WOUND AND FRACTURE

WOUND

A wound is a lesion caused by mechanical force on soft tissue, which is characterized by where there is a solution of continuity or tissue breakage.

Cellular and tissue lesions are irreversible in the wound since necrosis is produced. Necrosis characteristic of tissue breakage is limited to the surface area surrounding the closed wound.

An important factor conditioning how the wound evolves is the degree of the contusion suffered by the wounded tissue. The mechanical energy that produced the wound gradually spreads through the tissue and could cause:

- First-degree contusion. This is a reversible injury.

- Second-degree contusion. The evolution of this lesion could be reversible or irreversible. In this last case, necrosis could develop.

- Third-degree contusion. This is an irreversible lesion since the injury causes cell death by necrosis and the tissue suffers from infarction (Figure 1).

When the wound is surrounded by necrotic tissue, repair is difficult or hindered and therefore, the necrotic tissue must be removed. The removal of devitalized soft tissue is called debridement.

The frequent association of wounds with contusions in traumatized tissues leads to mixed lesions of evolutive nature.

The injury with breakage in the soft tissue might be external, i.e. skin and mucous membrane, or internal i.e. muscle tissue. External lesions break the epithelial barrier of the body, thus creating an open wound. Internal lesions are referred to as "closed" lesions.

In general, the breakage suffered by tissue affects its parenchyme (cells that necrose) and its stroma (lesion of the extracellular matrix, blood and

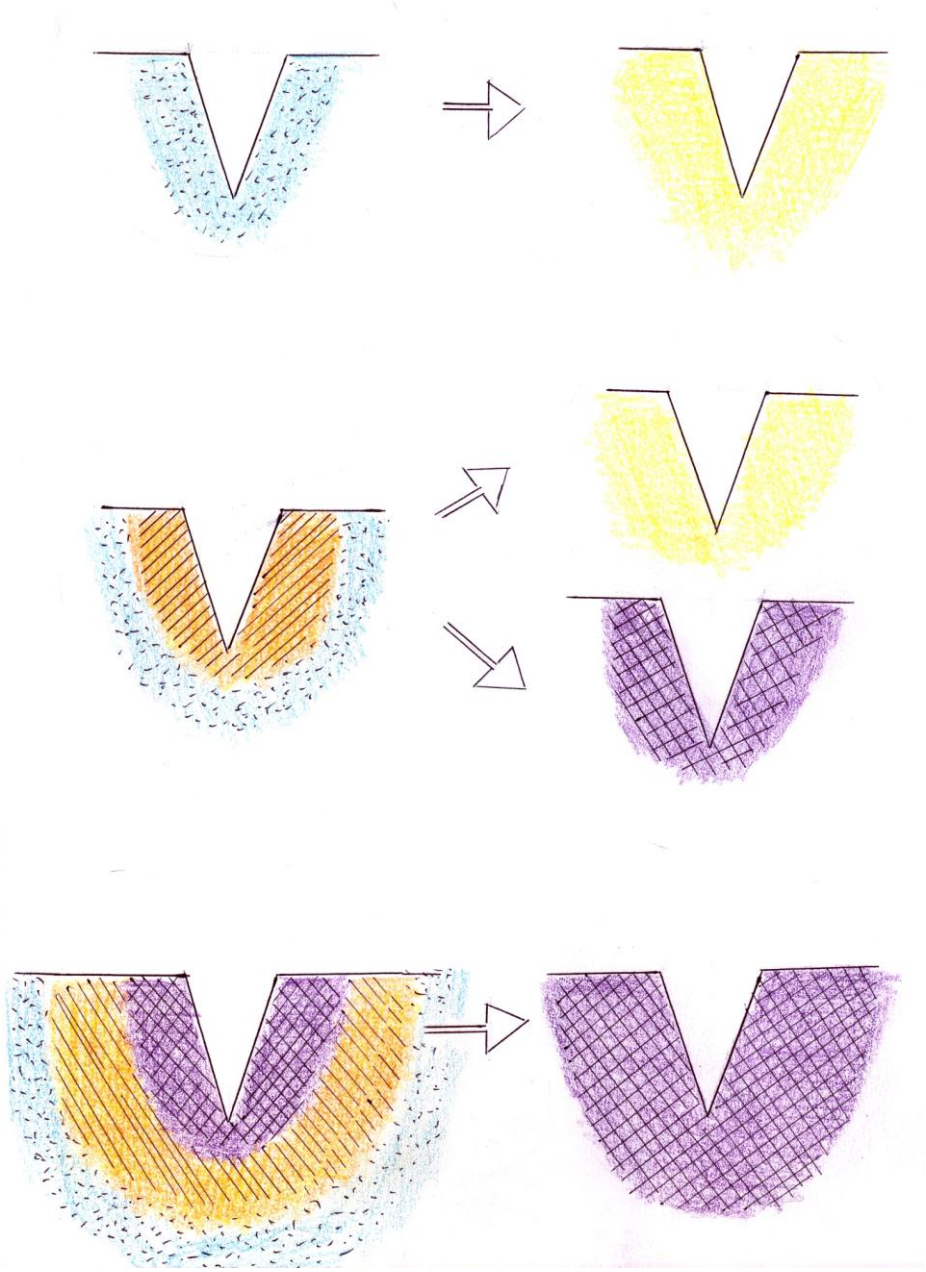

Figure 1. Schematic representation of wound evolution according to the degree of contusion of the surrounding tissue.

If the tissue suffers a first-degree contusion, the lesion is reversible and the wound will be surrounded by normal or vital tissue (top). If the tissue where the wound is located presents a second-degree contusion, it can evolve favorably if the contusive lesion is reversible. On the contrary, the evolution will be unfavorable and necrosis will be produced around the wound. In wounds with a third-degree contusion, debridement is required (bottom).

lymphatic vessels and nerves. Therefore, what a wound presents is quickly explained:

- Pain

- Hemorrhage

- Discrete lymphorrage

- Inflammatory response. Mainly triggered by necrosis.

* From the **microbiological** point of view, wounds can be classified as:

- *Clean wound*. Wounds caused in a sterile environment. For example, those produced by a surgeon in the operating room.

- *Wound contamination*. Bacteria are present in the wound without any host reaction.

- *Wound colonization*. Wounds with signs of bacterial multiplication but not host reaction.

- *Wound critical colonization*. Multiplication of bacteria causing delayed wound healing and pain.

- *Wound infection*. With deposition and multiplication of bacteria causing an associated host reaction.

The commonest pathogens are *Staphylococci* (*S.aureus*), *β-haemolitic streptococci* (*S.pyogenes*) and *Pseudomonas aeruginosa*.

Location

The location of a wound begins by defining the anatomical region affected with the greatest precision possible and then checking the depth of the open lesions.

- *Superficial wound*. It affects the skin, skin cell tissue, mucous membrane and submucous layer.

- *Deep wound*. It affects the aponeurosis and therefore there is a risk of muscle, vessel and nerve lesions.

- *Penetrating wound*. If a mesothelial barrier is ruptured, then so are the aracnoid, pleura, pericardium, peritoneum, vaginal, testicular and synovial membranes,these wounds penetrate the natural cavities of the body.

- *Puncture wound*. It's a kind of penetrating wound, although more serious since it harms organs.

Etiopathogeny

The producing mechanism of a wound is related to the characteristics of the etiological agent (Figure 2).

- *Incision wounds*. They are produced by sharp instruments, like a scalpel, penknife and knife. The edges are smooth with a minimal contusive component. They are called simple wounds. Simple wounds involve skin and soft tissues without damage to underlying bone or joint or neurovascular structures. They are not heavily contaminated and do not have significant skin or soft tissue loss.

- *Stab or puncture wounds*. They are wounds produced by sharp instruments, namely, objects with a sharp tip, such as stylets. Even though they produce a small external opening, they usually cause serious lesions. The wounds are usually deep, penetrating and piercing. Cat bites are also deep puncture wounds. The risk of infection after cat bites ranges from 28 to 80%. Plantar puncture wounds can also present cellulite (2 to10%) and less frequently with osteomyelitis, chondritis and septic arthritis.

- *Contusive wounds*. They are produced by pressure, traction or shearing and induce a second and/or third-degree contusion in the surrounding tissue. These are called complex wounds, with irregular edges and often are heavily contaminated.

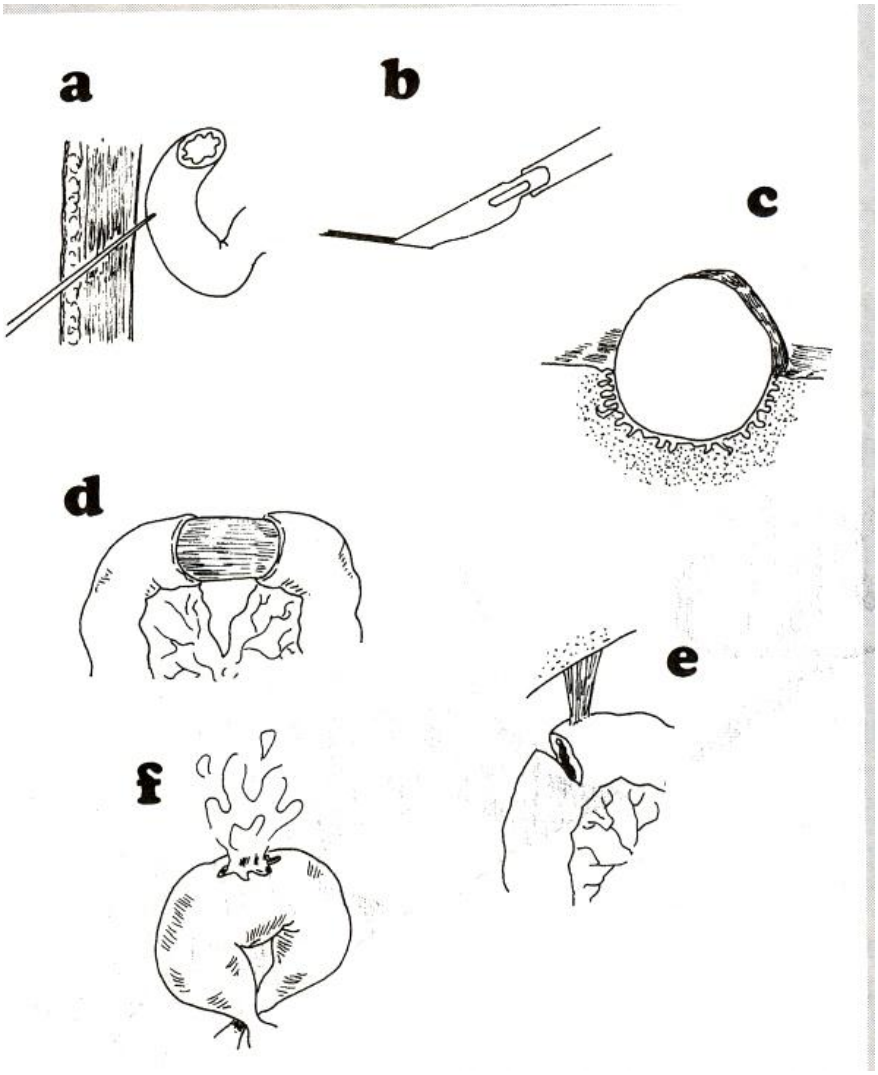

Figure 2. Wound types *A: Stab or puncture wounds. B: Incision wound; c: Contusive wound by crushing . d and e: Tear wound or laceration; f: Rupture wound.*

Wounds caused by fire arms, crushing, bull horns, dog and human bites, avulsion and tear or laceration are considered contusive wounds. Human bites, which are sustained over the metacarpo-phalangeal joints or “clenched-fist bites”, occur as a result of a person punching another person in the mouth and hitting a tooth. The tooth may lacerate the extensor tendon and joint capsule in the hand, inoculating the joint with saliva. These bites are especially prone to infection and generally require consultation with a specialist. Abrasions and deep abrasions are also considered contusive wounds. Abrasions are limited to the superficial dermis whereas deep abrasions extend below the dermis, especially if they involve underlying structures.

This classic division of wounds into cuts and incisions and contusive wounds is highly valued in teaching and practice. (Figure 2).

Lastly, in terms of surgical wounds *"dieresis"* is synonym to incision and *"exeresis"* means surgical separation of a body part, either naturally or accidentally, and is therefore synonym to excision.

Wound production

Wounds are produced by a direct or indirect mechanism:

Wounds produced by a *direct mechanism* are those produced in the place where the mechanical force agent directly impacts the body.

Wounds produced by an *indirect mechanism* are produced at a distance from the place impacted by the etiological agent. In these cases, the mechanical energy is transmitted, and reaches the tissues or organs that are more vulnerable than those impacted by direct mechanical force. Tears and organ ruptures can be produced by indirect mechanisms. Lesions caused at a distance require general physical exams of the trauma.

Wound shape and direction

The shape of wounds on the tissue and organ surface is diverse. In particular, the most frequent shapes found on the skin and mucous membrane are: pointed, linear, arched, angular, flap or pedunculated, stellate, crateriform and irregular, meaning no determined shape. Wounds with skin flaps found on the head are scalp wounds (Figure 3).

A factor that influences skin wounds are the Langer tension lines, which are determined by the orientation of the elastic skin fibers and whose direction varies according to the area in question. In wounds parallel to the Langer tension lines, the separation between edges is minimal, whereas the edge separation in wounds perpendicular to these tension lines is greater (Figure 4).

Wound direction with regard to the main axis of the region where the wound is located is either: longitudinal, transverse, oblique and spiral (Figure 3).

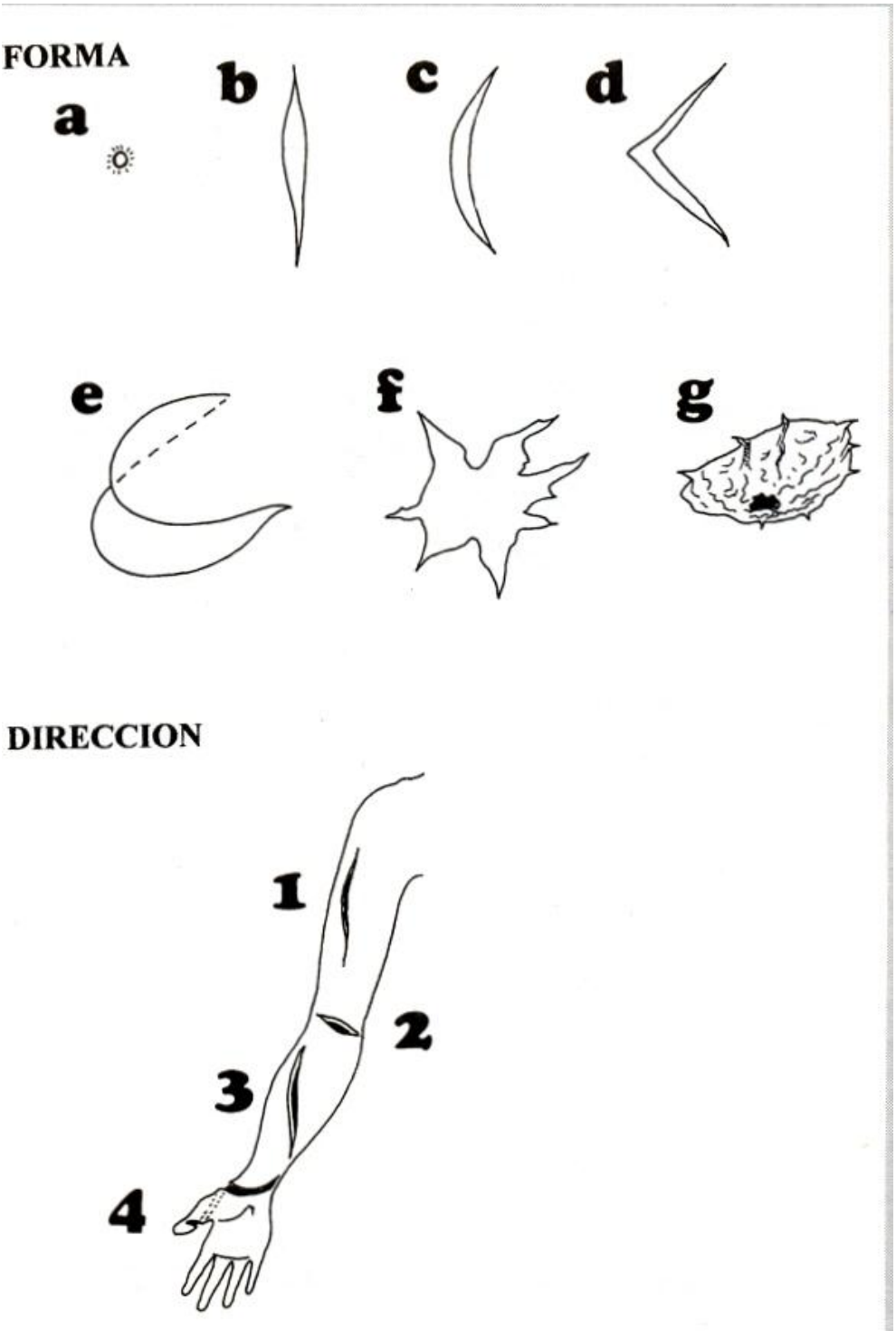

Figure 3. Shape and direction of wounds. *Shape: a – pointed; b – linear; c – arched d – angular; e – flap or pedinculated; f – stellate; g – crateriform. Direction: 1 – Longitudinal; 2 – Transversal; 3 – Oblique; 4 – Spiral.*

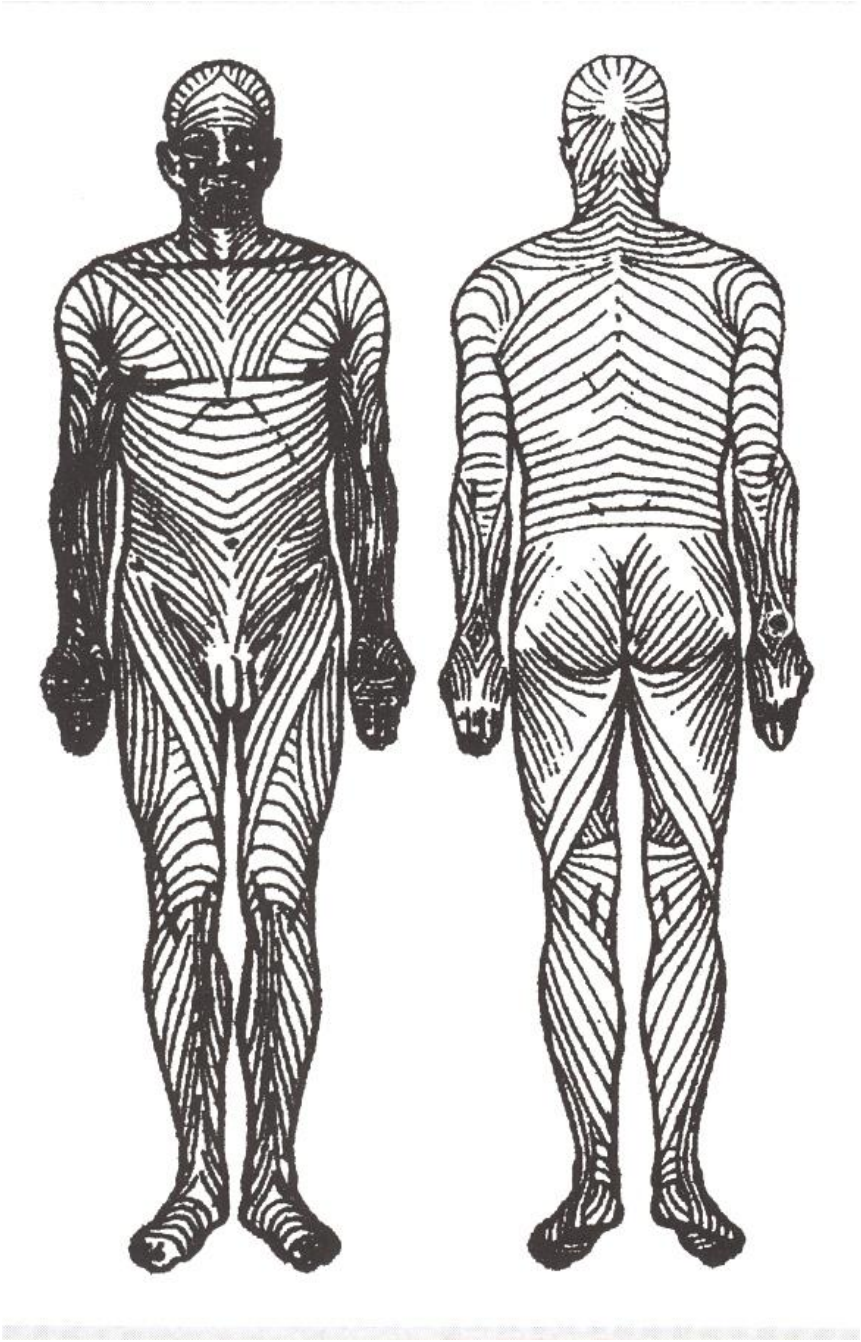

Figure 4. Langer tension lines

Types of wound treatment

The primary goal in the management of wounds is to achieve rapid healing with optimal functional and aesthetic results.

All wounds should be thoroughly cleaned with tap water or normal saline to eliminate any foreign residue. Necrotic tissue should be resected and a small hemostasis performed.

There are three types of wound closures:

- *Primary apposition or healing by first intention*, occurs when a wound is closed within 12 to 24 hours after it is produced. It occurs in clean, fresh wounds in well-vascularized areas i.e. clean surgical incisions and clean laceration. The wound may be treated with irrigation and debridement and the tissue edges are approximated directly (anatomic reconstruction) using sutures, tapes, tissue glue or a mechanical device (Table 1).

TABLE 1. First intention treatment phases of a wound.

1. Cleaned with saline
2. Debridement
3. Hemostasis
4. Reduction or anatomical reconstruction by approximation of edges.
5. Fixation. Sutures, tapes**,** tissue glue or mechanical device.

- *Secondary healing or healing by second intention*. This is used in wounds with extensive loss of soft tissue, when approximating the wound edges is difficult or a wound is too heavily contaminated. This method of healing relies on growing granulation tissue from the wound margins and deep tissue, followed by fibrosis, wound contraction and re-epithelization.

- *Tertiary healing or delayed primary healing*. This type of wound closure is performed when the contaminated or poorly delineated wound appears clean and well-vascularized, after 4 to 5 days of observation.

The choice of dressing depends on the cause, size, depth, location, degree of exudation, and level of contamination of the wound, as well as on cost. However, a moist environment accelerates healing by preventing cellular dehydration and stimulating wound repair. Occlusive dressings reduce pain, the loss of fluid through evaporation and the risk of infection, and may speed healing, although they are more expensive than topical antimicrobial agents and gauze dressings.

Abrasions limited to the superficial dermis should be treated with a topical antibiotic or an occlusive dressing. Skin tears without tissue loss, must be treated by approximating wound edges with surgical tapes and non-adherent dressing. Skin tears with partial or complete tissue loss can be managed with an absorbent dressing (hydrocolloids, hydrogels, foams or silicone-coated dressings) and are covered with a secondary absorbent gauze dressing that can be changed daily as needed. Elastic tubular nets should be used to support the underlying dressings.

The use of prophylactic systemic antibiotics in traumatic wound remains controversial, and they should not be used routinely.

Tetanus contamination is more likely in wounds contaminated with soil or manure, and in deep wounds containing devitalized tissue, especially muscle. The patient's tetanus-immunization status should be ascertained, and standard recommendations followed to ensure that the patient is protected against tetanus.

FRACTURE

A fracture is a lesion produced by mechanical force on the hard or mineralized tissues such as bone, which are characterized by whether there is a solution of continuity or tissue breakage (there is a break in the continuity of the bone).

Cellular and tissue lesions are irreversible in the fracture since necrosis is produced. The bone fracture can be produced by a high force mechanical

impact or mechanical stress (traumatic fracture) or by a banal mechanical injury, resulting from certain diseases that weaken the bone, such as osteogenesis imperfecta, osteoporosis, infection or bone cancer, in which the fracture is termed a pathologic fracture. Lastly, stress fractures are common injures that begin with repetitive and excessive stress of the bone. This leads to the acceleration of normal bone remodeling, the production of microfractures, caused by insufficient time for the bone to repair, the creation of a bone stress injury and, eventually a stress fracture.

The degree of contusion suffered by the bone tissue limiting the bone fracture conditions its evolution. A first-degree contusion is produced after a transverse fracture, and is reversible. A second-degree contusion may be associated with a multiple fracture. It could be reversible or irreversible, with necrosis of bone fragments. Lastly, third-degree contusions may be accompanied by a comminuted fracture; i.e. a fracture in which the bone has broken into a number of pieces (Figure 5).

Fractures can be also classified according to:

* *Fracture pattern* (Figure 6) simple, transverse, oblique, spiral, segmental or multifragmentary, which usually corresponds to the mechanical force causing the fracture.

The relative amounts of cortical and the inner cancellous bone determine how bones fail, i.e. femur diaphysis with thick cortex and little inner cancellous bone could have a transverse, spiral or oblique fracture pattern, and the calcaneum, which is mainly cancellous bone with very little cortex, could suffer a crush or compression fracture.

A child’s bone is more elastic and plastic, allowing it to deform a lot before breaking and generate different fracture patterns compared to those of an adult. The periostIum is thicker, stronger and fibrous and therefore can impart some stability to the fracture, as well as preserve the vascular supply necessary for rapid repair.

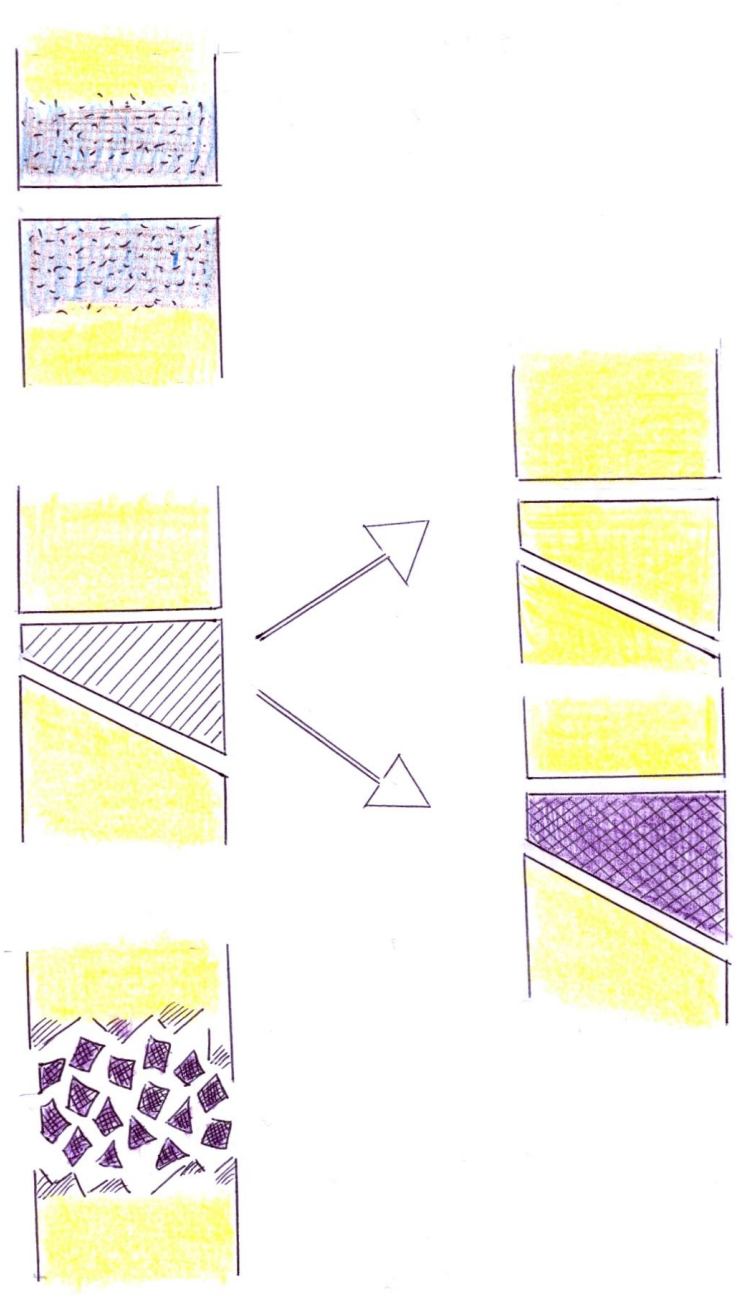

Figure 5. Contusion component in fractures*. a – Simple fracture associated with a first-degree contusion. b – Simple fracture associated with a second-degree contusion that could lead to necrosis of intermediate fragment. c – Comminuted fracture associated with a third-degree contusion.*

Other types of fractures are: Complete, i.e. in which bone fragments separate completely; and incomplete, i.e. in which the bone fragments are still partially joined.

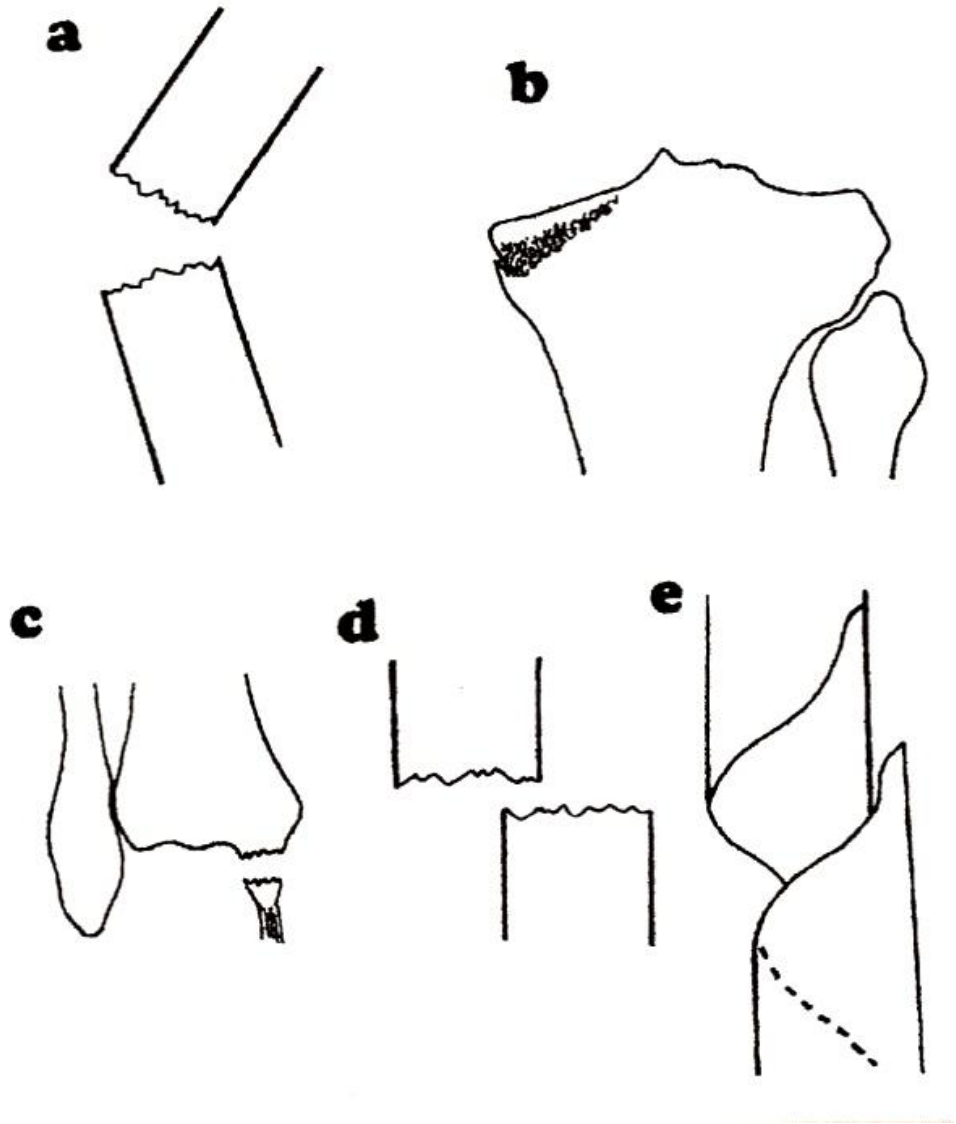

Figure 6. Schematic representation of fractures,. *a) by inflection; b) by compression; c) by traction; d) by shearing and e) by twisting*

All fractures can be broadly described as:

* *Closed or simple fractures* in which the skin is intact, and

* *Open or compound fractures*, in which a soft tissue wound communicates with an underling fracture. The invasion of microorganisms that colonize and infect the fracture is produced. Any fracture with a wound overlying the same limb compartment must be considered open, until proven otherwise. Complex open fractures, characterized by extensive damage to soft tissues, including muscles,

skin and neurovascular structures and a high degree of contamination, require a combined orthopedic and plastic surgical treatment and must be immediately referred to a specialist center.

Types of fracture treatment

The primary goal in the management of fractures is to achieve rapid healing with optimal functional and aesthetic results.

Healing of a fracture depends on the blood supply to the bone, the amount of force that produced the fracture and the condition of the soft tissues. In general, the greater the damage to bone and surrounding soft tissues, the slower the bone is to heal.

* *Primary healing* can be achieved through surgery with anatomical reduction of the fracture and internal fixation to obtain absolute stability at the fracture site and to generate very low interfragmentary strain. Revascularization occurs, with internal bone remodeling and bone forms directly with no callus formation.

* *Secondary healing*. This occurs in an environment of relative stability, with some interfragmentary motion under functional loading. The majority of fractures heal by secondary healing with hematoma formation and then inflammation with callus formation and remodeling. In children, remodeling is usually very effective. Even completely displaced fractures may heal and remodel without trace.

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