ALL ABOUT JOINTS

A Maintenance Guide

Irwin M. Siegel, M.D.

All About Joints

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"A good clinical teacher is himself a medical school."
Oliver Wendell Holmes (1809–1894)

This book is dedicated to my many teachers,
particularly the late Drs. Harold Sofield and Manley Page.

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Preface

All About Joints completes a trilogy. The first volume in our musculoskeletal journey was *All About Bone* (Demos, 1998) and the second was *All About Muscle* (Demos, 2000). Each of these books was written to provide the intelligent reader with practical information about his or her bones in the first place, and muscles in the second, to enable him or her to keep these systems in the best of health. However, the ultimate dynamic purpose of bone and muscle is to create and activate joints. Hence this book, *All About Joints*—the third and final part of this musculoskeletal troika.

The purpose of this book, similar to that of its predecessors, is to inform and instruct the reader. In this case, the subject is the many important skeletal articulations that enable a child to walk, an Olympic gold medalist to excel, or a virtuoso to play the violin. Along the way, we take a look at the development, anatomy, and physiology of our joints, learning enough to enable our understanding of how they work and what we should do to keep them in shape. We survey each major joint from head to toe. Injuries and common diseases are covered, as are such important matters as diet and exercise. While reading the book, questions are encouraged, and every effort will be made to answer them.

In the past decade, modern medical science created an orthopaedic armamentarium capable of replacing almost any joint in the body. Proceeding pari passu with advances in material science and biomechanical engineering, joints are now available for the shoulder, elbow, wrist, hand, hip, knee, ankle, and foot. The cutting edge of current research deals with biological constructs such as the transplantation of cartilage into a degenerated knee. Other studies focus on artificial substitutes for bone and ligament. Arthroscopic techniques for repair of injury are now available for many joints. Imaging, including enhanced MRI and three-dimensional CT scanning, can reveal the detail of a joint's interior with noninvasive technology.

All About Joints is, of course, not only about joints because our joints, in one way or another, interface with almost every other organ system of our body. The book was written to collate and integrate much practical information, which the author hopes will be of value to anyone more than just curious about his or her body works and how to keep it working in top form.

Foreword

Irwin M. Siegel, M.D., has provided the public with yet another excellent resource to add to their knowledge of the human anatomy. In his new book, *All About Joints*, Dr. Siegel offers a concise, easy-to-understand guide to the normal and disease states of human skeletal joints. With concise, easy-to-understand language, the reader is given expert advice on the management of a wide spectrum of joint conditions running the gamut from simple sprains, osteoarthritis, and gout to the complexities of rheumatoid arthritis.

Dr. Siegel draws from his vast experience spanning over forty years as an outstanding orthopaedic surgeon in Chicago. His interest in educating the public on topics related to orthopaedics and human anatomy is most evident in his two previous books *All About Bone* (1998) and *All About Muscle* (1999). He continues to provide a service to the public with this newest praiseworthy book, *All About Joints*. Carefully written and well-illustrated, it will be another beneficial guide for the layperson who seeks to learn more about joint disorders.

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Introduction

BONES AND JOINTS: A HISTORICAL OVERVIEW

During our lives, our bones and joints provide us with a dynamic skeleton, produce and store blood cells, hold and distribute minerals, and furnish form and support for our bodies. After we are gone, our skeletons are museums of much of what has transpired in our lives. Disease, use, and injury leave indelible marks on our bones and joints. A man buried by the eruption of Vesuvius 1,900 years ago was found with a sword by his side. His arm bones had been enlarged by years of carrying a shield in one hand and throwing a spear with the other hand. His knees were adapted to a horseman's muscles. We already knew that the Romans had a professional military, including cavalry, but if we did not, these bones would certainly bear testimony to this fact.

Harris lines, where bone is compacted similar to the lines in a tree trunk, appear in a growing bone when growth resumes after a period of malnutrition or illness. The distance from the end of the bone at the joint tells us when a Harris line was formed, and this can be correlated with the age of the individual at that time. Both chronically malnourished and well-nourished people show few Harris lines. The former rarely recover fully, and the latter have nothing from which to recover. A similar banding in tooth enamel—Wilson's bands—also reflects illness or stress in the growing years.

Wilson's bands, Harris lines, and dental caries all increase dramatically in Amer-Indians who depended heavily on maize for food as compared with other more nutritious grains. Another striking change in ancient skeletons is a general decrease in height after agriculture replaced hunter-gathering.

Study of the bones of some prehistoric Americans reveals that infant mortality was lower than in many poor, modern societies. Mortality peaked at ages 6 to 12 and 20 to 30 years. Life is apparently threatened after weaning, possibly by nutritional stress, and in early adulthood, no doubt by combat, hunting, and child-bearing. Nonetheless, many individuals survived both periods of life; skeletons have been found in England of Neanderthals, and almost 50 percent of their skulls bear marks of injury, many from stone axes. Researchers have also found well-healed fractures in chimpanzees and gorillas. When broken, bone heals with bone, not with a scar, a trait that sets it apart from almost all other body tissue.

Although the skeleton has served as a poignant reminder of death (pirates sailing under the skull and crossbones, and the dreaded Nazi SS wearing a white death's head on his uniform), bones were believed to be endowed with magical powers. In ancient Russia, burglars would fill a shin bone with marrow and hold this macabre candle aloft, circling a house in the hope of putting its inhabitants into a deathly slumber. They also carved flutes from leg bones and played them to mesmerize their marks. Some Australian aborigines severed the arm bone of their dead, in which they believed the spirit dwelled. They buried the rest of the skeleton and then, with elaborate ceremony, broke the arm bone, freeing the imprisoned spirit without incurring risk to the living or dead.

In many cultures, people have shaped bone and joint to their concept of what is beautiful. Skulls can be molded and elongated from birth, as was done by the Chinook Indian tribe of the Pacific Northwest. Such a sculptured skull was a mark of nobility, serving as a sign of elevated social rank. Although seldom practiced today, this custom has its modern equivalent in fancy hairstyling. The Chinese custom of binding women's feet, prized for its erotic appeal, provided dainty feet and a mincing step, but crippled the women treated in this way. The Chinese "lotus foot" has its contemporary counterpart in ultra-high-heeled shoes.

Old English folk tales relate that, in punishment for the twelfth century murder of Thomas à Becket, the Archbishop of Canterbury, the people of Kent were cursed to be born with tails, a sign of kinship with the devil. Every human being does, in fact, have the vestige of a tail. It is tucked under the sacrum (sacred bone), with which it articulates through a small joint, and called the coccyx (cuckoo = "bill"). The coccyx is composed of four fused vertebrae and is the only portion of the spinal column without a function. It can be bruised or broken during a fall and sometimes has to be removed because of persistent pain at the sacrococcygeal joint.

Ancient treatment for bone and joint injury began on the battlefield. In *The Iliad*, Homer describes 147 wounds, often in precise clinical language. *The Smith Papyrus*, composed about 1650 B.C., is one of the first known medical texts. It contains information on how to treat 48 wounds and injuries to bones and joints. It is thought to express the wisdom of Imhotep, a physician who learned his art healing workers injured building the Pyramids he designed.

A professor of medicine in Paris, Nicholas André, coined the term *orthopaedics* from the Greek word "orthos" (straight) and "paidios" (child). André spent his career devising means to correct bone and joint deformity.

The largest animal ever to live, the blue whale, can weigh up to 150 tons. Nonetheless, it moves with the grace of a feather floating on air because the ocean buoys its weight by meeting it with equal force to provide external support. But out of water, large animals such as dinosaurs rely solely on their skeletons for support. Like their cousins who live in the sea, birds (the direct descendants of dinosaurs) and mammals must conquer the force of gravity. The bones and joints of the bird are designed for flight, being as light and streamlined as possible. The elephant, the largest of land animals, can reach a weight of eight tons. To sustain its weight, an elephant's bones are as sturdy as tree trunks. By contrast, the femur, the longest and strongest of human bones, can resist a compressive force of 1,200 pounds per cubic inch when we walk. Although bone has the power to remodel and reshape itself under stress, it will break when tension exceeds 10 tons per square inch.

Bone derives its strength by weaving protein and mineral into a resilient fabric. Ninety-nine percent of the calcium and 85 percent of all the phosphorus in the body is found in the bones. An elastic protein called *collagen* is ounce-for-ounce stronger than steel when blended with bony crystals. After the minerals in the bone are removed, the bone becomes so rubbery that it can be tied into a knot like a garden hose. Try placing a chicken bone in a jar of vinegar. The acetic acid will leach out the minerals, leaving a bone that can be bent and twisted like a string. Scientists believe that the mineral crystals somehow seal the bone, protecting collagen from decomposition. A close artificial analogue to bone is fiberglass, which is made of slender glass threads embedded in epoxy.

Bone is the only tissue containing cells that destroy its structure (osteoclasts = Gr. bone, to break) as well as cells that build it up (osteoblasts = Gr. bone, germ). Throughout life, bone regenerates and repairs itself through an endocrine-driven system. Any disruption of this process can lead to a variety of metabolic bone diseases, including osteoporosis, rheumatoid arthritis, Paget's disease, and periodontal pathology.

In addition to providing support, small piezoelectric currents are transmitted in bones at points of compression. Bone may act as a kind of generator, translating mechanical forces into electrical response. Utilizing this knowledge, devices that generate magnetic currents are used to speed healing in broken bones and joints.

Although ancient bones and joints have provided information regarding our planet, the prehistory of the Earth, as well as human ancestry, it is a good thing that bones and joints do eventually decompose. It has been estimated that the total weight of all living things that have ever inhabited the Earth equals the weight of the planet itself! If bones did not decompose, every square foot of dry land would be piled yards high in skeletal remains.

Leonardo Da Vinci's experience in engineering led him to consider the skeleton as a set of rigid levers. From his understanding of the function of muscles, da Vinci deduced the operation of these levers. This genius of the Renaissance created models of joints to gain a deeper understanding of their function.

The skeleton's most important role is that of support. However, *articulations* are necessary to orchestrate movement. For example, consider the adult spine, engineered for both strength and flexibility. Its 33 vertebrae, separated by flexible discs, are gracefully curved to facilitate the upright posture. These vertebrae have become specialized, with differences dictated by requirements for movement. The adult spinal discs absorb shock and allow motion between the vertebrae. The spinal column crosses the line of gravity, its curve providing more stability and strength than if the spine were straight. The spine has adapted to our erect stance, allowing us to walk on two feet, freeing our hands for tasks more complicated than bearing weight. Anthropologists believe that bipedalism (two-legged walking) has led to an increase in the size of the human brain.

With this brief overview of some of the history of bones and joints, we begin our review of the wonderful skeletal structures that distinguish us from lower life forms and enable us to experience the joys and rewards of highly controlled movement.

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Joints By and Large

> "This frame, compacted with transcendent skill,
> of moving joints, obedient to my will . . ."
>
> *John Arbuthnot*
> *Know Yourself*

The need for strength requires bones to be rigid. However, movement would be almost impossible if our skeletons were solid bone. Nature has solved this problem in vertebrates, including humans, by casting the skeleton into many bones and creating joints where they intersect. Joints are custom-formed to serve the functional needs of the limbs that contain them. They are held together by fibrous tissue (capsule and ligaments) and continuously lubricated to offset friction. In this way joints permit motion, which grants us humans a much more complex repertoire of movement than, say, most insects, spiders, and crustaceans, which, like the joints in your fingers, move only in one plane. However, we are not quite as versatile as invertebrates and certain millipedes, which can rotate one skeletal ring upon the next, curving their axis in any direction, even walking with their legs on the ground at a right angle to their coiled position.

The words *articulation* (L. articulatio—the junction between bones) and *joint* (L. junctio—a joining or connection) are used synonymously to refer to those structural arrangements that connect two or more bones. Although most joints permit at least some movement between the bones they connect, this is not essential for a connecting structure to be called a joint. The function of some joints is to allow the joined

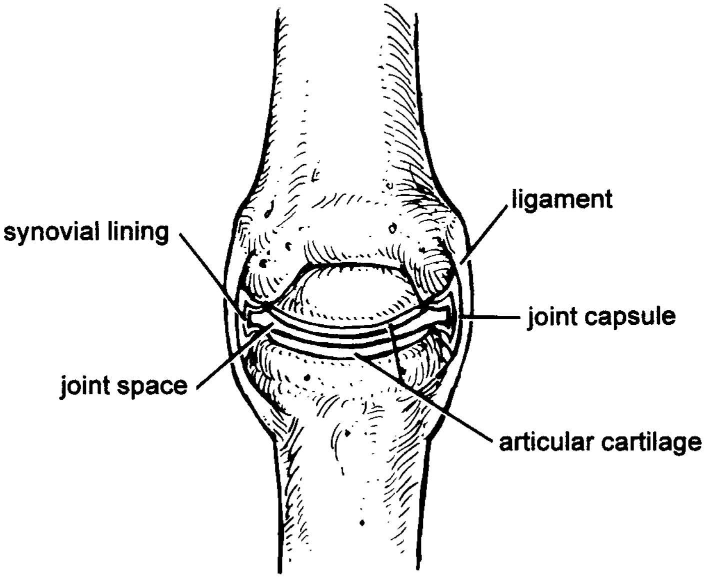

FIGURE 1-1 Components of a typical joint.

structures to grow until they in turn become as solid as the bones they connect.

Where joints are immovable, as in the articulations between the bones of the growing skull, the adjacent margins of the bone are separated merely by a thin layer of fibrous tissue. Where slight movement but great strength is required, the joint surfaces are united by tough elastic fibrocartilages, as in the joints between the vertebral bodies. In freely movable joints, such as the shoulder or knee, the surfaces are completely separated and the bones expanded for greater convenience of mutual connection. They are covered by *cartilage* and enveloped by fibrous tissue capsules.

ARTICULAR CARTILAGE

Articular cartilage is of a type called *hyaline* (glasslike) cartilage because thin sections of it are translucent or even transparent to light. In contrast to bone, it is easily cut. It is deformable under pressure, but elastic so that it quickly recovers its shape. These properties are important for its function under conditions of *loading* (bearing weight). A membrane lines the interior of such joints.

This *synovial* (Gr. syn.—together; L. ovum—egg) membrane secretes a thick viscous liquid that lubricates the joint. It also regulates protein and electrolyte (ionic or electrically charged molecule) metabolism in the joint and removes waste from the joint.

Joints are strengthened by *ligaments*, strong fibrous bands that connect the bones that form the joint (Fig 1.1).

DEVELOPMENT

Bone and joint both develop from the middle layer of tissue in the embryo. Circumscribed condensation of cells in this mesoderm (middle skin) become chondrified (turned into cartilage) and finally ossified (turned into bone) to form the bones of the skeleton. The intervening noncondensed portions of tissue develop into joints.

As soon as the joint cavity appears during development, it contains watery fluid. The tissue surrounding the original mesodermal cellular core forms fibrous sheaths for the developing bones, which continue between their ends as the capsules of the joints. Ligaments develop both in these capsules and as derivations from tendons surrounding the joint. After the joint cavity is established during the third month of gestation, the muscles that move the joint begin to contract. This movement enhances nutrition of the articular cartilage and prevents fusion of the apposed joint surfaces. Early restriction of joint motion can result in permanent loss of the joint cavity, whereas later restriction can lead to abnormalities of the soft tissues associated with the joint. Because normal positioning of the fetus in the uterus permits a fair degree of movement of the upper limbs but restricts the legs—which are folded and pressed firmly against the body—the lower limbs are more vulnerable to *congenital* (found at birth) joint deformity such as clubfoot or congenital hip dislocation. In several of the movable joints, a portion of the mesodermal tissue that originally existed between the ends of the bones persists and forms an *articular disc*. An example of this is the *menisci* (cartilages) of the knee joint.

TYPES OF JOINTS

There are various types of joints. The skull type is immovable, the vertebral type is slightly movable, and the limb type is freely movable. Joints of the skull are temporary until they fuse, those of the vertebrae are secure, and limb type joints or synovial articulations, although freely movable, are insecure. Immovable joints are called *synarthroses*, slightly movable joints are labeled *amphiarthroses*, and freely movable joints are called *diarthroses*.

The greatest number of joints in the body are diarthroses. Varieties of these joints have been determined by the kind of motion each allows. Joints permit:

- ❏ *gliding* movement
- ❏ *flexion*, where the angle between adjoining bones is decreased, as when the forearm is moved forward and upward
- ❏ *extension*, where the angle between adjoining bones is increased, as when the forearm is straightened
- ❏ *abduction*, when an extremity is moved away from the body or adduction, when an arm or leg is moved toward the body
- ❏ *circumduction* (circular movement), best seen in ball-and-socket joints
- ❏ *rotation*, where a bone moves around a central axis without undergoing any displacement.

Some examples of *hinge joints* are the elbow and the knee; *ball-and-socket joints*, the shoulder and hip; *gliding joints*, the small bones of the foot and the wrist, the ribs, and the vertebrae. A *saddle joint*, which permits movement in two directions, unites the thumb with the hand.

MECHANICS

Bones in a freely movable joint articulate in pairs, each pair distinguished by its own pair of conarticular surfaces. These surfaces constitute “mating pairs.” Each mating pair consists of a “male” surface and a “female” surface. Following an engineering convention, a joint surface is called male if it is convex and female if it is concave.

In all positions of a diarthrosis—except one—the conarticular surfaces fit imperfectly. Such incongruence is not great and

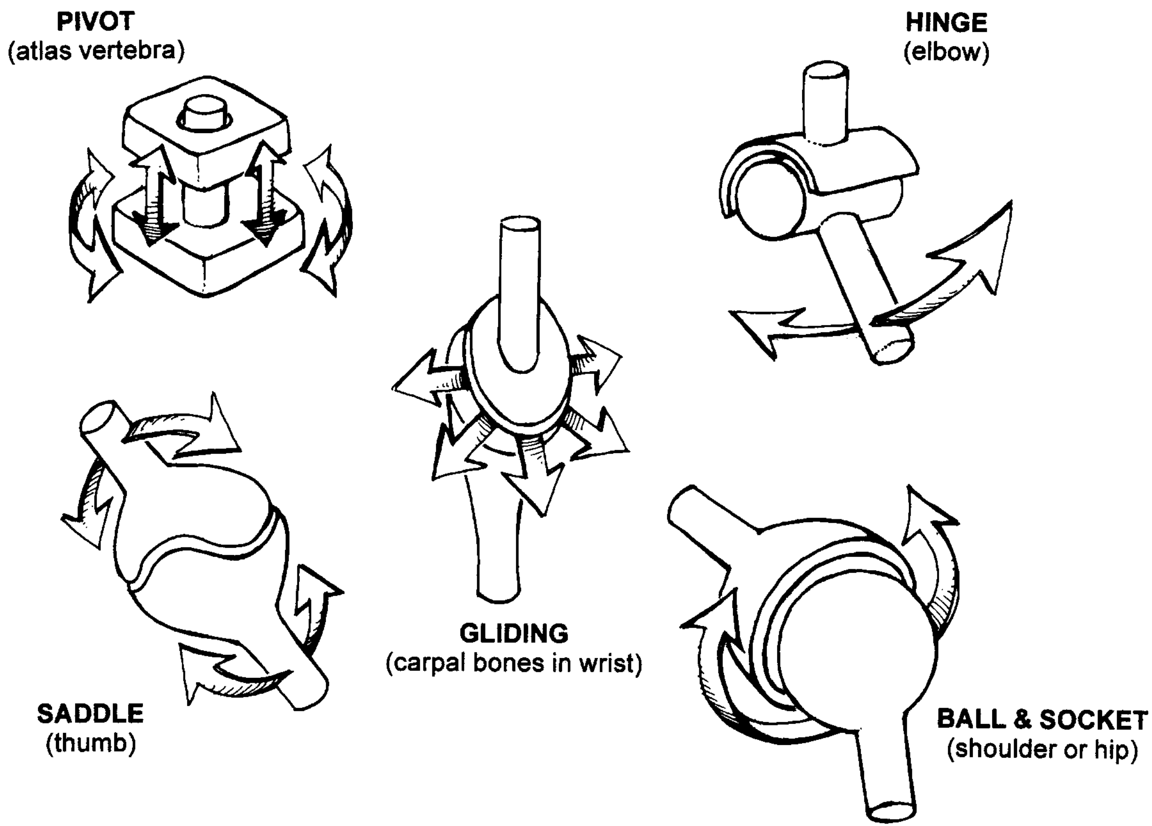

FIGURE 1-2 Some joint types.