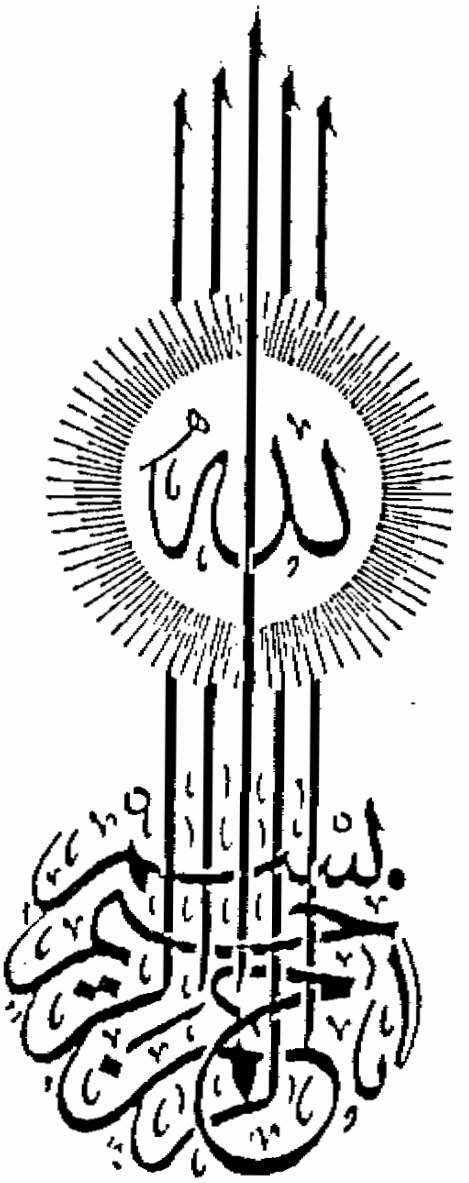

FRACTURE HEALING

Essay
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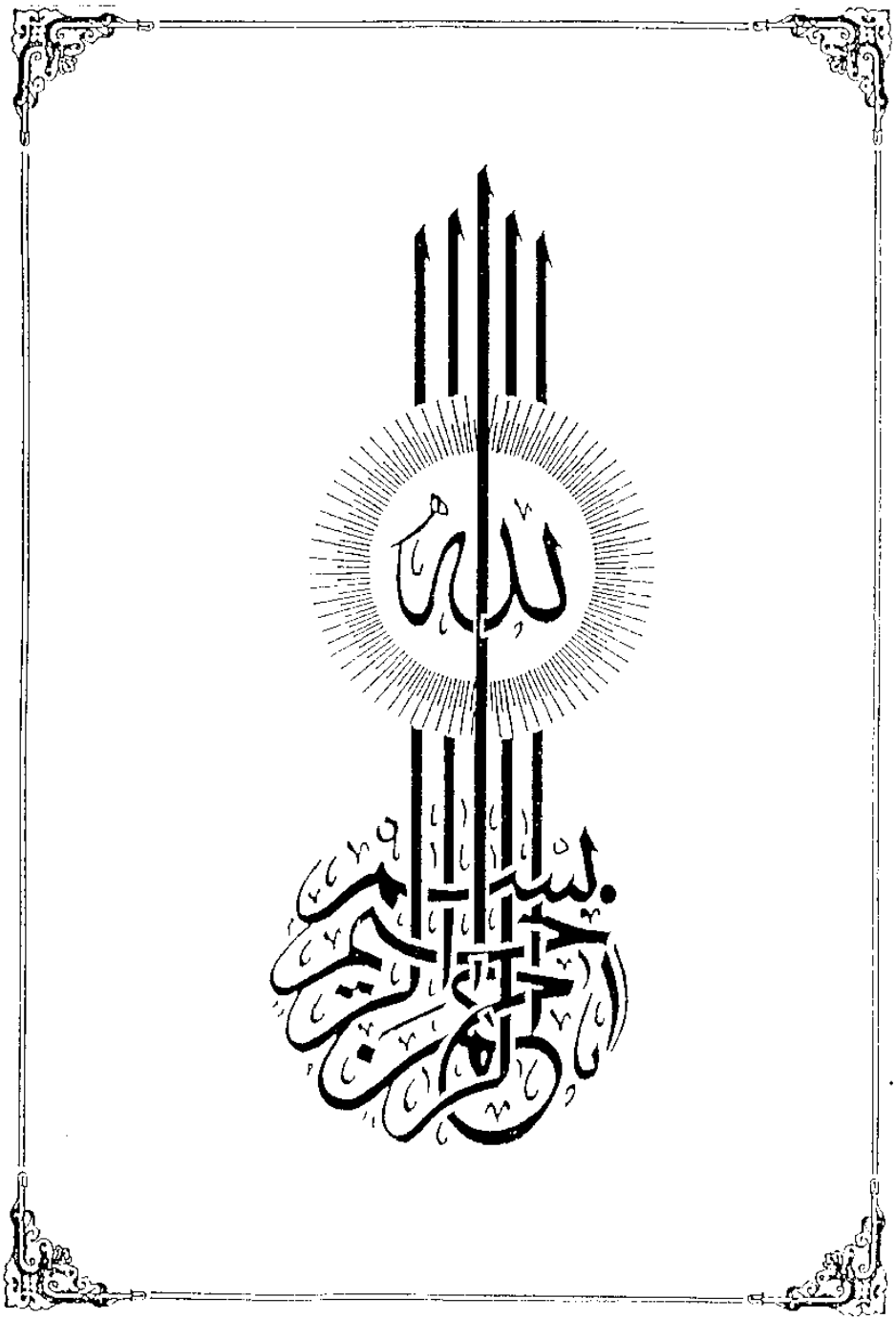

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INTRODUCTION

The healing of fractures, its mechanism and the factors affecting it are essential knowledge for the orthopaedic surgeon to treat fractures properly.

Such knowledge should be based on good informations about certain basic aspects of bone: its hostolog, biochemistry, blood supply and biophysical properties.

In this essay, we will try to focus on these aspects first, then we are going to discuss the process of fracture healing and the factors affecting it. Finally, we will discuss the methods of accelerating fracture healing.

CONTENTS

Chapter One

Histology of bone

HISTOLOGY OF BONE

Bone is a connective tissue with a collagenous protein matrix that has been impregnated with mineral salts specially phosphates of calcium.

Types of bones :

There are two types of bone :

1. Spongy (cancellous) bone :

It consists of bone trabeculae of various shapes and thicknesses branching and anastomosing with each other, leaving between them bone marrow spaces of irregular shapes and sizes. The trabeculae are generally arranged along the lines of maximum stress or tension. The trabeculae are made of varying number of adjoining bone plates, where osteocytes are present within their lacunae communicating with each other by canaliculi (Fig. 1).

2. Compact bone :

It is a continuous bone mass formed of lamellae deposited in a regular manner. It is made up of a large number of haversian systems, between which are interstitial or ground lamellae. On the outer and inner aspects of the compact bone are basic or circumferential lamellae, which are arranged circumferentially in relation to the main bone (Fig. 2). They are penetrated by Volkman's canals, through which nutrient vessels enter the bone to reach the medulla and the

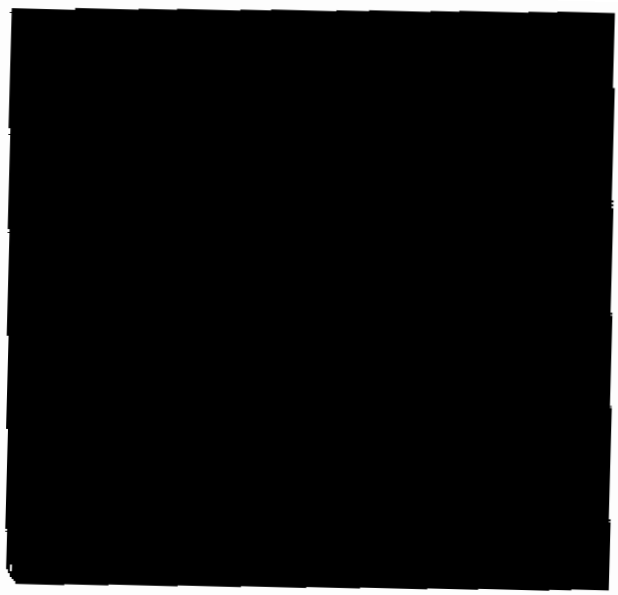

Fig. 1 : Microscopic appearance of a segment of a human rib, showing the bone trabeculae (Gray's Anatomy, 36th ed.).

vessels in the haversian canals. They are not surrounded by concentrically arranged plates (Ham & Cormack, 1979).

The basic structural and functional unit of the mature bone is designated as the haversian system or osteon. It consists of lamellae concentrically arranged about the haversian canal, which is 3-9 mm in length. Within each canal are one or two capillaries and usually some nerve fibers mostly non-myelinated (Williams *et al.*, 1980).

The size of the osteon is limited by the fact that the haversian canal supplies the nutrition to bone cells that cannot survive farther than 0.1 mm away from the capillary. The capillaries in the haversian canal show transcapillary clefts through which water soluble minerals pass to reach the bone crystals (Hughes & Mc Carthy, 1986).

Most haversian systems are directed in the long axis of the bone. Large number of canaliculi pass radially from the canal to the lacunae and intercommunicate with each other. The function is supposedly for diffusion of nutrient fluids toward the osteocytes and waste products toward the nutrient vessels (Fig. 2).

Bones can also be classified as either mature or immature according to the arrangement and relative amounts of the various components of their intercellular substance and by the relative number of osteocytes in relation to the intercellular substance (Ham & Cormack, 1979) :

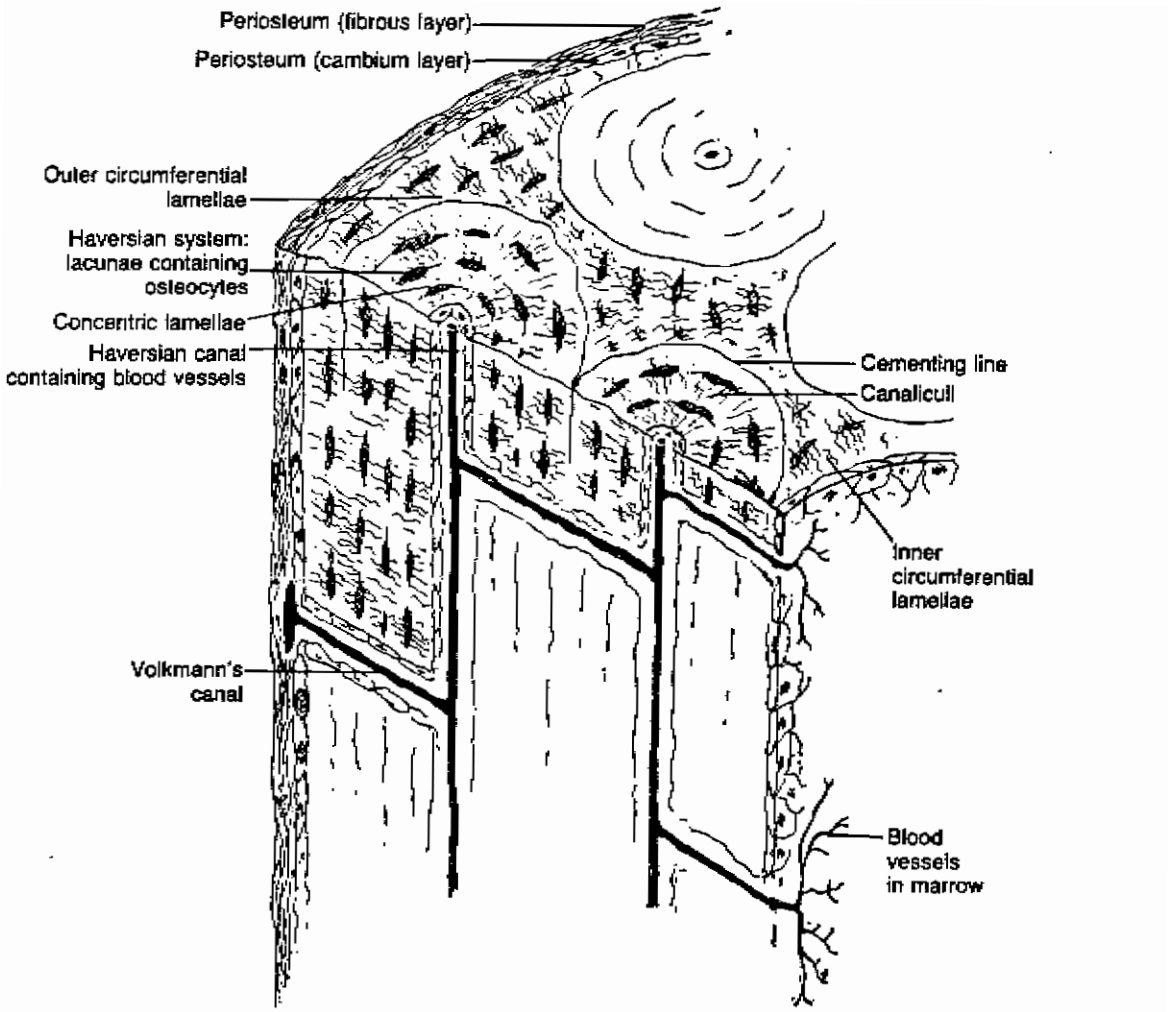

Fig. 2 : A cross and longitudinal section of the cortex of a long bone, showing the haversian systems and Volkmann's canals (Turek. Orthopaedics. 4th ed.).

1. Immature bone (woven bone) :

It has more cells than mature bone and the bundles of collagen fibers of its matrix run in various directions. It contains less calcium. It is formed in three conditions :

a) When bone forms in a sheet of differentiating mesenchyme e.g. in membranous bones e.g. skull, clavicle and mandible.

b) When bone forms in the midst of differentiating granulation tissue. This is seen in fracture healing.

c) In osteogenic bone tumors and other bone disorders (Walter & Israel, 1979).

2. Mature bone (lamellar bone) :

It is characterized by new layers being added to bony surfaces in an orderly way, either in the form of concentric haversian systems or flat plates. The osteoblasts responsible for producing the successive layers of mature bone become incorporated as osteocytes within or between the layers of bone matrix they have formed. Mature bone is formed under three conditions :

a) Whenever there has been a previous model of cartilage.

b) Whenever there has been a previous model of woven bone whether formed during the embryonic life or in fracture healing. Thus, almost all immature bone formed during the embryonic life is replaced by mature bone except in tooth sockets, near cranial sutures and in the osseous

labyrinth where immature bone persists.

c) Once lamellar bone has been formed, its progressive growth and remodelling result in mature bone formation (Walter & Israel, 1979).

Distribution of bone types :

Both types of bones (spongy and compact) are present in almost every bone. In typical long bones, the diaphysis consists of a wall of compact bone enclosing a large cylindrical bone marrow cavity. The epiphysis (end of bone) consists of spongy bone with outer wall of compact bone, the articular end of which is covered by articular cartilage. In a growing bone the epiphyseal cartilage plate from which longitudinal growth occurs, lies between the epiphysis and the diaphysis. The metaphysis (spongy bone directly beneath the epiphyseal plate) is composed of the most recently formed bone arising out of the growth process at the plate before its closure.

In flat bones e.g. the skull, the inner and outer layers of compact bone (tables) enclose a spongy bone (diploe). In small bones e.g. carpals, the outer wall of compact bone encloses spongy bone (Turek, 1984).

Components of bone :

The periosteum :

The periosteum is the membrane which covers the outer surface of the bone except where it articulates with other bones. It plays an active role in fracture healing and growth. It is subdivided into an outer layer which is thin, made of irregularly arranged connective tissue containing some fibroblasts, and an inner layer known as the cambium layer which is looser in composition, and is more vascular and contains osteogenic cells which are flattened, spindle-shaped cells (Fig. 3).

Sharpy's fibers are thick bundles of collagenous fibers that pass from the periosteum into the basic external circumferential lamellae, they fix the periosteum firmly to the surface of the bone, particularly where tendons and muscles attach to the bone. The periosteum contains blood vessels some of which enter and leave the bone.

The periosteum and its blood supply have been found to have great importance for bony union, and they are essential if the medullary circulation has been destroyed (e.g. by an intramedullary nail).

The periosteum has a much greater osteogenic potential in child than in adult. This is important in the fracture healing process since nonunion is very rare in children. When periosteum is stripped away from the bone, it carries

Fig. 3 : The microscopic appearance of the resting periosteum showing the thick fibrous layer (Fib. L.) and the osteogenic layer (Os.L.). (Ham's Histology, 8th ed.).