Musculoskeletal Radiology: Definition and Types of Fractures

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Fractures are a common acute presentation to the emergency departments worldwide. Fractures can be associated with severe long-term morbidity, increased mortality, a huge burden on the healthcare system, and may be intentional or accidental. Abuse, conflicts between people, falls, and motor vehicle accidents are the most common causes of fractures. The number of fractured bones tends to be higher in motor vehicle accidents and falls compared to fractures caused by other causes.

Pathophysiology of Fractures

Causes of fractures

Fractures usually occur when **significant force is applied to the bone**. Fractures in long bones tend to be more common with direct trauma to the involved upper or lower limb, whereas stress fractures more commonly involve the small bones of the hand or foot. Stress fractures are dependent on:

- Repetitive insult to the bone
- Bone's elasticity, strength, and density
- Presence of systemic disease or vitamin or mineral deficiencies

Types of fractures

When direct trauma is applied to a bone, **tapping fractures, penetrating fractures or crush fractures are the most common types** of fractures encountered. Traction, compressive or rotational fractures result from the indirect application of force to the axis

of the bone.

Complete vs. incomplete fracture

Complete	Incomplete
Fracture extends through the entire cortex	Fracture extends through part of the cortex
• Transverse • Oblique • Spiral • Comminuted	• Buckle • Greenstick

Healing process

Once a fracture occurs, healing starts by either **primary direct healing or secondary healing**. Primary healing is achieved with the **proper anatomic reduction of the fractured segments along with compression**. Primary healing is characterized by modeling of the bone without the formation of callus.

Secondary healing occurs **when anatomic reduction or compression is not feasible** and is characterized by the formation of a callus around the fractured segment, followed by external bony re-modeling; therefore, secondary healing is characterized by four main stages:

1. Fracture phase,
2. Soft callus formation,
3. Hard callus formation, and finally
4. Re-modeling phase.

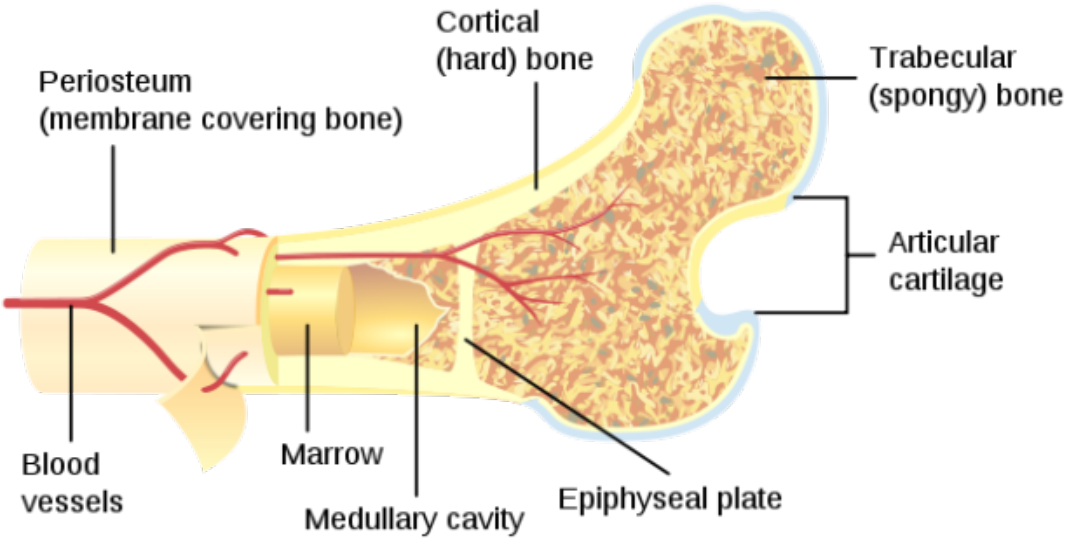

Image: “Bone cross-section” by Pbroks13. License: CC BY 3.0

Risk factors

Younger patients, those without comorbid conditions such as diabetes, those who do not take immunosuppressive medications, non-smokers, those who are well-nourished and those with single limb fractures tend to have better and faster healing, compared to those with such risk factors. The ability to restore the anatomic relationship of the fractured bones and the application of compression can also facilitate healing.

Epidemiology of Fractures

Trauma is a significant cause of deaths in the United States and is the leading cause of death in children and young adults. Approximately, **50 million new cases of fractures** require treatment at an emergency unit per year in the United States. The costs of fracture care in the United States are as high as $400 billion.

Fractures are **more common in patients with risky lifestyles** such as those involved in sports. Patients with comorbid conditions, such as epilepsy, are more likely to experience sudden falls and perhaps fractures. Additionally, boys are more likely to have fractures than girls in pre-school years.

Clinical Presentation of Fractures

Case history

Whenever a patient presents with possible signs of a single-limb fracture, careful history taking and physical examination are indicated. The mechanism and events that lead to the trauma should be explored to **exclude the possibility of non-accidental injury**. The factors that lead to the fall should also be explored to **exclude a pre-existing medical condition such as syncope or epilepsy**.

Social history including smoking and drinking should be obtained because cigarette smoking and alcohol consumption are known to negatively impact the healing process. A physical examination is indicated to define the bony fracture region, document soft-tissue injury and whether the fracture is an open or closed one.

Physical examination

Neurologic and vascular examinations are also indicated. A **full-body exam** is also indicated to exclude injuries to other regions, such as the spine or head which are commonly injured in falls.

Assessment of the range of motion should be attempted **only if possible**. In some cases, the use of analgesia is indicated before a range of motion assessment to exclude the possibility of intra-articular injury or tendon or ligamentous injury.

Patients with **polytrauma** should receive a **formal trauma assessment based on advanced trauma life support protocols**. Evaluation of the airway, breathing, and circulation should be performed in all polytrauma patients. Spine protection during examination is essential until the possibility of spinal injury is reliably excluded by adequate clinical examination and computed tomography imaging studies.

Hemodynamic stability of polytrauma patients might be compromised at any moment, especially when the risk of major blood vessel injury is high, i.e., patients with open-book pelvic fractures.

Types and Classification of Fractures

Causes of fractures

Fractures are defined as the **disruption of the integrity of the bone marrow,**

periosteum and adjacent soft tissues. Fractures can be caused by:

- Trauma
- Stress due to repetitive trivial injury
- Can be pathologic such as osteoporotic fractures
- Greenstick fracture is more common in children

Classification of fractures

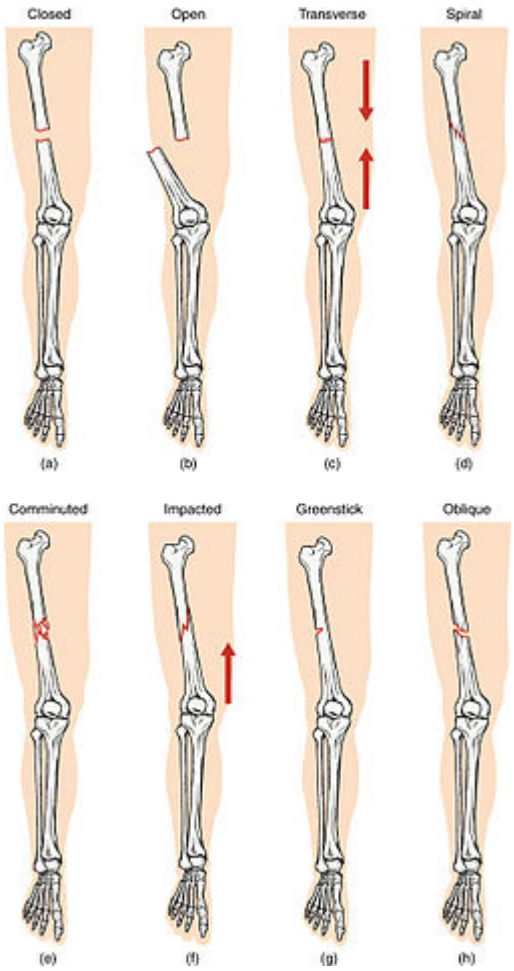

Image: “612 Types of Fractures” by OpenStax College.
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Fractures can be classified according to the **involved bone and the fractured location within the bone, diaphysis, physis, epiphysis or metaphysis**. This classification is very important and can be readily done using X-rays.

Fractures can also be classified as **intra-articular versus extra-articular**. Intra-articular fractures usually need surgical intervention for the restoration of the perfect anatomical relationship of the involved bones.

Displacement should also be noted on the X-ray. Fracture angulation of the distal fragment in relation to the proximal fragment should be also noted into your classification. **Rotation and shortening** should also be excluded.

Pattern of the fractures

The pattern of the fracture should be documented in your radiographic assessment.

Simple fractures can be **spiral, oblique or transverse**. A fracture that has more than two fragments is known as a **multi-fragmentary fracture**. Wedge fractures can be spiral or bending, but the distal and proximal fragments are still in contact with each other.

Multi-fragmentary fracture with one or more fragments that are no longer in contact with the proximal and distal main fragments is known as a complex multi-fragmentary fracture. Multi-fragmentary fractures are more likely to need surgical intervention than simple fractures.
The fracture can be also classified according to the **pattern of soft-tissue injury**.
Type 1 fractures are characterized by a wound that is less than 1 cm.
Type 2 fractures are characterized by a wound that is longer than 1 cm, slight contamination but no major soft-tissue damage.
Type 3 fractures are characterized by larger wounds with severe soft-tissue disruption and defects.

Type 3 open fractures can have sufficient adjacent healthy soft-tissue for adequate covering, might need a local or distant flap for adequate coverage, and may be associated with neurologic or vascular injuries.

Radiographic Evaluation of Fractures

Radiographic evaluation of the involved limb is **mandatory** in any patient suspected to have a fracture. **An anteroposterior view and a lateral view are indicated in most cases**. Intra-articular injuries might be associated with injuries to adjacent joints; therefore, a two-joint radiograph is indicated.

Additionally, it is always advisable to **compare images of the involved limb with those of the non-injured limb**. X-rays should be performed pre-reduction and post-reduction to confirm satisfactory bony alignment after reduction.

When evaluating a radiograph, the following **six “A”s** should be checked and commented about:

1. **A**natomy involved (distal femur)
2. Involvement of the **a**rticular surface
3. **A**lignment of the fragments
4. Degree of **a**ngulation
5. The **a**pex
6. The presence of **a**pposition

Radiographic evaluation of certain regions

Radiographic evaluation of certain regions should be modified from the typical anteroposterior and lateral views. **Cervical spine injuries can be readily excluded by an odontoid view**. Spine instability should be checked with flexion and extension views. The scapula is better visualized in a Y view. The pelvis should be evaluated with an inlet and outlet view. The scaphoid bone is better visualized with a posteroanterior view with ulnar deviation.

Computed tomography scan

Computed tomography is **usually not needed in the routine evaluation of fractures**. Complex fractures, spinal injuries, and intra-articular fractures should be

examined with a computed tomography scan to visualize the involved bony segments in a 3D configuration. Computed tomography scans are also indicated to assess the reduction of complex, multi-fragmented and intra-articular fractures.

Computed tomography scans of the spine are indicated for the exclusion of bony injuries. Spinal cord injuries can be evaluated with conventional computed tomography scans. Instead, a **magnetic resonance imaging study should be performed when the neurologic examination shows signs suggestive of spinal cord injury**.

References

Buckley, Richard. 2016. “General Principles of Fracture Care Workup.” Available at: http://emedicine.medscape.com/article/1270717-workup

Notes