38.2E: Bone Remodeling and Repair

Bone is remodeled through the continual replacement of old bone tissue, as well as repaired when fractured.

Learning Objectives

• Outline the process of bone remodeling and repair

Key Points

• Bone replacement involves the osteoclasts which break down bone and the osteoblasts which make new bone.
• Bone turnover rates differ depending on the bone and the area within the bone.
• There are four stages in the repair of a broken bone: 1) the formation of hematoma at the break, 2) the formation of a fibrocartilaginous callus, 3) the formation of a bony callus, and 4) remodeling and addition of compact bone.
• Proper bone growth and maintenance requires many vitamins (D, C, and A), minerals (calcium, phosphorous, and magnesium), and hormones (parathyroid hormone, growth hormone, and calcitonin).

Key Terms

• callus: the material of repair in fractures of bone which is at first soft or cartilaginous in consistency, but is ultimately converted into true bone and unites the fragments into a single piece
• spicule: a sharp, needle-like piece
• fibroblast: a cell found in connective tissue that produces fibers, such as collagen
Bone Remodeling and Repair

Bone renewal continues after birth into adulthood. Bone remodeling is the replacement of old bone tissue by new bone tissue. It involves the processes of bone deposition or bone production done by osteoblasts and bone resorption done by osteoclasts, which break down old bone. Normal bone growth requires vitamins D, C, and A, plus minerals such as calcium, phosphorous, and magnesium. Hormones such as parathyroid hormone, growth hormone, and calcitonin are also required for proper bone growth and maintenance.

Bone turnover rates, the rates at which old bone is replaced by new bone, are quite high, with five to seven percent of bone mass being recycled every week. Differences in turnover rates exist in different areas of the skeleton and in different areas of a bone. For example, the bone in the head of the femur may be fully replaced every six months, whereas the bone along the shaft is altered much more slowly.

Bone remodeling allows bones to adapt to stresses by becoming thicker and stronger when subjected to stress. Bones that are not subject to normal everyday stress (for example, when a limb is in a cast) will begin to lose mass.

Figure \(\PageIndex{1}\): Stages of fracture repair: The healing of a bone fracture follows a series of progressive steps: (a) A fracture hematoma forms. (b) Internal and external calli form. (c) Cartilage of the calli is replaced by trabecular bone. (d) Remodeling occurs.

A fractured or broken bone undergoes repair through four stages:

1. Hematoma formation: Blood vessels in the broken bone tear and hemorrhage, resulting in the formation of clotted blood, or a hematoma, at the site of the break. The severed blood vessels at the broken ends of the bone are sealed by the clotting process. Bone cells deprived of nutrients begin to die.
2. Bone generation: Within days of the fracture, capillaries grow into the hematoma, while phagocytic cells begin to clear away the dead cells. Though fragments of the blood clot may remain, fibroblasts and osteoblasts enter the area and begin to reform bone. Fibroblasts produce collagen fibers that connect the broken bone ends, while osteoblasts start to form spongy bone. The repair tissue between the broken bone ends, the fibrocartilaginous callus, is composed of both hyaline and fibrocartilage. Some bone spicules may also appear at this point.
3. Bony callous formation: The fibrocartilaginous callus is converted into a bony callus of spongy bone. It takes about two months for the broken bone ends to be firmly joined together after the fracture. This is similar to the endochondral formation of bone when cartilage becomes ossified; osteoblasts, osteoclasts, and bone matrix are present.
4. Bone remodeling: The bony callus is then remodelled by osteoclasts and osteoblasts, with excess material on the exterior of the bone and within the medullary cavity being removed. Compact bone is added to create bone tissue that is similar to the original, unbroken bone. This remodeling can take many months; the bone may remain uneven for years.

LICENSES AND ATTRIBUTIONS

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Updated: Wed, 14 Apr 2021 14:53:03 GMT
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