

Pathophysiology of an Ankle Fracture Requiring Open Reduction and Internal Fixation

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Introduction

Open reduction and internal fixation, commonly abbreviated as ORIF, is a surgical procedure used to treat fractures that cannot be managed adequately through casting, splinting, or closed reduction alone. The term *open reduction* means that the orthopedic surgeon makes an incision to access the fracture and return the displaced bone fragments to their normal anatomical positions. *Internal fixation* refers to the use of implanted devices, such as plates, screws, pins, wires, rods, or nails, to maintain the corrected alignment while the bone heals.

The American Academy of Orthopaedic Surgeons explains that during internal fixation, fractured bone fragments are first “reduced,” or repositioned into normal alignment, and then secured with specialized implants (American Academy of Orthopaedic Surgeons [AAOS], n.d.-a). Stabilizing the fracture helps maintain alignment, protect surrounding tissues, reduce abnormal movement, and create a mechanical environment that supports bone healing.

In the case presented, Edward Smith is a man in his fifties who was admitted after falling from a ladder and sustaining a right ankle fracture. His symptoms included severe ankle pain and impaired physical mobility. His medical history included chronic lower back pain, previous lower-back surgery, and hypertension. He subsequently underwent ORIF to restore the alignment and stability of his injured ankle.

Although pain, swelling, and difficulty moving the ankle are expected manifestations of a fracture, hypertension, a mild temperature elevation, previous spinal surgery, and low hemoglobin are not themselves indications for ORIF. The decision to perform surgery would normally be based on the fracture pattern, degree of displacement, ankle instability, joint incongruity, associated ligament injury, open injury, or failure to maintain alignment through nonsurgical treatment. This distinction is important because the clinical reason for ORIF should be separated from the patient’s comorbidities and postoperative findings.

Anatomy and Function of the Ankle

The ankle is a complex weight-bearing joint formed by the distal tibia, distal fibula, and talus. The

lower ends of the tibia and fibula form a socket known as the ankle mortise, which surrounds the upper portion of the talus. The medial malleolus is located at the lower end of the tibia, while the lateral malleolus is located at the lower end of the fibula. A third area, the posterior malleolus, forms the posterior portion of the distal tibia.

The ankle is also stabilized by several ligament groups. The deltoid ligament supports the medial side of the ankle, while the lateral ligament complex helps resist excessive inversion. The syndesmosis connects the distal tibia and fibula and helps preserve the width and stability of the ankle mortise. Damage to one or more of these structures can allow the talus to shift out of its normal position, producing instability and abnormal joint loading.

Ankle-fracture treatment aims to restore the alignment and stability of this joint. Inaccurate alignment can alter the distribution of forces across the ankle cartilage and contribute to chronic pain, reduced function, stiffness, and post-traumatic arthritis. A thorough assessment must therefore consider both the visible bone fracture and possible injuries to the surrounding ligaments, blood vessels, nerves, skin, and soft tissues (Hermena & Slane, 2025).

Mechanism of Edward Smith's Injury

Edward Smith reportedly fractured his ankle after falling from a ladder. A fall from height can expose the ankle to axial compression, rotation, bending, or a combination of these forces. The exact fracture pattern would depend on the position of the foot when Smith landed, the height of the fall, the direction of the force, and the strength of his bones and ligaments.

If the foot was planted while the body rotated, twisting forces may have fractured one or more malleoli and damaged the ankle ligaments. If Smith landed directly on his foot, axial force may have driven the talus against the distal tibia and fibula. A higher-energy fall may also cause greater bone fragmentation and more severe soft-tissue injury than a simple low-energy twisting event. The energy of the trauma generally influences the degree of displacement, comminution, swelling, and tissue damage (Hermena & Slane, 2025).

The case information does not specify whether Smith sustained a unimalleolar, bimalleolar, trimalleolar, syndesmotic, or fracture-dislocation injury. Nevertheless, the decision to perform ORIF suggests that the orthopedic team considered the fracture displaced, unstable, or unlikely to maintain acceptable alignment with nonsurgical treatment.

Pathophysiology of the Ankle Fracture

A fracture occurs when an applied force exceeds the bone's ability to absorb and distribute mechanical stress. When the ankle fractured, the continuity of Smith's bone was disrupted. The injury likely damaged the periosteum, bone marrow, small blood vessels, surrounding soft tissues, and

possibly the ankle ligaments.

The immediate disruption of blood vessels caused bleeding into and around the fracture site. This bleeding produced a fracture hematoma, which is a collection of blood between and around the injured bone fragments. The hematoma is not simply an unwanted consequence of trauma. It also creates the initial biological environment in which inflammatory cells, signaling proteins, and repair cells begin the healing process.

At the same time, tissue damage triggered the release of inflammatory mediators. These substances increased local blood flow and capillary permeability, allowing fluid and immune cells to enter the injured region. The resulting inflammatory response contributed to swelling, warmth, tenderness, and pain. Although excessive or prolonged inflammation may interfere with recovery, an appropriately controlled inflammatory response is necessary to remove damaged tissue and initiate bone repair (ElHawary et al., 2021).

Development of Pain and Swelling

Smith's severe ankle pain was most likely caused by several overlapping mechanisms. The fracture itself damaged pain-sensitive structures, including the periosteum, ligaments, muscles, skin, and other soft tissues. Movement of unstable bone fragments could further stimulate pain receptors and aggravate surrounding tissue injury.

Inflammatory mediators released after the trauma sensitized peripheral nerve endings, making the injured area more responsive to pressure and movement. Edema increased tension within the surrounding tissues, while muscle spasms may have developed as the body attempted to protect the unstable joint. Together, these mechanisms explain why ankle-fracture pain often becomes worse with movement, dependent positioning, or attempts to bear weight.

Swelling developed because damaged blood vessels leaked fluid into the interstitial tissues and because the inflammatory response increased vascular permeability. Keeping the injured limb in a dependent position could worsen edema through gravity and impaired venous return. Elevating the leg above heart level, when clinically appropriate, can therefore help reduce swelling. However, elevation reduces edema rather than mechanically stabilizing the fracture.

Pain and swelling alone do not establish the need for ORIF because they can occur with both stable and unstable fractures. The decision for surgery depends more directly on imaging findings, joint stability, fracture displacement, soft-tissue condition, and the risk of losing normal ankle alignment.

Indications for ORIF in an Ankle Fracture

Stable, nondisplaced ankle fractures can often be treated with a cast, brace, or walking boot. In

contrast, surgery may be necessary when a fracture causes instability or when the bone fragments have moved out of position.

Examples include displaced medial or lateral malleolar fractures, many bimalleolar fractures, unstable trimalleolar fractures, fracture-dislocations, large displaced posterior malleolar fragments, and fractures accompanied by unstable syndesmotic injuries. The AAOS notes that most bimalleolar fractures require surgery because injuries on both sides of the ankle commonly make the joint unstable. Syndesmotic injuries associated with fractures may also require fixation with screws or a suture-button construct (AAOS, n.d.-b).

In Smith's case, ORIF was presumably selected to accomplish several objectives:

1. Restore the normal length, rotation, and alignment of the fractured bone.
2. Reconstruct the shape and stability of the ankle mortise.
3. Prevent displacement while the fracture heals.
4. Reduce the risk of malunion, nonunion, chronic instability, deformity, and post-traumatic arthritis.
5. Permit an appropriately timed rehabilitation program.

Severe pain, hypertension, mild fever, and a history of lower-back surgery may influence perioperative management, but these findings do not independently justify internal fixation.

How ORIF Supports Fracture Healing

During ORIF, the orthopedic surgeon exposes the fracture through an incision and removes any tissue that prevents satisfactory reduction. The bone fragments are returned to their anatomical positions and secured with the fixation system selected for the fracture. Plates commonly act like internal splints, while screws compress or hold individual fragments together.

The hardware does not biologically heal the fracture. Instead, it creates sufficient mechanical stability for the body's natural healing processes to proceed. Internal fixation may also reduce painful movement between fragments and maintain joint congruity while repair tissue develops.

The degree of stability produced by the fixation construct affects how the bone heals. Very rigid compression may encourage direct or primary bone healing with little visible callus. Relative stability permits a limited degree of controlled strain and usually produces secondary bone healing through callus formation. The surgeon selects the method according to the fracture pattern, bone quality, soft-tissue condition, and anatomical location.

Internal fixation may help patients return to function earlier and may lower the likelihood of malunion or nonunion in appropriately selected fractures. However, it does not eliminate every risk. Infection, hardware failure, poor alignment, delayed union, nonunion, stiffness, nerve injury, and wound

problems can still occur (AAOS, n.d.-a).

Stages of Bone Healing After ORIF

Inflammatory Phase

Bone healing begins immediately after the injury. Bleeding creates a hematoma around the fracture, while damaged and dead cells release molecular signals that attract inflammatory cells. Neutrophils, macrophages, and other immune cells remove debris and release cytokines that coordinate repair.

New blood-vessel formation is essential during this phase because the damaged tissues require oxygen, nutrients, and access to repair cells. The inflammatory phase overlaps with later phases rather than ending abruptly. A properly regulated response helps prepare the fracture site for new tissue formation (ElHawary et al., 2021).

Reparative Phase

During the reparative phase, mesenchymal progenitor cells differentiate into fibroblasts, chondrocytes, and osteoblasts. Fibrous tissue and cartilage form a soft callus that begins to bridge the fracture gap. This soft callus provides early stability but cannot yet tolerate normal weight-bearing forces.

The soft callus gradually mineralizes and is replaced by a harder callus containing immature woven bone. Osteoblasts produce new bone matrix, while blood vessels continue to grow into the healing region. The timing of this process varies according to age, fracture severity, blood supply, mechanical stability, smoking status, nutrition, infection, medication use, and underlying disease.

Remodeling Phase

During remodeling, woven bone is gradually replaced by stronger lamellar bone. Osteoclasts remove unnecessary or poorly organized bone, while osteoblasts deposit new bone along lines of mechanical stress. The medullary canal and external shape of the bone are progressively restored.

Remodeling may continue for months or years after clinical union. The patient may therefore regain functional stability before the internal structure of the bone has fully returned to its mature form.

Clinical Interpretation of Smith's Findings

Severe Ankle Pain

Smith's excruciating pain is consistent with acute tissue injury, inflammation, edema, and fracture instability. Pain should be assessed regularly by location, intensity, quality, timing, aggravating factors, and response to treatment.

A sudden increase in pain must not automatically be interpreted as ordinary postoperative discomfort. Pain that is disproportionate to the expected course, especially when it is not relieved by prescribed analgesia or worsens with passive movement, may signal neurovascular compromise or compartment syndrome. Compartment syndrome develops when pressure rises within a closed fascial space and reduces tissue perfusion. Untreated ischemia can progress to nerve and muscle necrosis, making the condition a surgical emergency (Torlincasi et al., 2023).

Hypertension

Hypertension is not an indication for ORIF. Smith's elevated blood pressure may represent pre-existing hypertension, acute pain, anxiety, medication effects, or a combination of factors. The nurse should monitor blood pressure, compare it with the patient's baseline, administer prescribed antihypertensive medication, assess pain, and report persistent or severe abnormalities.

Uncontrolled hypertension may increase perioperative cardiovascular and bleeding risks. However, the clinical response should be based on the severity, symptoms, baseline values, and prescribing clinician's plan rather than on a single isolated reading.

Mild Temperature Elevation

A mild temperature increase soon after surgery can occur as part of the body's inflammatory response. However, persistent fever, worsening pain, redness, purulent drainage, foul odor, or increasing swelling may suggest infection and requires further assessment.

A surgical-site infection can involve the skin, deeper tissues, or implanted material. The Centers for Disease Control and Prevention identifies redness, increasing pain, cloudy wound drainage, and fever among the possible signs of surgical-site infection (Centers for Disease Control and Prevention [CDC], 2024).

Low Hemoglobin

The original case states that Smith's hemoglobin was low because blood was lost through the surgical incision. That conclusion should not be made without reviewing laboratory trends, estimated blood loss, fluid administration, and the patient's baseline hemoglobin.

A postoperative reduction in hemoglobin may result from bleeding related to the fracture, operative blood loss, hemodilution from intravenous fluids, or pre-existing anemia. The nurse should monitor hemoglobin and hematocrit results together with symptoms such as fatigue, pallor, dizziness, tachycardia, dyspnea, hypotension, or reduced activity tolerance.

Low hemoglobin is not a reason that ORIF had to be performed. Instead, anemia is a separate clinical issue that may affect oxygen delivery, rehabilitation tolerance, and recovery.

Impaired Physical Mobility

Impaired mobility is expected after an unstable ankle fracture and ORIF. Pain, edema, immobilization, weight-bearing restrictions, fear of falling, muscle weakness, and Smith's history of lower-back problems may all reduce his ability to move safely.

A previous back operation does not indicate a need for ankle ORIF, but it may affect transfers, gait, positioning, the selection of assistive devices, and the patient's ability to use crutches. Physical and occupational therapists should therefore consider both the ankle injury and Smith's spinal history when developing a mobility plan.

Priority Nursing Assessments After ORIF

Neurovascular Assessment

Frequent neurovascular assessment is one of the most important nursing responsibilities following ankle ORIF. The nurse should assess and compare both lower extremities, documenting skin color and temperature, capillary refill, swelling, pulses, sensation, movement, and pain.

The dorsalis pedis and posterior tibial pulses should be checked when accessible. Sensory changes such as numbness, tingling, burning, or reduced sensation should be reported. Motor function can be evaluated through permitted toe movement and other surgeon-approved actions. Neurovascular status should be reassessed after repositioning, splint adjustment, increased swelling, or a significant change in pain.

Delayed recognition of neurovascular compromise can result in permanent nerve injury, tissue loss, loss of the limb, or death. Patients with fractures and those who have undergone internal fixation therefore require structured and repeated observations (Royal Children's Hospital Melbourne, n.d.).

Pain Assessment and Management

Pain management should be multimodal and individualized. Prescribed treatment may include

acetaminophen, anti-inflammatory medication when appropriate, opioids for selected patients, regional anesthesia, elevation, ice when ordered, repositioning, reassurance, and nonpharmacological techniques.

The nurse should assess both pain intensity and function. A target such as “2 out of 10 by the end of the shift” may be unrealistic for some patients immediately after surgery. A better outcome is that Smith reports pain at or below his agreed acceptable level and can rest, participate in necessary care, and perform safe transfers.

Pain medication should be reassessed for effectiveness and adverse effects. Opioid therapy requires monitoring for excessive sedation, respiratory depression, nausea, constipation, confusion, and fall risk.

Wound and Infection Monitoring

The surgical dressing should be inspected according to institutional policy and the surgeon’s instructions. The nurse should observe for bleeding, drainage, odor, redness, warmth, separation of wound edges, and increasing tenderness.

Hand hygiene and aseptic technique are necessary when caring for the wound. Smith should be instructed not to remove or contaminate the dressing unless directed. He should also know whom to contact if he develops fever, drainage, spreading redness, worsening pain, or another sign of infection after discharge (CDC, 2024).

Prevention of Venous Thromboembolism

Lower-limb trauma, surgery, reduced mobility, and non-weight-bearing restrictions may increase the risk of deep-vein thrombosis. A clot formed in the leg can travel to the lungs and cause a pulmonary embolism.

Smith should receive an individualized venous-thromboembolism risk assessment. Preventive measures may include prescribed anticoagulant medication, mechanical devices, hydration, early safe mobilization, and exercises involving unaffected joints. The exact approach depends on the patient’s bleeding risk, medical history, fracture, mobility, and institutional protocol.

NICE recommends VTE risk assessment for adults discharged with lower-limb immobilization and appropriate education about clot symptoms and preventive treatment (National Institute for Health and Care Excellence [NICE], 2021).

Skin Integrity and Repositioning

Reduced mobility places Smith at risk of pressure injury. Repositioning may be needed at regular intervals, but the schedule should be individualized according to his condition, support surface, skin tolerance, mobility, pain, and postoperative restrictions.

When repositioning Smith, staff should support the operated limb and avoid twisting or placing pressure on the fracture site. The heels, sacrum, elbows, and other pressure points should be inspected regularly. Moisture control, nutrition, pressure redistribution, and assistance with mobility are also important.

Nursing Care Plan for Edward Smith

Nursing problem	Expected outcome	Key nursing interventions
Acute pain related to fracture, inflammation, tissue trauma, and surgery	Smith will report pain at an acceptable level and participate in essential care	Assess pain regularly, administer prescribed analgesics, elevate the limb as ordered, use cold therapy if permitted, and reassess treatment effectiveness
Impaired physical mobility related to pain, fixation, and weight-bearing restrictions	Smith will transfer and mobilize safely using the prescribed assistive device	Confirm weight-bearing status, consult physical therapy, assist with transfers, protect the operated limb, and encourage approved exercises
Risk for peripheral neurovascular dysfunction	Smith will maintain adequate circulation, sensation, and movement in the affected foot	Assess pulses, capillary refill, color, temperature, sensation, movement, swelling, and pain; report deterioration immediately
Risk for infection related to surgical incision and implanted hardware	Smith's wound will remain clean and show no evidence of infection	Use appropriate wound-care technique, monitor temperature and wound appearance, administer prescribed antibiotics, and provide discharge teaching

Nursing problem	Expected outcome	Key nursing interventions
Risk for venous thromboembolism related to surgery and immobilization	Smith will remain free of DVT and pulmonary embolism	Complete VTE assessment, administer prescribed prophylaxis, encourage safe mobility, maintain hydration when permitted, and teach warning signs
Risk for falls related to pain, weakness, assistive-device use, and mobility restrictions	Smith will remain free from falls	Keep needed items within reach, assist with toileting and transfers, provide nonslip footwear, maintain a clear environment, and reinforce use of the call system
Risk for impaired skin integrity related to reduced mobility	Smith will maintain intact skin	Inspect pressure areas, reposition safely, use pressure-redistributing surfaces, keep skin clean and dry, and support adequate nutrition

Range-of-Motion Exercises and Rehabilitation

The original care plan recommends passive range-of-motion exercises. This intervention requires clarification. Passive movement should not be performed automatically at the operated ankle because premature or excessive motion could stress the fracture, wound, or fixation.

Range-of-motion exercises for the ankle should begin only when authorized by the orthopedic surgeon and guided by the rehabilitation team. Exercises involving the toes, knee, hip, and unaffected extremities may be encouraged when safe to maintain circulation, reduce stiffness, and preserve strength.

Weight-bearing status must also be confirmed. Some patients are permitted early protected weight bearing, while others must remain non-weight bearing for a defined period. Smith should not assume that reduced pain means the fracture is ready to support his full body weight.

Nutrition and Bone Healing

Adequate nutrition supports wound healing, immune function, muscle maintenance, and bone repair. Smith should receive sufficient calories and protein, as well as appropriate amounts of calcium, vitamin D, vitamin C, and other micronutrients. If he has poor appetite, anemia, weight loss, or another nutritional concern, referral to a dietitian may be beneficial.

Nutrition alone will not correct significant postoperative anemia or replace medical treatment. Iron

supplementation should be provided only when iron deficiency or another clinical indication has been established. Laboratory results and the treating clinician's plan should guide treatment.

Smoking should also be addressed because it can interfere with tissue oxygenation, wound healing, and bone repair. Alcohol intake, diabetes control, medication adherence, and other modifiable factors should be reviewed as part of recovery planning.

Patient Education and Discharge Planning

Before discharge, Smith should demonstrate an understanding of his weight-bearing status, medication schedule, wound-care instructions, follow-up appointments, and assistive-device use. He should know how to elevate the limb without placing harmful pressure on the heel or incision.

He should seek urgent medical attention for:

- rapidly increasing or disproportionate pain;
- new numbness, tingling, weakness, or inability to move the toes;
- a pale, cold, blue, or increasingly swollen foot;
- a tight or painful cast or splint;
- fever, spreading redness, purulent drainage, or wound separation;
- calf pain or swelling;
- sudden shortness of breath, chest pain, coughing blood, or fainting;
- a fall or new injury involving the operated leg.

Home safety should also be considered. Loose rugs, clutter, stairs, poor lighting, and unsuitable bathroom arrangements may increase his fall risk. His previous back condition may make crutch use difficult, so the rehabilitation team should determine whether a walker, wheelchair, knee scooter, or another device is more appropriate.

Evaluation of the Nursing Outcomes

The original short-term goal stated that Smith would report right-leg pain of 2 out of 10 by the end of the shift. Although this is measurable, a fixed numerical target may not reflect the patient's baseline pain, the timing of surgery, or what is realistically achievable.

A more patient-centered outcome would state that Smith will report pain at or below his acceptable level, show improved comfort, maintain stable neurovascular findings, and participate in required repositioning or mobility activities by the end of the shift.

The outcome can be considered met if Smith reports meaningful pain reduction, demonstrates no signs of neurovascular compromise, remains free from falls, and explains his medication, mobility,

and wound-care instructions. If his pain remains severe or increases unexpectedly, the nurse should reassess the cause rather than simply administering additional medication.

Conclusion

Edward Smith's ankle fracture resulted from trauma severe enough to disrupt bone continuity and damage surrounding blood vessels and soft tissues. Bleeding, inflammation, edema, tissue injury, and fracture instability contributed to his severe pain and inability to move normally.

ORIF was performed to restore anatomical alignment and stabilize the ankle while natural bone-healing processes occurred. The likely reason for surgery was an unstable or displaced fracture rather than hypertension, previous lower-back surgery, mild fever, low hemoglobin, or pain alone.

Following ORIF, nursing care should prioritize pain control, serial neurovascular assessment, wound monitoring, infection prevention, VTE risk management, skin protection, safe mobility, fall prevention, nutrition, and patient education. Elevation may reduce swelling, but it does not replace mechanical fixation. Similarly, range-of-motion and weight-bearing activities must follow the surgeon's restrictions rather than being applied routinely.

Smith's recovery depends on more than the surgical procedure. Successful outcomes require coordinated care among the orthopedic surgeon, nurses, physical and occupational therapists, pharmacists, dietitians, the patient, and his family. Careful monitoring and clear discharge teaching can help identify complications early, support fracture healing, and enable Smith to regain safe function.

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