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CLINICAL ASPECTS OF THE DISRUPTIVE EFFECTS OF ROAD ACCIDENTS ON THE HUMAN BODY

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A great deal of detailed study has been made of the interaction of forces generated by accidental violence and the damaging effects of impact on motor vehicles and their occupants. One of the beneficial results has been the identification of shortcomings in the design and construction of motor cars and the protective devices installed in them. An understanding of the strength of materials is an obviously important part of the science of structural engineering, and application of engineering methods to the human body has led to greatly improved understanding of how best to design both implants and external appliances. It has also enhanced respect for what can truly be referred to as the marvels of the human body.

The clinician has much to thank his engineering colleagues for, but it is fair to say that even if he is largely lacking in mathematical ability and knowledge of engineering the accident surgeon has at his disposal a vast store of information about the body's ability to withstand violence and even more about the way in which violence damages it. Careful examination of the injured part by inspection, palpation, manipulation and surgical exploration is particularly useful when combined with knowledge of how the injury occurred. An accurate account of the nature, direction and amount of force applied can explain the anatomical damage so well that when a similar pattern of anatomical damage is seen on another occasion the circumstances of injury can be correctly inferred.

Alternatively, accurate knowledge of how the force was applied may warn the accident surgeon of damage that may be hidden within the depths of the body. As an animal leaves its spoor, so can accidental violence declare its nature by the traces of its application.

INJURIOUS FORCES

In terms of accidental injury the body may be damaged by impact (which includes compression), by twisting, or by distraction. In the case of road accidents, impact is much the most frequent primary force causing injury, although the effect of impact upon movable and deformable structures such as the foot or the soft parts of the limbs or trunk include shearing, twisting and distraction.

PATTERNS OF INJURY

Many of the effects of road accidents upon the human body have characteristic patterns which may include the association of an obvious injury with a much less obvious but possibly more severe one. Specific examples are fracture of the shaft of the femur which distracts attention from an accompanying dislocation of the hip, and fracture of the lower part of the legs masking an injury of the foot. In each case the swellings of the two injuries are continuous and may not be recognized as having separate sources.

The patterns of injury vary according to whether the person is struck by a vehicle or is inside it, and if he is inside it the patterns vary according to whether he is restrained or free to move and whether or not the vehicle is deformed. Knowing the circumstances may put the examiner on his guard and cause him to look with particular care to see whether or not certain likely injuries have in fact been inflicted. The more detail that can be obtained from witnesses, rescuers or the victims, the better equipped the examiner will be to avoid making mistakes. Failure in diagnosis in cases of multiple injuries often occurs because the injured person is examined to find out what his injuries are rather than to confirm or exclude those that could well be present. Pedestrians are usually thrown up in the air and land on the bonnet of the vehicle if they are struck low down, or are thrown forwards and to the ground to suffer further injury if they are struck higher up. The resulting injuries are usually mainly, if not entirely, on one side of the body (Figure 1).

Motorists

The injuries typical of the unrestrained occupant of a motor vehicle are too well known to warrant more than a mention (Figure 2) but the injuries caused by means of restraint deserve attention.

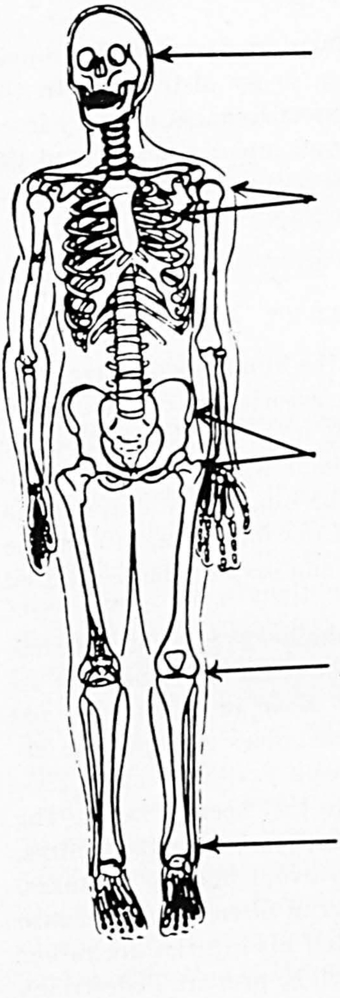


Figure 1. Sites of injury in pedestrians struck by motor vehicles.

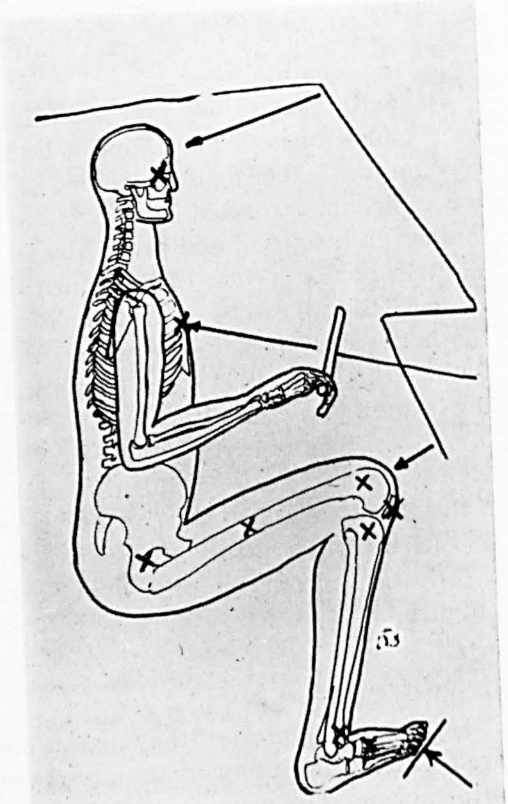


Figure 2. Sites of injury in unrestrained drivers of motor vehicles.

Injuries resulting from restraint. Gissane & Bull (1968) found that in 50 persons injured and 13 killed while wearing seat belts there was no case in which a correctly fitted and correctly adjusted belt of approved design had inflicted serious injury. Eastwood (1972) has recorded rupture of the breast by the oblique band of a two-band restrainer, but the price of effectual restraint is usually not more than a slightly sore chest or shoulder. On the other hand, there have been many instances of injury caused by lap belts that have crossed the belly instead of the pelvis (Friedman et al. 1969, Williams & Kirkpatrick 1971, Towne & Coe 1971).

It has been suggested that if the body is held firmly in place in a crash, the head and neck will be flexed with increased violence and consequently be more vulnerable than if the body could move forwards as well. It is certainly the case that the chin can strike the sternum with sufficient force to fracture it and even to rupture the underlying heart, but this requires the much greater violence of an aircraft crash (Mason 1973).

Injuries caused by deformation include decapitation and severance of limbs; instantly fatal crushing; and trapping, usually by the lower limbs, either by displacement of the dashboard or by displacement of the floor and pedals.

Inversion (supination) is the most frequent cause of injury in the foot, not because it is the most violent force to which the foot is subjected but because this is the movement most easily produced by ordinary variations of everyday forces. It causes such injuries as tearing of the lateral ligament of the ankle or avulsion of the base of the fifth metatarsal bone, but some of the most interesting, and severe, injuries can be regarded as being caused by impact upon the inverted foot. Figure 3 shows an injury of this type in which the foot was broken by violent inversion that destructively accentuated the longitudinal arches.

Among the effects of such violence are total dislocation of the talus; fracture of the neck of the talus with anterolateral displacement of the body of the bone; talocalcaneonavicular dislocation; and midtarsal fracture-subluxation in which the navicular swings with the distal bones into adduction round the head of the talus, against which it is pressed with such force that, as the bony surfaces in contact are reduced in area, they give way so that the two bones show mutual indentation (Figure 4). The signs of lateral distraction are often obvious in these injuries.

Figure 3 a.

Figure 3. This foot was trapped and crushed by deformation of the floor of the driver's compartment.

Eversion of the foot is a less frequent cause of injury and usually leads to tarsometatarsal disruption. Both the shape of the foot and its radiological appearance are characteristic (Figure 5) but the significance of these signs may not be recognized.

Occasionally the navicular and a greater or lesser part of the foot

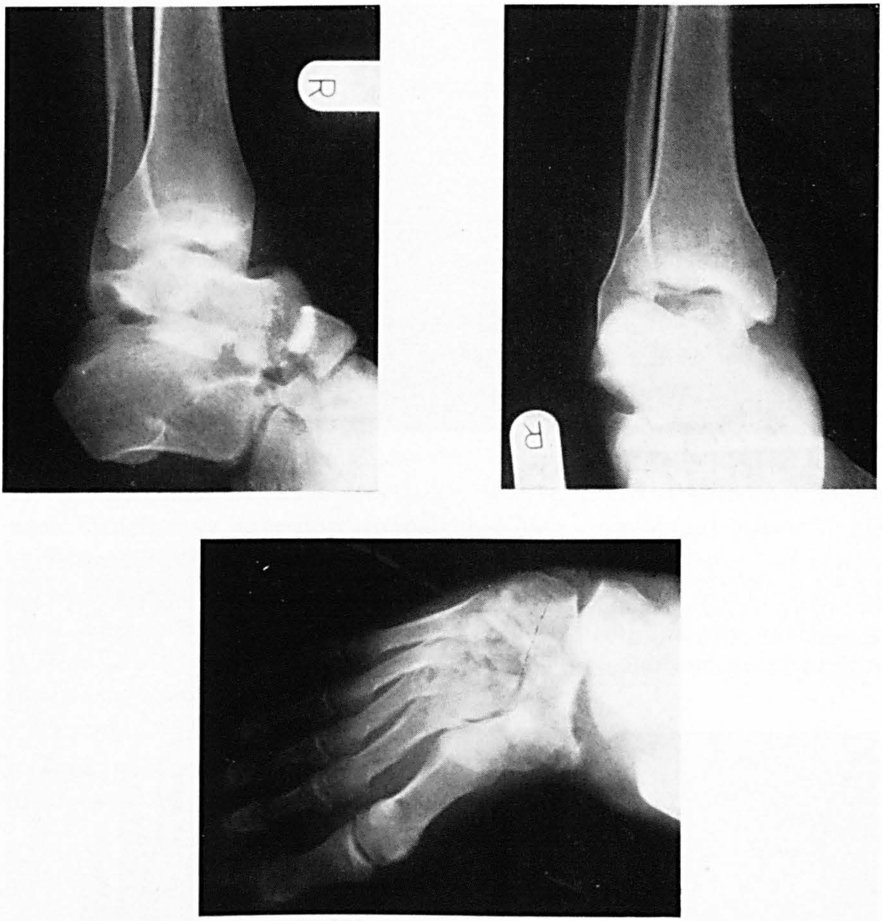


Figure 3 b.

are displaced dorsad or in a plantar direction from the talus, but these injuries are more likely to follow falls than road accidents.

The ankle. The apparent paradox that whereas the most frequent injury of the foot is by inversion the most frequent fracture of the ankle is the result of lateral rotation of the talus within the mortice is resolved by the phenomenon of torque conversion. In spite of its anatomical complexity the talocalcaneonavicular joint can be regarded as having a straight axis of movement that runs obliquely upwards and mediad. Thus, when the foot is inverted while the weight of the body is on it, the obliquity of the axis of movement results in an outward

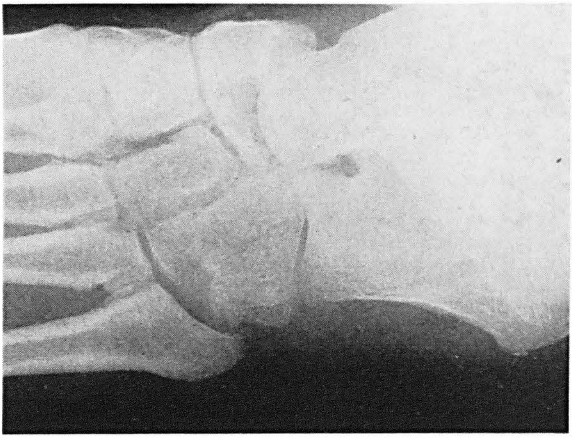
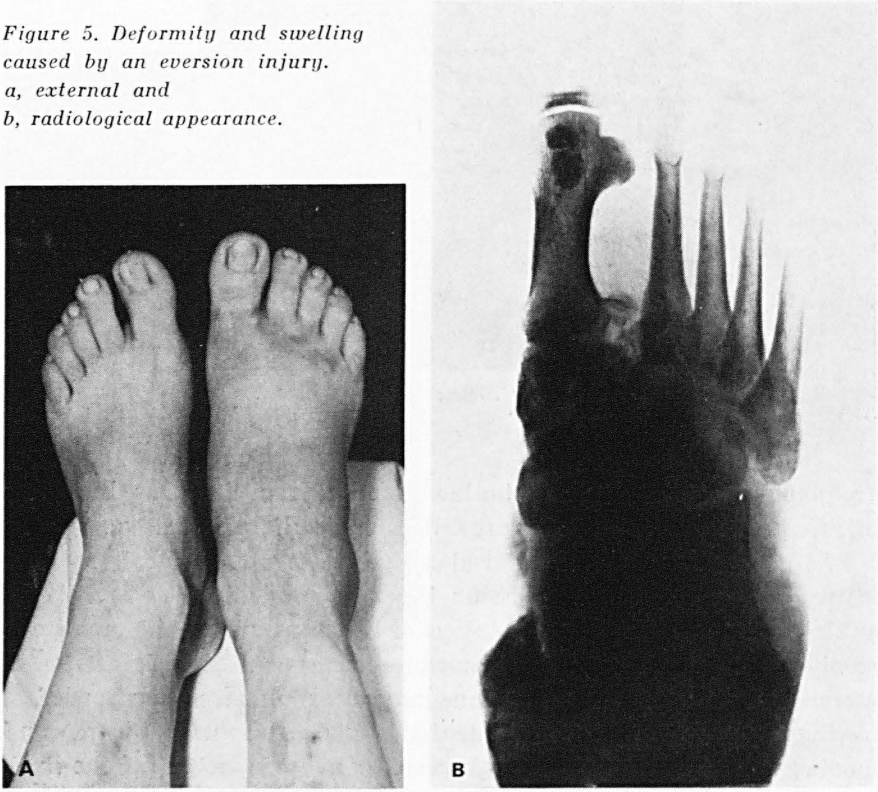


Figure 4. Mutual indentation of talus and the navicular bone.

Figure 5. Deformity and swelling caused by an eversion injury. a, external and b, radiological appearance.



counterthrust of the talus on the lateral malleolus. This phenomenon has been clearly described by Hicks (1953) and is implicit in classifications of fracture-subluxations of the ankle (Ashurst & Bromer 1922, Hansen 1942).

IMPACT ON A YIELDING STRUCTURE

The head

It is well known that a blow on the head is much more likely to cause commotio cerebri if the head is free to move than if it is fixed (Denny-Brown & Russell 1941, Holbourn 1943, Pudenz & Sheldon 1946, Gudjian & Lissner 1961) but it is perhaps less well known that a blow on the head can lead to serious injury of the neck with no more than a faint graze or bruise at the place of impact (Figure 6). This is usually on the face or forehead and is associated with hyperextension injury of the neck, which may have no demonstrable bony component and is liable to be unrecognized, particularly in an unconscious patient. It is necessary to bear this possibility in mind and to supplement careful radiological examination with a careful search for clinical evidence of damage to the spinal cord and nerve roots, which is more likely to occur in persons with cervical spondylosis.

The converse action occurs when impact on the rear of a motor car sets the body suddenly in forward motion relative to the head, but these injuries are usually more painful than serious.

Figure 6. The frontal graze resulting from a fall and accompanied by an extension fracture of the neck.

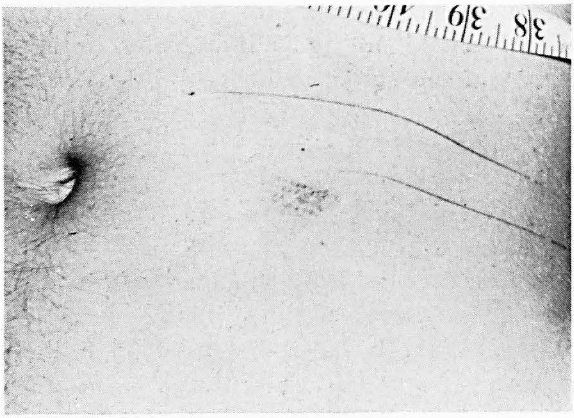


Figure 7. Bruising stamped onto the abdominal wall and accompanied by rupture of the spleen and haematoma of the mesocolon.

The soft tissues

Closed injuries. A blow on the belly wall when it is relaxed can drive it back against the spine, where the crushing effect can transect structures in the abdominal wall or within the abdominal cavity. In such cases there may be the tell-tale marks of bruising with the pattern of clothing (Figure 7). These marks have also been found on the neck as external evidence of rupture of the trachea. In other parts of the body a forcible blow can crush muscles and vessels against bone, destroying both. The injury may appear to be no more than a large bruise but if it is palpated firmly it will be found that the skin can be impressed until it comes up against bone (Figure 8).

Another result of impact on soft tissues occurs when a limb is run over by a rubber-tyred wheel. The crushing effect of the wheel tears the soft parts away from one another and may tear them from their attachment to bone; this disruption is aggravated by the fact that the tyre grips the skin and tears it from its deep attachments (Figure 9).

Open injuries. Paré was aware that alterations in posture after a penetrating injury could lead to the staggering of holes in different layers so that there was no longer direct access to anything embedded

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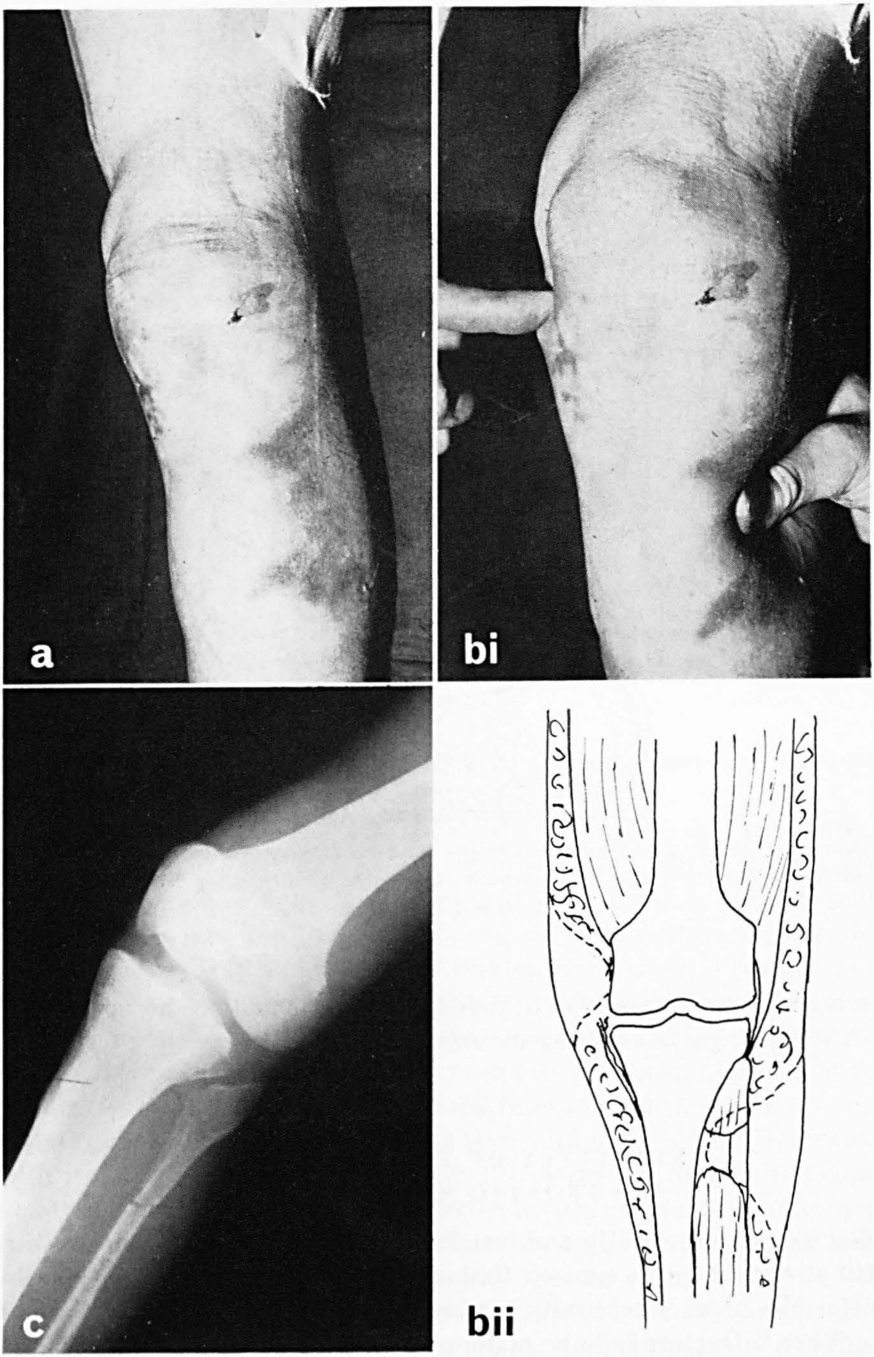
Figure 8 a. The external appearance of a leg had been struck by a motor vehicle. Figure 8 b. Rupture of the medial ligament of the knee and transection of the extensor muscles by crushing made it possible to indent the skin through the haematoma until the bare bone of the femur and of the tibia could be clearly felt.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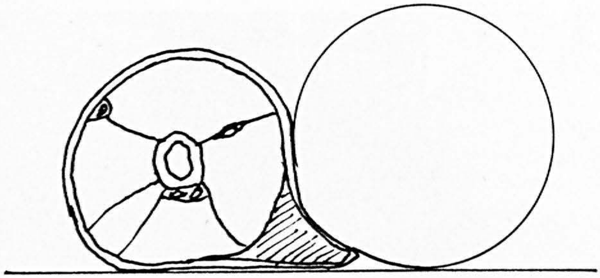

Figure 9 a. As the tyre reaches the skin it drags it from the deep fascia over much of the circumference of the limb.

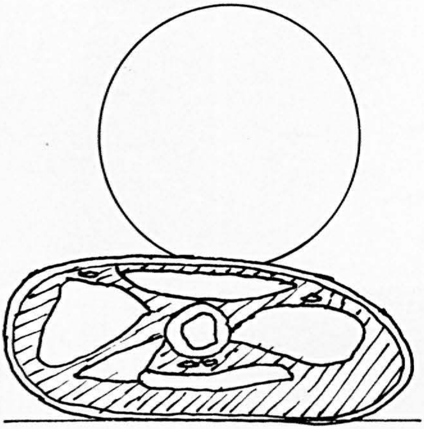

Figure 9 b. As the wheel passes over the limb all the connective tissue planes are torn open, leaving spaces that accommodate large quantities of blood if the skin does not split open.

in the wound (Figure 10) (Keynes 1951). This should be borne in mind when exploring penetrating wounds.

STABILITY OF FRACTURES AND DIAGNOSTIC MANIPULATION

The concept of stability and instability of fractures is well established but it should be recognized that a fracture may be stable either in deformity or after deformity has been corrected.

When a fracture is to be manipulated, what the manipulator should

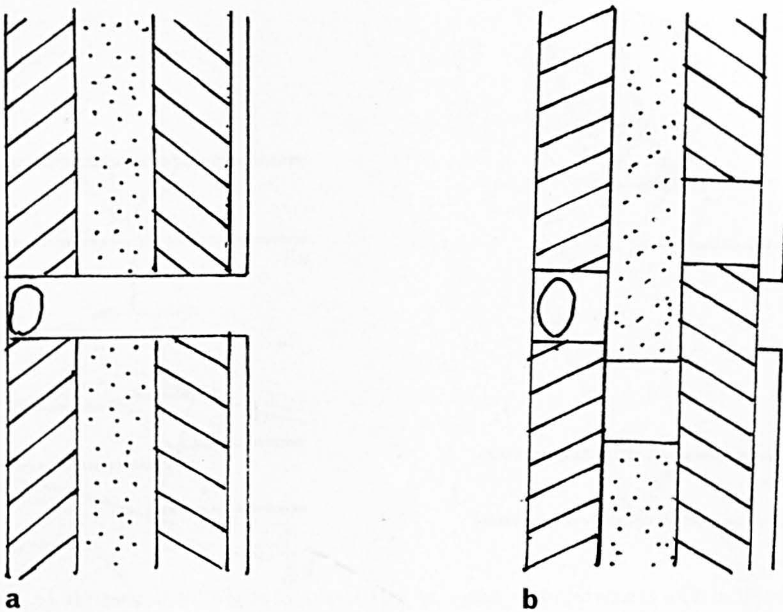

Figure 10. a. At the moment of injury the track of penetration is straight, but an alteration of posture can shift the layers of the injured part (b).

try to find out is not the best position that can be achieved but the best position that can be maintained by simple means.

Diagnostic manipulation will enable the surgeon to decide whether or not the fracture will be stable in an acceptable position without recourse to traction or to internal fixation. The first step is to try to pull the fragments into line and, having done so, to push them together to find out how easily they slip and overlap once more. Fracture 11a would resist shortening, whereas fracture 11b would not. Traction alone is not always enough, especially when the fracture is transverse and has become overlapped without losing its periosteal hinge. In such a case, the correct action is to bend the fracture and then to move the distal fragment until it comes edge to edge with the proximal fragment, with which it is then aligned (Figure 12). A further diagnostic manipulation will enable the surgeon to decide whether or not the end to end contact is adequate. The fragments are pushed firmly together and rocked to see how easily this movement can be brought about both backwards and forwards and from side to side (Figure 13).

Diagnostic manipulation will often enable the manipulator to decide

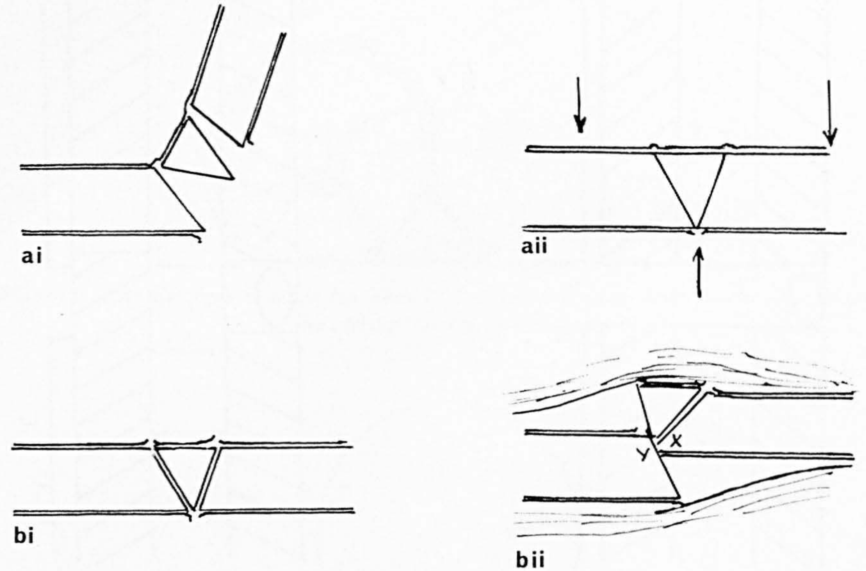

Figure 11 a. The fracture has a hinge of soft tissue that makes it possible to hold it accurately in place by using 3-point fixation, as shown by aii.
Figure 11 b. The hinge has been broken and the fracture will be stable only when displaced enough to tighten the more distant soft tissues or to engage point x in the marrow cavity at y.

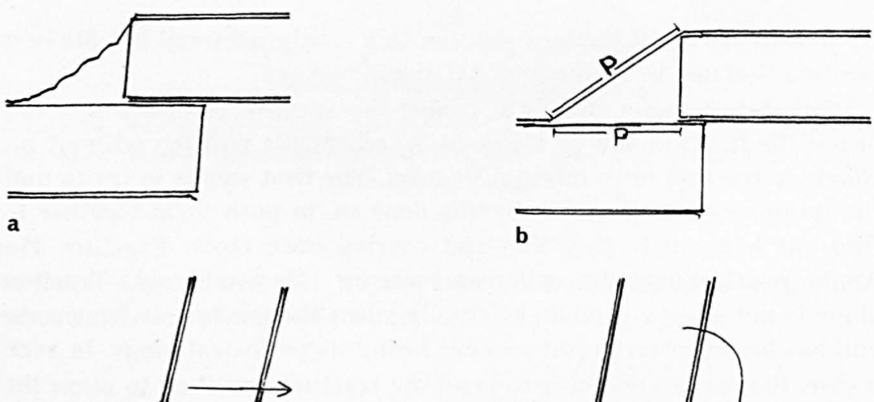

Figure 12 a, b. Traction alone will not bring end to end the fragments of a transverse fracture with a hinge.
Figure 12 c, d. The fracture has first to be bent to slacken the hinge.

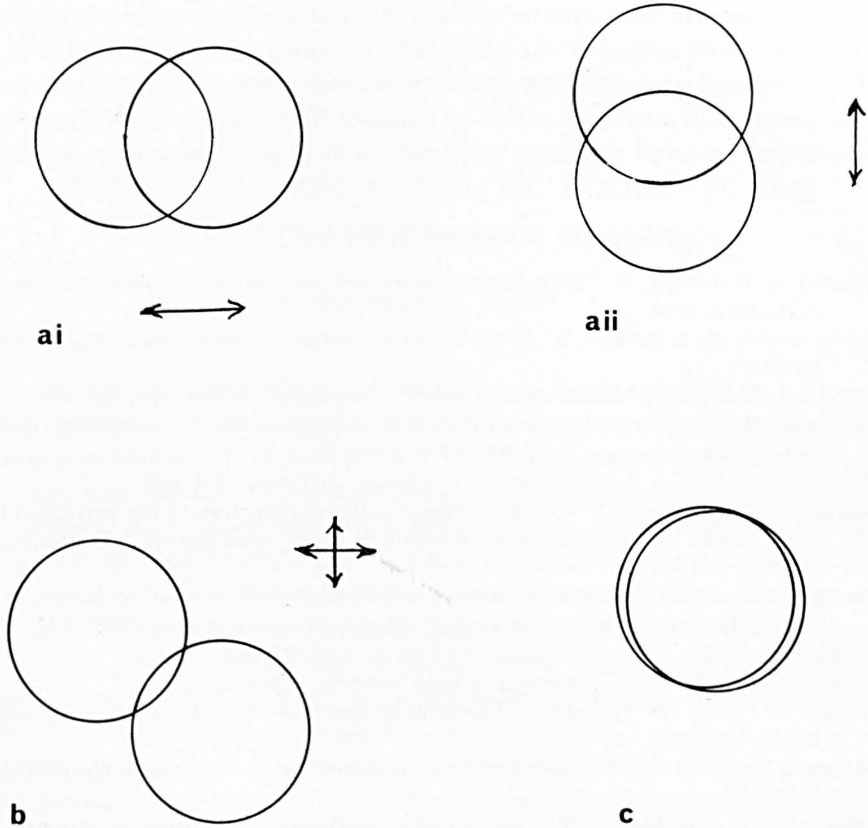

Figure 13. According to the areas in contact, transverse fractures can be recognized by feel as being easily rocked in one direction (a), both directions (b) or neither direction (c).

whether or not operation is needed and, if it is not, whether an acceptable degree of correction can be achieved. When it is combined with what x-rays show and what operating on a fracture reveals, diagnostic manipulation becomes increasingly informative and reliable as a guide to treatment. It also helps the experienced manipulator to cut down the amount of diagnostic radiography needed to guide him.

SUMMARY

Knowledge of the patterns of injury from road accidents helps to reduce the risk of diagnostic error through oversight.

Understanding the patterns of disruption of the body gives surgeons a better understanding of the nature of the injury and of the behaviour of the injured tissues. This is of particular value in the diagnostic manipulation of fractures to decide whether they need internal fixation or whether external splintage will keep them in an acceptable position.

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