THE EFFECT OF HEAD INJURY ON FRACTURE HEALING
A QUANTITATIVE ASSESSMENT

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Using a simple method of quantifying fracture healing, 53 patients who had limb fractures and also severe head injuries were studied; they were compared with 30 patients who had limb fractures but no head injury. Those with head injuries had a greater healing response and united more rapidly.

Radiological and histological analysis revealed that the terms "myositis ossificans" and "heterotopic bone" may be more appropriate than "fracture callus" to describe the healing response in these patients.

Patients with head injuries have frequently been observed to have an abundant healing response to fractures, leading to rapid union. The author, however, is not aware of any previous report quantifying either this response, or the severity of the head injury.

The material produced around fractures in patients with head injuries is frequently referred to as "callus", but this may not be the most appropriate term as ossification may occur spontaneously in these patients (Garland, Blum and Waters 1980).

The aim of this present study was to establish the quantity and nature of the fracture healing response in patients with precisely defined levels of head injury.

PATIENTS AND METHODS

During a two-year period between October 1983 and October 1985, 366 patients with significant head injuries were admitted to King Edward VIII Hospital, Durban. Forty-five (12%) died as a result of their injuries. Fifty-three patients with severe head injuries and fractures of the limbs, spine or pelvis survived. Their head injuries were rated, in the first 48 hours, at 10 or less on the Glasgow coma scale. There were 47 males and six females with an age range of 4 to 67 years (mean 30 years). Motor vehicle accidents were the commonest cause of injury. A total of 82 fractures were sustained (Table I); 32 patients had two or more fractures (the tibia and fibula, and the radius and ulna each counted as only one fracture). Patients with fat embolism or suffering from alcohol withdrawal were excluded.

Most of the fractures were treated conservatively, but internal fixation was used for eight fractures, seven of which involved the femur. The head injuries also were mostly treated conservatively by observation and intracranial pressure monitoring, but in 10 patients burr holes were made or a craniotomy performed.

The factors assessed were the fracture healing response (see below), the time to clinical union (as defined by Apley and Solomon 1982), the cerebral CT scan findings, the severity and duration of neurological deficit and any complications.

The fracture healing response was calculated by the simplest possible method which allowed reproducibility. The healing mass is frequently fusiform, though often irregular and eccentric, resembling no mathematically definable shape. However, the largest diameter of even the most amorphous tube-like structure is substantially the most important determinant of volume in the absence of massive variations in length. A numerical value for fracture healing response was therefore calculated as follows:

Fracture healing response = A/B

where A is the largest diameter of the healing mass measured from serial radiographs taken at 90° to each other, and B is the bone diameter at or adjacent to the

| Table I. The 82 fractures sustained in 53 patients with head injuries |
|-----------------------------|-----------------|---|
| Tibia and fibula            | Tibial plateau  | 2 |
| Femur                      | Ankle           | 2 |
| Humerus                    | Fibula          | 2 |
| Pelvis                     | Foot            | 1 |
| Clavicle                   | Olecranon       | 1 |
| Radius/ulna                | Scapula         | 1 |
| Hand                       | Femoral condyle | 1 |
| Cervical spine             |                 |   |

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Fracture healing response = A/B

Fig. 1
Fracture healing response (A/B).

Controls mean 1.24
Head-injured mean 1.37

Healing response.

Figure 2 - Tibia.

Controls mean 1.61
Head-injured mean 1.70

Figure 3 - Femur.

Controls mean 1.68
Head-injured mean 1.70

Figure 4 - Humerus.

Time to union.

Figure 5 - Tibia.

Figure 6 - Femur.

Figure 7 - Humerus.

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fracture site on the same radiograph (Fig. 1). The numerical value obtained was used to compare the patients who had head injuries and fractures of the tibia, femur and/or humerus, with a group of 30 controls matched for age and sex who had similar fractures but no head injury. A similar number of open fractures was present in both groups. Patients aged under 16 years, and fractures which underwent internal fixation were not used for comparative purposes.

In addition to the radiological assessment, the fracture healing response was also assessed histologically in four patients, two in the group with head injuries and two without but who had late internal fixation.

RESULTS

The healing response in the tibia, femur and humerus are shown in Figures 2, 3 and 4, and the estimated time to clinical union in Figures 5, 6 and 7. A significant difference between patients with head injuries and the controls was found with respect to both healing response and time to union. Moreover, a linear correlation was found between the healing response and the time to union in the patients with head injuries (Table II).

In the patients with head injuries the radiographs often showed rapid formation of a peripheral layer of radiodensity. By contrast, the controls exhibited a standard healing response, a zone of callus spreading in uniform density outwards. Similarly, histological analysis of the healing mass sampled three weeks after injury showed peripheral maturity in the patients with head injuries but not in the others (Fig. 8).

Internal fixation appeared to potentiate the healing response in the patients with head injuries (Fig. 9), suggesting that surgical trauma or the release of osteogenic cells in the vicinity of the fracture encourages new bone formation.

<table>
<thead>
<tr>
<th>Table II. Correlation between the healing response and the time to union in patients with head injuries</th>
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<tr>
<td>Correlation Coefficient</td>
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<tr>
<td>--------------------------</td>
</tr>
<tr>
<td>Tibia 19</td>
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<tr>
<td>Femur 5</td>
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<tr>
<td>Humerus 11</td>
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* Significant at a 5% level
** Significant at a 1% level

Malunion, including shortening, occurred in 12 fractures, eight of which showed an “abundant” healing response. The bones most commonly affected were the humerus and the femur.

Delayed diagnosis (over 48 hours after admission) of a significant injury occurred in 11 patients. Fractures accounted for seven of these, knee ligament injuries for two, a brachial plexus injury and a ruptured spleen for one each.

Head injuries. The CT scans of the 53 patients with head injuries revealed an intracerebral haematoma or a contusion in 18, cerebral oedema in 17, a subdural haematoma in 16, and an extradural haematoma in two patients. An abundant fracture healing response (defined as a response equal to or greater than the upper limit in the control group) was observed in 73% of patients with the more severe degrees of cerebral injury. There was no correlation between the healing response and ipsilateral spasticity, nor with bilateral spasticity.
Nor was any correlation found between the healing response and the time taken to reach a stable neurological status (range 4 hours to 3 months), or with the depth of coma on admission, which ranged from 3 to 10 on the Glasgow coma scale. Twenty-seven patients (51%) made a complete neurological recovery.

**DISCUSSION**

Sevitt (1981) stated that some kind of influence on ossification is exerted by the nervous system; this much is well known to clinicians. However, despite numerous reports of rapid and abundant fracture healing in patients with head injuries, the matter has not been resolved, partly because of the difficulty in quantifying the fracture healing response. The severity of the head injury also is important and a precise neurosurgical diagnosis can probably be obtained only by CT scanning.

The study of internally fixed fractures to demonstrate fracture healing patterns in patients with head injuries has been used, but can be called into question, since the operation is liable to cause muscle damage, and this may contribute to new bone formation via locally released morphogens (Urist et al. 1978).

The exact nature of the healing mass in patients with head injuries has not been established. “Heterotopic ossification” is the term used by Garland et al. (1980) to describe the periarticular ossification which occurs spontaneously in some of these patients, and the same term is used by Garland and Miller (1984) to describe the nature of the fracture healing in such patients. Many other terms also have been used to describe this pattern of fracture healing, including “hyperplastic callus” (Glenn, Miner and Peltier 1973), “heterotopic bone” (Garland and Rhoades 1978), “myositis ossificans” (Bellamy and Brower 1974), “ossifying hematoma” and “calcifying hematoma” (Kernohan et al. 1984).

It is clear from the present study that the material is bone, and it resembles most closely “myositis ossificans” or “heterotopic bone” in that it tends to be mature at its periphery (Heffner 1984); this is the converse of the normal fracture healing response as described by Peacock (1984). The precise mechanism for this abnormal response is unclear, but it probably results from a combination of general and local effects. What is apparent is that movement at the fracture site, though frequently implicated, is unlikely to be the major factor. Although many questions remain unanswered, this study has demonstrated, using a simple and reproducible method, that an abundant fracture healing response occurs after severe head injury, as a result of which there is rapid union. The healing response is atypical in nature, and the term “callus” is probably not appropriate.

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**REFERENCES**


