6.4C: Bone Remodeling

LEARNING OBJECTIVES

• Explain the effects of growth factors on bone

Remodeling or bone turnover is the process of resorption followed by the replacement of bone with limited change in shape; this process occurs throughout a person’s life. Repeated stress, such as weight-bearing exercise or bone healing, results in the bone thickening at the points of maximum stress.

It has been hypothesized that this is a result of bone’s piezoelectric properties that cause bone to generate small electrical potentials under stress. Osteoblasts and osteoclasts, coupled together via paracrine cell signaling, are referred to as bone remodeling units. The purpose of remodeling is to regulate calcium homeostasis, repair micro-damaged bones (from everyday stress), and to shape and sculpture the skeleton during growth.
Bone remodeling: Bone tissue is removed by osteoclasts, and then new bone tissue is formed by osteoblasts. Both processes utilize cytokine (TGF-β, IGF) signaling.

Bone volume is determined by the rates of bone formation and bone resorption. The action of osteoblasts and osteoclasts are controlled by a number of chemical factors that either promote or inhibit the activity of the bone remodeling cells, controlling the rate at which bone is made, destroyed, or changed in shape. The cells also use paracrine signalling to control the activity of each other.

Role of Growth Factors

Recent research has suggested that certain growth factors may work to locally alter bone formation by increasing osteoblast activity. Numerous bone-derived growth factors have been isolated and classified via bone cultures. These factors include insulin-like growth factors I and II, transforming growth factor beta, fibroblast growth factor, platelet-derived growth factor, and bone morphogenetic proteins.

- Insulin-like growth factors protect cartilage cells, and are associated with the activation of osteocytes.
- The transforming growth factor beta superfamily includes bone morphogenetic proteins involved in osteogenesis.
- Fibroblast growth factor activates various cells of the bone marrow including osteoclasts and osteoblasts.
- Platelet-derived growth factor has been found to enhance bone collagen degradation.

Evidence suggests that bone cells produce growth factors for extracellular storage in the bone matrix. The release of these growth factors from the bone matrix could cause the proliferation of osteoblast precursors. Essentially, bone growth factors may act as potential determinants of local bone formation.

Research has suggested that trabecular bone volume in postmenopausal osteoporosis may be determined by the relationship between the total bone forming surface and the percent of surface resorption.

Clinical Note

Osteoporosis means porous bone, which is caused by an over-reaction to osteoclastic bone resorption, and makes bones quite fragile for the elderly. Falls are dangerous for the elderly because they are more likely to break a bone. Hip
fractures are especially troublesome as they result in a long recovery period during which complications that may lead to death are quite common.

### Key Points

- Bone remodeling involves resorption by osteoclasts and replacement by osteoblasts. Osteoblasts and osteoclasts are referred to as bone remodeling units.
- The purpose of bone remodeling is to regulate calcium homeostasis, repair micro-damage to bones from everyday stress, and to shape the skeleton during growth.
- Bone growth factors affect the process of bone remodeling. These factors include insulin-like growth factors I and II, transforming growth factor beta, fibroblast growth factor, platelet-derived growth factor, and bone morphogenetic proteins.
- Bone volume is determined by the rates of bone formation and bone resorption. The action of osteoblasts and osteoclasts are controlled by a number of chemical factors that either promote or inhibit the activity of the bone remodeling cells.
- Postmenopausal osteoporosis is the result of imbalances in the relationship between bone resorption and replacement.

### Key Terms

- **growth factors**: Naturally occurring substances that stimulate cell growth, proliferation, healing, and cellular differentiation.
- **piezoelectric**: Accumulation of an electric charge due to mechanical stress.
- **bone remodeling**: The resorption of bone by osteoclasts and replacement by osteoblasts.