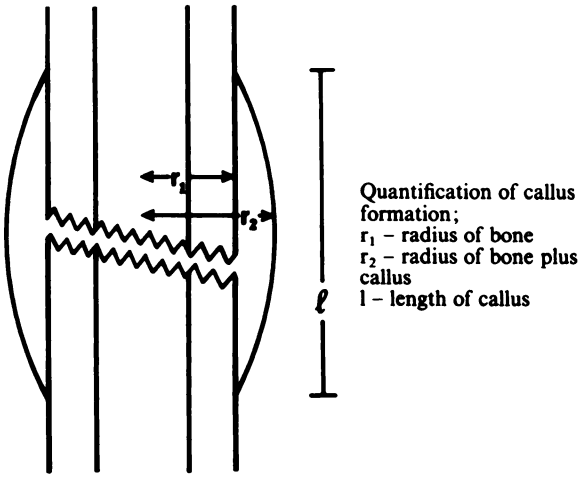

Fig. 1

Fig. 2

Fig. 3

Figures 2 – A fractured femur with an associated head injury before closed AO nailing. Figure 3 – Twelve weeks after operation there is exuberant callus formation.

only three patients. Similarly in Group I, seven patients had their AO nail inserted by an open technique compared with only two patients in Group II. Nevertheless, statistical analysis revealed no significant variation between callus formation or time to healing in those patients whose operation was delayed or in whom it was performed by an open technique compared with those patients fixed soon after admission with a closed technique.

However, the volume of callus in the patients with head injuries (Figs 2 and 3) was clearly greatly in excess of that in the control group (Figs 4, 5 and 6) and appeared to be directly attributable to the head injury per se ($p < 0.00005$). There appeared to be no correlation between the volumetric response and the duration of coma. The fractures of the femur in Group I healed in an average time of 12.4 weeks compared to 15.7 weeks in the control group ($p < 0.01$).

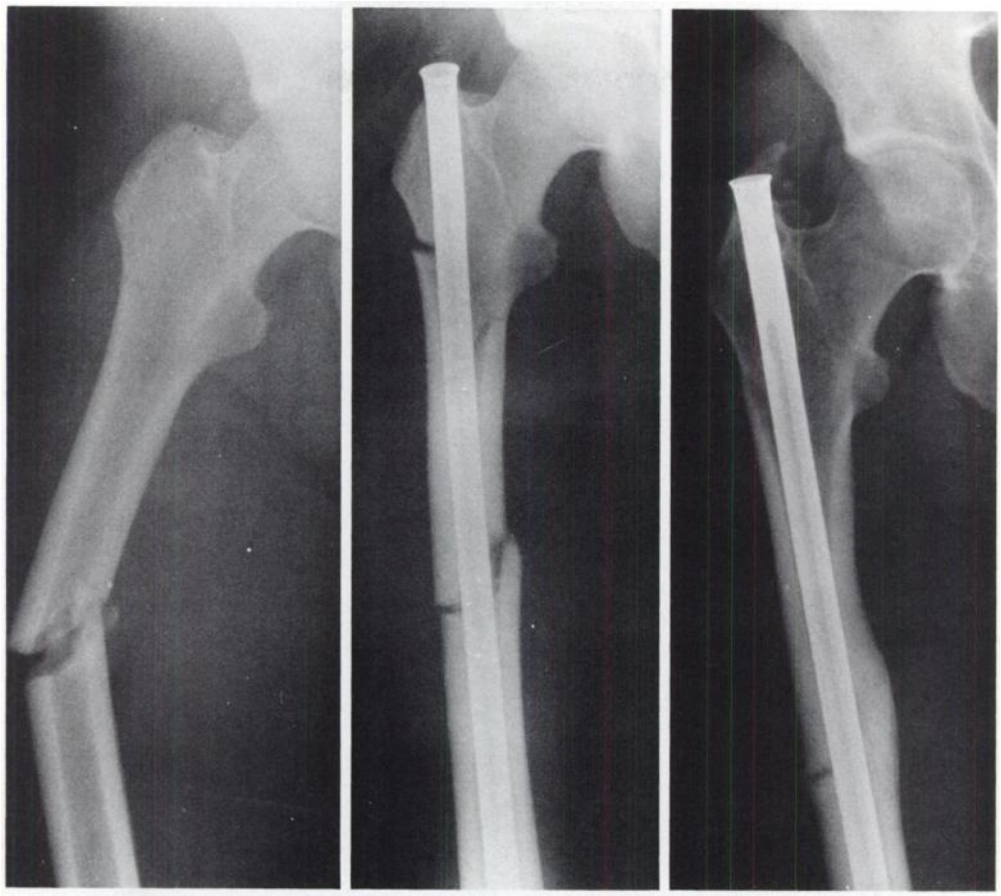

Fig. 4 Fig. 5 Fig. 6

Figure 4 – A fractured femur with no associated head injury. There is also an undisplaced fracture at the upper end. Figure 5 – After fixation. Figure 6 – After union, with small callus response.

DISCUSSION

There is little supporting evidence available to verify the belief held by many orthopaedic surgeons that fractures of long bones frequently heal with excessive callus and at a faster rate when associated with severe head injuries. Review of the orthopaedic literature reveals that the hypothesis remains unproven and reinforces the necessity of quantifying the parameters being researched (i.e. callus production) and, equally important, the availability of an adequate control series.

This study has tried to overcome these difficulties by selection of a constant fracture treated in a uniform way. We realise that our two groups remain dissimilar in several respects other than the presence or absence of a head injury. Statistical analysis, however, has demonstrated no association between the delay before nailing and the extent of callus production in Group II patients. Similarly, the degree of comminution, the rigidity and whether the operation was performed by closed or open methods were not significant in terms of callus production.

We feel, therefore, that the increased volumetric callus response and the shorter time to union in our patients with head injuries is likely to be real and is directly or indirectly related to the head injury.

It is beyond the scope of this paper to speculate as to the mechanism of this increased callus production but it may be related to the occurrence of heterotopic new bone formation which occurs as a complication of head injuries.

Perhaps the most interesting aspect relates to the realisation that central mechanisms exist in the control of fracture healing, but whether they be neural as a direct consequence of the head injury or metabolic or biochemical as an indirect consequence remains to be resolved.

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Table I. Details of patients and the estimated volume of callus and rate of healing of nailed femoral fractures with and without associated head injuries

Patient	Severity of head injury	Comminution of fracture	Time to nailing in days	Fixation	Procedure	Volume of callus	Time to union (*weeks*)
1	Severe	1	24	Rigid	Closed	40	16
2	Severe	1	21	Not rigid	Closed	84	9
3	Severe	1	4	Rigid	Closed	46	11
4	Severe	1	6	Rigid	Closed	85	6
5	Severe	1	14	Rigid	Closed	36	10
6	Severe	1	1	Rigid	Closed	46	12
7	Severe	1	0	Rigid	Closed	46	12
8	Severe	1	28	Rigid	Open	60	10
9	Severe	1	21	Rigid	Open	46	20
10a	Severe	1	21	Not rigid	Open	27	9
10b	Severe	1	21	Not rigid	Open	27	9
11	Severe	1	1	Not rigid	Open	20	16
12	Severe	1	7	Rigid	Closed	46	11
13	Severe	2	4	Rigid	Closed	73	12
14	Moderate	1	7	Not rigid	Closed	33	10
15	Moderate	1	7	Not rigid	Closed	27	10
16	Moderate	1	1	Rigid	Closed	19	16
17	Moderate	1	9	Rigid	Open	26	14
18	Mild	1	1	Rigid	Closed	24	10
19	Mild	3	1	Not rigid	Closed	6	14
20	Mild	2	1	Rigid	Closed	13	12
21	Mild	1	1	Rigid	Closed	6	12
22	Mild	1	1	Rigid	Open	2	24
23	No	1	1	Rigid	Closed	7	16
24	No	1	1	Not rigid	Closed	5	10
25	No	2	5	Not rigid	Closed	8	12
26	No	2	1	Not rigid	Closed	11	14
27	No	1	1	Not rigid	Closed	7	20
28	No	1	1	Rigid	Closed	5	12
29	No	0	1	Rigid	Closed	4	20
30	No	1	1	Rigid	Closed	5	14
31	No	2	1	Rigid	Closed	7	12
32	No	1	1	Rigid	Closed	6	14
33	No	2	1	Not rigid	Closed	13	16
34	No	2	1	Rigid	Closed	9	12
35	No	2	1	Not rigid	Closed	10	20
36	No	2	1	Not rigid	Closed	1	20
37	No	2	1	Rigid	Closed	3	20
38	No	1	1	Rigid	Closed	5	12
39	No	1	1	Rigid	Closed	8	12
40	No	1	14	Rigid	Closed	9	16
41	No	2	10	Rigid	Closed	13	14
42	No	1	1	Rigid	Open	9	20
43	No	2	1	Not rigid	Open	19	24
44	No	2	1	Rigid	Closed	10	16