Follow-up Radiographs to Detect Callus Formation After Fractures

QUESTION
When should one see a callus on a follow-up radiograph of a fracture?

SOLUTION

SEARCH STRATEGY
A MEDLINE search was performed (1966 to present, limited to the English language and about humans) on the following medical subject heading (MeSH) terms: callus + fracture, callus + radiology, fracture, ununited. Also, leading orthopedic texts were reviewed.

BACKGROUND

Follow-up radiographs are important to assess proper alignment and adequate healing of a fracture. The formation of a callus is one characteristic used to follow these features, but the timing and size of its appearance is variable. Therefore, when to expect to see a callus on radiographs requires a general understanding of the fracture healing process and the many variables that can affect callus formation. The callus, or immature bone, results from a precise chronological process. Many factors can alter the sequence of events that result in the delay or absence of callus formation.1-4 Therefore, when to expect to see a callus on a follow-up radiograph is one characteristic used to follow these features, but the timing and size of its appearance is variable. Therefore, when to expect to see a callus on radiographs requires a general understanding of the fracture healing process and the many variables that can affect callus formation. The callus, or immature bone, results from a precise chronological process.1-3 Many factors can alter the sequence of events that result in the delay or even absence of callus formation.1-4-7

The fracture healing process begins immediately after the fracture with the inflammatory phase.1-pp186-199,7-9 In this phase, damage to the surrounding blood vessels and tissue lead to the formation of a hematoma. Inflammatory mediators are released causing inflammatory cells to migrate to the region.1-pp186-199,10 These cells are involved in producing the framework in which the callus forms. This stage lasts 5 to 7 days,2,11 with some overlap into the next phase.1-pp186-199,10

The next stage, the reparative phase, is when the callus develops. This stage lasts from 4 to 40 days, composing about 40% of the healing process time with overlap into the final phase.1-pp186-199,10,11 The hematoma formed in the initial phase serves as a structure in which the callus forms into mature bone. Through the action of growth factors and other proteins, granulation tissue is converted to radiolucent cartilaginous callus. Eventually, this is mineralized by the deposition of calcium salts.1,2,3,8,10 Once the calcification occurs, the callus becomes evident radiographically. This woven bone, or periosteal callus, creates an irregular radiographic appearance1 that is fluffy, amorphous, and biologically plastic.1-pp70-86 If not properly protected, this immature bone can be disrupted, resulting in prolongation of the fracture’s healing process and the development of bone deformities. Endosteal callus or intramedullary callus also develops as part of the healing process.3,6 This type of callus is usually not visible on x-ray film. Fractures of short or irregular bones, such as the scaphoid or calcaneus, primarily heal internally and rely chiefly on endosteal callus formation for repair.3 This is because these types of bone have little cortex to produce radiodense callus.5

The last stage of repair is the remodeling phase. This phase lasts from 4 to 40 days,1-pp186-199,10 and can last for well over 1 year.2 This phase is characterized by conversion of periosteal callus into lamellar or mature bone.1-7 Unnecessary callus is resorbed and trabecular bone produced. The final product is a mechanically stable bone similar to its original state in form and function.1,7,14

The fracture’s healing process, including the formation of the callus, is influenced by the patient, tissue, and treatment variables.1,7,11-15 Subsequently, these factors can influence the time when one would expect to see a callus on a follow-up radiograph. Age is one of the most important variables that influences fracture healing.1-pp186-199,14 although the influence of aging on fractures has undergone little investigation.4 The younger the individual, the faster a break tends to heal.1-pp186-199,8,10,12,15 For example, the healing period of a femur fracture can be 3 to 5 weeks in an 8-year-old, 12 to 14 weeks in a 12-year-old, and 20 to 24 weeks in an adult.15 This may be related to the increased vascularity and ability of the cells to differentiate in the younger individual’s periosteum.1-pp186-199,8 Other patient factors that influence healing include nutritional deficiencies (ie, calcium and phosphorus) and concurrent medical illnesses, such as diabetes mellitus, hormonal deficiencies, and iron deficiency anemia.1-pp186-199,8,10

Certain tissue variables can also affect the development of callus formation. Radiographic evidence of callus is dependent on the type of bone involved, as well as the nature of the fracture.6,13,15,16 Fractures, particularly in the diaphyseal region, develop more callus than metaphyseal fractures and those of smaller, irregular bones.5 This difference is related to the amount of periosteum enveloping the bone. Fractures of the phalanges, scaphoid, calcaneal, skull, and those of intra-articular surfaces develop minimal to no callus that is evident on radiography.5,15 In these cases, clinical parameters, such as lack of pain with movement or tenderness to palpation, are used to assess fracture healing. This is also true for impacted fractures, but is not the case for comminuted fractures or those with wider gaps between the bony fragments.5,11 Other tissue factors, such as bone cancer, can adversely affect the healing process.
Fracture management also influences the amount of visible callus. The extent of periosteal stripping, the fixation of the fracture, and the amount and timing of weight bearing can be contributing factors to when a callus appears radiographically. Also, some pharmacological agents can influence callus formation. These include steroids, nonsteroidal anti-inflammatory agents, anticoagulants, chemotherapeutic agents, and tobacco.

There is a paucity of research specifically aimed at determining when to expect to see a callus on a follow-up x-ray film of a fracture. Most investigations focus on the biomechanical process of fracture healing. In a study assessing limb-lengthening procedures in 9- to 16 1/2-year-olds, Vade and Eisenstat found callus formation on radiographs at 7 days. Postacchini et al studied long bones in normal adults and found calcification foci histologically by 7 days, and many new trabecular bone were identified by 15 days.

Despite the lack of research, some of the review articles and textbooks address the timing regarding radiographic evidence of the callus. In a review, Chapman points out that periosteal new bone or callus can be seen in an infant as early as 3 days after an injury, although 7 to 14 days is more typical. Rockwood et al report that in a child 10 to 14 days postfracture, a callus can be seen radiographically. Frost suggests that mineralization in long bone fractures takes at least 4 weeks before being evident on radiographs. Monahan cautions that the exact timing of radiographic examination depends on many variables, which include the nature and location of the fracture along with the patient’s age.

In the office, family practitioners frequently encounter many types of fractures. Included in the most common sites of these are distal radial, phalangeal, fibular, scaphoid, metatarsal, and clavicular fractures. Keeping in mind the discussion above, for the common, simple, nondisplaced fractures one should expect to see callus formation on x-ray film in 1 to 2 weeks for children and in 2 to 3 weeks for adults. This general rule does not hold true for scaphoid fractures in which little to no callus will be seen radiographically because of its relative lack of periosteum and blood supply. Also, for Salter-Harris I classification and greenstick fractures, callus will not be visible because of little disruption to the periosteum and in particular for most cases of Salter-Harris I fractures because of a lack of a fracture gap. In both of these types of fractures clinical examination and follow-up radiographs are most important to assure proper alignment.

**BOTTOM LINE**

There are many variables that influence callus formation and its initial radiographic appearance. These include: the patient’s age, the type and site of the fracture, comorbid conditions, the management of the fracture, and blood supply. The radiographic appearance of callus formation is relevant to the patient’s care because it provides objective evidence that the fracture healing process is occurring as expected, thus allowing the physician and patient to have more information on the prognosis and time to recovery.

Under normal conditions, one should expect bony callus formation to show up radiographically anywhere between 7 days to 4 weeks. Most authorities suggest getting follow-up radiographs in the first 1 to 2 weeks to assess for alignment and radiographic evidence of healing. After 4 weeks, if no bony callus is evident, suspicion should be raised about delayed union or nonunion. Further investigation into why the fracture is not healing and closer follow-up may be warranted along with consideration for orthopedic consultation.

**REFERENCES**