THE PRINCIPLES AND OUTLINE OF FRACTURE TREATMENT

By the Fracture Committee of the American College of Surgeons

FOREWORD

THE Fracture Committee of the American College of Surgeons presents this publication to the medical profession trusting that it may be helpful in the treatment of fractures. The fracture lesion and the process of repair following a fracture are described.

The principles underlying the treatment of fractures are stated and a generally acceptable form of treatment for certain fractures is outlined.

No attempt has been made to describe operative procedures, the technique of skeletal traction or of local anesthesia in the treatment of fractures. Such descriptions may be found in appropriate publications.

The Committee recognizes that the emergency initial treatment of a fracture is often carried out by the general practitioner. The functional usefulness of the part injured is of primary importance. Delay in the treatment of a fracture may be followed by serious consequences. The treatment of difficult fractures requires the care of experienced surgeons.

PATHOLOGY OF THE FRACTURE LESION

The local lesion in fracture cases is of paramount importance in establishing the general principles of treatment. When bone is broken there is coincident tearing of bone and soft parts,—endostem and peristem,—with vascular and lymphatic ruptures and thromboses. There may be laceration and contusion of muscle, fascia and skin. There is death of bone, as well as of injured soft parts. The tissues are infiltrated by blood, lymph, and inflammatory exudate as well as transudate because of mechanical circulatory interference.

This infiltration of the tissues causes the swelling and pain of the part, and is increased by handling of the extremity and movement of the fragments of bone. It is of significance that the blood, lymph and inflammatory exudate rapidly clot, and that the two latter are even richer than blood in fibrinogen. Within forty-eight hours this extensive fibrin shows active organization by cell growth, and is replaced by organizing tissue.

The tissue of the soft parts and the bone that have been killed by the trauma are autolyzed by ferments furnished by the death of the cells, and tissue fluids in the region of the fracture are permeated by a calcium compound derived from autolyzed bone. There are some who hold that the source of calcium is the blood stream. This process is slow and occupies several days. The swelling and infiltration reach their maximum in eight to twelve hours, and then circulatory disturbance from pressure and thrombosis adds an actual edema to the picture. The clotting of blood and exudate leaves a residue of their fluid contents which gradually diffuse toward the surface. This residue is important because the more fluid, whether exudate or transudate, present at the site of fracture the less efficient is the organization of the fibrin. In addition to this common picture there may be associated injuries of contiguous muscles, nerves, vessels, joints, tendons and tendon sheaths, which must be considered as part of the lesion.

PROCESS OF NORMAL BONE REPAIR AFTER FRACTURE

The actual mechanism whereby calcium is deposited in the tissues to form bone is unknown, as is the chemical form in which that calcium exists. But the rest of the process is sufficiently
well established to give a definite idea of what happens. After the fracture lesion as previously described has appeared, the bone ends and the surrounding soft parts (soft parts of bone, and extra-skeletal tissue which has undergone laceration and is present at the fracture site) are bound together by the interlacing mesh of the fibrin from clotted blood, lymph, and inflammatory exudate always present at the site of fracture. There is a certain amount of edema. Within a few hours fibroblasts appear in this fibrin clot as the beginning of the formation of granulation tissue. The more fluid element present, the less effective and rapid is the cell proliferation. Within forty-eight hours this organization has proceeded to a considerable degree.

The growing tissue is infiltrated with the calcium derived from autolysed dead bone either in solution or in colloid state. The cells forming this tissue are derived from the soft parts of the bone—endosteum, marrow reticulum and periosteum—from the soft parts around the site of fracture, and from the lymphocytes infiltrating the part as a result of the inflammatory reaction. Within seventy-two to ninety-six hours this mass of cells, while loose meshed and friable, becomes an organized tissue uniting the ends of the bone and the adjacent soft parts. Unless there exists such mechanical obstruction as interposition of tissue, all fractures heal in this manner. This is the manner in which the healing process occurs for any wound wherever situated.

Calcium is then deposited in this newly formed living tissue, which then constitutes early callus formation. The deposition of calcium has been observed as early as seventy-two hours in sections removed from actual fractures. The calcium is apparently derived, for the greater part, from the calcium freed by autolysis of dead bone, and not from the blood calcium. The process then goes on to progressively denser concentration of deposited calcium until the callus becomes hard bone. With use and the action of normal stress and strain over a period of months this bone arranges its lines and channels to form the normal histological picture of bone. It frequently takes a year or more for the completion of this process.

In the meantime the organization of granulation tissue proceeds in the fibrin mesh throughout the affected soft parts, and becomes organized tissue within a week. The effectiveness and rapidity of growth of tissue is dependent upon efficient circulation in the parts from which the cells are derived, and, as stated above, is retarded and limited by excessive fluid exudate at the site of fracture. Healing by granulation tissue takes place in all fractures except where mechanical obstruction exists between the fragments. The slow deposition of calcium in the tissue produces so-called delayed union, whereas its absence produces so-called non-union. Delayed and non-union are more apt to occur in certain bones and certain portions of those bones even when all other factors are equal. Certain sites of fracture in some bones are therefore characterized by a prolonged “healing time” as the usual and expected result. Therefore, in addition to the other factors cited, the time needed for sufficient ossification of the healing process to allow function depends on what the function of the part calls for in the way of solidity.

**General Principles of Treatment**

*First Aid*—When a bone is broken the adjacent soft parts are usually injured as well. Often the displacement of fragments and additional injury to the soft parts are caused by the subsequent handling of the injured part or increased by it. Therefore first aid treatment should include:

(a) Application of some form of protection before the patient is moved. “Splint ’em where they lie.”

(b) Avoidance of all unnecessary manipulations.

(c) Transportation with extreme care and gentleness. In fractures of the upper extremity the hinged splint (Thomas-Murray) (Fig. 1) is an adequate and comfortable splint for protection and transportation. In fractures of the lower extremity the Thomas splint (see Figs. 2, 3) may be used for protection and transportation. Slight traction (Fig. 4) may be used in transportation.

(d) Prevention and treatment of shock.

*Examination*—After the patient has been transported to the place where suitable treatment can be instituted, as complete and thorough an examination as possible should be made without causing additional injury.

(a) Begin with painless procedures, such as:

1. Inspection, which will reveal swelling, ecchymosis and deformity.

2. Palpation, which will reveal a local point of tenderness by both direct and indirect methods. A false point of motion should be searched for with extreme gentleness. Irregularity of bony contour should be noted. Crepitus which is caused by the broken ends rubbing against each other,
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Fig. 1. Thomas-Murray hinged splint, for upper extremity fractures. Note slings to arm, traction on forearm, elbow extended. Whole upper extremity at side of body. Injured arm ready for transportation, guarded and protected.

should be searched for only when absolutely essential. Movement to elicit crepitus will cause additional injury.

3. Comparative measurements of the injured and uninjured extremities.

4. Roentgen-ray examination should be made as early as possible and its result be studied in detail.

(b) Search for additional injuries, especially those of nerves.

Diagnosis—The simple diagnosis that a fracture exists is not sufficient. All details of the condition of the patient, of the bone and of the soft parts should be considered. The lesions frequently are multiple and a knowledge of all the local conditions is essential in order that the problem of obtaining and maintaining reduction of any displacement may be thoroughly visualized.

Treatment—Each fracture should be considered as an individual problem and the treatment directed not only to the injury of the bone but to that of the soft parts as well.

(a) Success in the reduction of displacements depends upon observance of the following principles:

1. Since the reactions of the injured tissues to the trauma begin very soon after the injury and since these reactions interfere with the ease and perfection of reduction, and so greatly influence the process of repair and the end result, reduction of any displacement should be made as soon after the injury as possible, without waiting for the roentgen-ray examination if it is not immediately available.

2. Reduction should be made as gently as possible.

3. Reduction should be as complete as the case requires. Restoration of the normal axis and overcoming shortening and rotation may be quite satisfactory in the shaft of a long bone. In fractures into joints the articular surfaces should be restored as nearly as possible to normal.

4. Fluoroscopic control of reduction is sometimes very useful.

5. Reduction should be checked by roentgen-ray examination as soon as practicable.

6. Reduction should be carried out under an anaesthetic with but few exceptions.

7. Further attempts at reduction should be made as soon as the need is recognized.

8. The method of reduction is important and may be by:

(a) Manipulation

(b) Traction by

(1) Gravity.

(2) Manual pull.

(3) Block and pulley.

(4) Weight attached to limb.

(c) Open operation.

Usually the reduction of displaced fragments will require a combination of traction and manipulation. The purpose should be first to disengage the fragments and then gently to restore them
to their normal relationship. In order to carry out such procedures with as little additional injury as possible, each case should be handled according to its actual deformity which has been determined by examination rather than according to any routine procedure. The roentgen films should be in sight while reduction is being effected.

(b) Maintenance of reduction, or immobilization, is necessary. If there is no displacement of the fragments of bone or if displacement has been overcome, correct position of the fragments must be maintained. The method to be employed should be selected according to the peculiar needs of each case and the proper appliances should be assembled before reduction is attempted. Such immobilization serves to hold the fragments in place until union has occurred and provides the rest that is so essential to any injured tissue.

1. Reduction can be maintained by:
   (a) Position—as by flexion of the elbow for certain fractures near that joint;
   (b) Splints and other external appliances;
   (c) Traction and suspension;
   (d) Internal appliances such as plates, screws, bands, etc.

   The inherent value of any apparatus is of less importance than the skill with which it is used. The surgeon should prevent localized pressure, especially over bony prominences and avoid constricting bandages. It should be remembered that most bandages will shrink and that the injured extremity will swell. The correctness of the position of the fragments should be confirmed by roentgen-ray examination after the apparatus is applied and after the patient has recovered from anesthesia and muscle tone has returned. Plaster-of-Paris must be kept dry until ready for use, or it will crumble and the plaster splints will break or soften. To immobilize a broken bone the contiguous joints must be immobilized. For a description of apparatus for traction and suspension, see page 28.

2. In the selection and employment of the method of immobilization to be used and in reaching a decision as to its duration, the physician should bear in mind the factors which influence repair and be guided by them. These factors are:
   (a) The condition of the circulation of the affected part. It may be interfered with by the original or subsequent injury, by the position of the adjacent joints (as by too great flexion), by constriction of bandages, by gravity when the extremity is allowed to be dependent, by pressure from displaced fragments of bone or by internal pressure caused by excessive hemorrhage;
   (b) The age of the patient. Repair is much more rapid in infancy than in later years. The compensatory changes which tend to obliterate angular deformity are great in infants and less in adults;
The character and extent of the injury to the bone;
(d) The amount of permanent displacement of fragments;
(e) The amount of stripping of the periosteum from the bone;
(f) The character of the bone. Repair in cancellous bone is far more rapid than in cortical bone;
(g) The degree of immobilization;
(h) The coexistence of infection which interferes with bone formation;
(i) The general condition of the patient;
(j) The presence of a foreign body which interferes with formation of bone in immediate points of contact of it with the bone.

(c) Treatment of the soft parts.
Much of the treatment required to protect the injured bone may be injurious to the soft parts. Too active treatment of the soft parts may disturb the position of bone fragments. Therefore careful judgment is required in order to accomplish the greatest good with the least harm. Prolonged inactivity after injury may result in atrophy of muscles, limitation of movements of joint and tendon, impairment of circulation and hence delay in bone repair.

The most important method of regaining function is by active movements. At first it will often be necessary to guide and assist such movements. Massage, heat and electricity may be of help if carefully and gently employed, while if roughly applied they may be harmful. Of the different forms of massage one must differentiate between gentle stroking without deep pressure, stroking with deep pressure, and kneading. Nothing but the first form should be permitted in the affected region until union has well started. These various aids should be applied as soon as the danger of additional injury or of displacement of fragments has passed. They may cause slight discomfort but should never cause pain. The pain of more active measures indicates harmful stretching or tearing of soft parts, often with hemorrhage, which will require additional repair. In the early stages of repair massage and movements should be carried out only by the physician; otherwise they are better omitted until union is well established.

(d) Operative treatment is indicated when a satisfactory reduction cannot be obtained and maintained by nonoperative methods, provided there is no contra-indication, and when the expected result of the open method
is sufficiently better than that of the closed to justify the additional risk.

Furthermore, it is generally recognized and accepted that it is impossible to obtain satisfactory restitution except by operative methods in certain types of fractures. The operative method is recommended to those surgeons who have had special training and experience, who have the necessary skill and judgment, and who have the hospital facilities and surgical armamentarium with which to do this work properly. In the case of those who do not have such facilities, operation is not advised.

(e) Treatment of compound fractures. In all compound fractures the use of tetanus antitoxin should be seriously considered.

In the case of compound fractures with small wounds in which it is evident that the wound of the soft parts is made by the protrusion of bone from within outward through the skin they must be regarded as potentially infected. These wounds should have a thorough preparation of the skin by washing with benzoin, shaving in a direction away from the wound, drying with ether and the application of tincture of iodin to the skin, followed by the application of sterile dressings. If it is not possible to carry out the foregoing cleansing treatment, the wound may be covered by a sterile gauze pad and the patient be transported to a hospital.

When a roentgen-ray examination is to be made before reduction, all the steps enumerated above, except reduction, are to be completed before the roentgen-ray is taken.

In the case of extensive compound fractures with a large wound:
1. A tourniquet should be applied only when it is obvious that some large vessel has been lacerated.
2. The wound should be carefully protected from contamination by a sterile gauze pad while the skin is being cleansed, following the foregoing routine. If this procedure can be undertaken without too much pain and shock to the patient, it should be carried out before he is sent to the roentgen-ray department; if this is not possible, tincture of iodin should be applied only to the edges of the wound, and a large sterile dressing applied before roentgen-ray examination. The procedure may be completed when the patient is anesthetized.

3. The operative procedure consists of:
   (a) Excision of, at least, 0.5 cm. of skin from the edges of the wound;
   (b) Excision en bloc of traumatized and infected tissues;
   (c) Thorough exposure of the wound by generous incisions;
   (d) Excision of dead and dying fat, fascia and muscle with sharp instruments until fresh bleeding occurs;
   (e) Removal of small fragments of bone that are unattached to periosteum and of soiled bone surfaces by a rongeur;
   (f) Careful evacuation of a haematoma which is dissecting between muscle planes;
   (g) Frequent changes of gloves and instruments to insure against carrying infection into the deep parts of the wound;
   (h) Irrigation of the wound with salt solution to wash out particles of dirt, if necessary;

4. The final dressing of the wound varies according to indication. It may consist of:
   (a) Incomplete closure after lavage with an antiseptic solution;
   (b) Incomplete closure, as above, but with dependent drainage; or
   (c) Application of Carrel tubes for the immediate use of 0.5 per cent solution of sodium hypochlorite.