INTRODUCTION

A joint or articulation (or articular surface) is the connection made between bones in the body which link the skeletal system into a functional whole. They are constructed to allow for different degrees and types of movement. Some joints, such as the knee, elbow, and shoulder, are self-lubricating, almost frictionless, and are able to withstand compression and maintain heavy loads while still executing smooth and precise movements. Other joints such as sutures between the bones of the skull permit very little movement (only during birth) in order to protect the brain and the sense organs. The connection between a tooth and the jawbone is also called a joint, and is described as a fibrous joint known as a gomphosis. Joints are classified both structurally and functionally.

CLASSIFICATION OF JOINT

Joints are mainly classified structurally and functionally. Structural classification is determined by how the bones connect to each other, while functional classification is determined by the degree of movement between the articulating bones. In practice, there is significant overlap between the two types of classifications.

A facet joint is the joint between two articular processes between two vertebrae.

Structural classification (binding tissue)

Structural classification names and divides joints according to the type of binding tissue that connects the bones to each other. There are three structural classifications of joints:

- fibrous joint – joined by dense regular connective tissue that is rich in collagen fibers
- cartilaginous joint – joined by cartilage
- synovial joint – not directly joined – the bones have a synovial cavity and are united by the dense irregular connective tissue that forms the articular capsule that is
normally associated with accessory ligaments.

**Functional classification (movement)**

Joints can also be classified functionally according to the type and degree of movement they allow: Joint movements are described with reference to the basic anatomical planes.

- **synarthrosis** – permits little or no mobility. Most synarthrosis joints are fibrous joints (e.g., skull sutures).
- **amphiarthrosis** – permits slight mobility. Most amphiarthrosis joints are cartilaginous joints (e.g., intervertebral discs).
- **synovial joint** (also known as a *diarthrosis*) – freely movable. Synovial joints can in turn be classified into six groups according to the type of movement they allow: plane joint, ball and socket joint, hinge joint, pivot joint, condyloid joint and saddle joint.

Joints can also be classified, according to the number of axes of movement they allow, into nonaxial (gliding, as between the proximal ends of the ulna and radius), monoaxial (uniaxial), biaxial and multiaxial. Another classification is according to the degrees of freedom allowed, and distinguished between joints with one, two or three degrees of freedom. A further classification is according to the number and shapes of the articular surfaces: flat, concave and convex surfaces.¹ Types of articular surfaces include trochlear surfaces.
Biomechanical classification

Joints can also be classified based on their anatomy or on their biomechanical properties. According to the anatomic classification, joints are subdivided into simple and compound, depending on the number of bones involved, and into complex and combination joints:

1. Simple joint: two articulation surfaces (e.g. shoulder joint, hip joint)
2. Compound joint: three or more articulation surfaces (e.g. radiocarpal joint)
3. Complex joint: two or more articulation surfaces and an articular disc or meniscus (e.g. knee joint)

Fibrous Joints

The bones of fibrous joints are held together by fibrous connective tissue. There is no cavity, or space, present between the bones, so most fibrous joints do not move at all.

There are three types of fibrous joints: sutures, syndesmoses, and gomphoses. Sutures are found only in the skull and possess short fibers of connective tissue that hold the skull bones tightly in place.
Sutures

Sutures are fibrous joints found only in the skull.

Syndesmoses are joints in which the bones are connected by a band of connective tissue, allowing for more movement than in a suture. An example of a syndesmosis is the joint of the tibia and fibula in the ankle. The amount of movement in these types of joints is determined by the length of the connective tissue fibers. Gomphoses occur between
teeth and their sockets; the term refers to the way the tooth fits into the socket like a peg.

The tooth is connected to the
socket by a connective tissue called the periodontal ligament. Fibrous joints classified as synarthroses, or immovable, include: sutures, gomphoses, and synchondroses

Gomphoses

*Gomphoses are fibrous joints between the teeth and their sockets.*

**Cartilaginous Joints**

Cartilaginous joints are those in which the bones are connected by cartilage. There are two types of cartilaginous joints: synchondroses and symphyses. In a synchondrosis,
the bones are joined by hyaline cartilage. Synchondroses are found in the epiphyseal plates of growing bones in children. In symphyses, hyaline cartilage covers the end of the bone, but the connection between
bones occurs through fibrocartilage. Symphyses are found at the joints between vertebrae and between the pubic bones. Amphiarthroses allow only slight movement; therefore, either type of cartilaginous joint is an amphiarthrosis.

**Synovial Joints**

Synovial joints are the only joints that have a space between the adjoining bones. This space, referred to as the synovial (or joint) cavity, is filled with synovial fluid. Synovial fluid lubricates the joint, reducing friction between the bones and allowing for greater movement. The ends of the bones are covered with articular cartilage, a hyaline cartilage. The entire joint is surrounded by an articular capsule composed of connective tissue. This allows movement of the joint as well as resistance to dislocation. Articular capsules may also possess ligaments that hold the bones together. Synovial joints are capable of the greatest movement of the three structural joint types; however, the more mobile a joint, the weaker the joint. Knees, elbows, and shoulders are examples of synovial joints. Since they allow for free movement, synovial joints are classified as diarthroses.
Characteristic of Synovial Joint

Synovial joints are most evolved and therefore most mobile type of joints. They possess the following characteristic features:

- There articular surfaces are covered with hyaline cartilage. This articular cartilage is avascular, non nervous and elastic. Lubricated with synovial fluid, the cartilage forms slippery surfaces for free movements.

- Between the articular surfaces there is a joint cavity filled with synovial fluid. The cavity may be partially or completely subdivided by an articular disc known as
• The joint is surrounded by an articular capsule which is fibrous in nature and is lined by synovial membrane. Because of its rich nerve supply the fibrous capsule is sensitive to stretches imposed by movements.

• The synovial membrane lines the entire joint except the articular surfaces covered by hyaline cartilage. It is this membrane that secretes the slimy fluid called synovial fluid which lubricates the joint and nourishes the articular cartilage.

• Varying degrees of movements are always permitted by the synovial joints.

**Types of synovial joints:**

![Diagram of Types of Synovial Joints]

Scheme of Types of Synovial Joints

Synovial joints are of the following types;

**Plane synovial joints:**

The articular surfaces of plane synovial joints are more or less plane. These joints permit gliding movements in various directions. Examples are intercarpal joints, intertarsal join
ts, and joints between the articular processes of vertebrae.

**Plane Synovial Joints of Carpus**

**Hinge joints:**

In these joints the articular surfaces are pulley shaped. There are strong collateral ligaments to provide stability to the joint. Movements are permitted in one plane around a transverse axis. Examples are elbow joint, ankle joint, interphalangeal joint.
Hinge Joint (Elbow Joint)

**Pivot joints:**

Pivot joints are formed by a central bony pivot surrounded by an osteo-ligamentous ring. Movements are permitted in one plane around a vertical axis. Examples of this type are superior and inferior radioulnar joints and the median atlantoaxial joint.

Proximal Radioulnar Joint

**Condylar joints:**
These are also known as bicondylar joints. There articular surfaces consist of two distinct condyles in which one is convex surface (called the male surface) fitting into a concave surface (called the female surface) of the other bone. These joints mainly permit the movement in plane around a transverse axis. Example of this type of joints is knee joint.
Knee Joint (Posterior View)

**Ellipsoid joints:**

In this case the articular surfaces include an oval convex male surface fitting into an ellipsoid female surface. The movements are permitted around two axis; flexion and extension around the transverse axis and adduction and abduction round antero-posteri or axis. Combination of these movements produces Circumduction. Typical rotation around a third vertical axis does not occur. Examples of this type of joints are wrist joint, metacarpophalangeal joint and atlanto-occipital joint.
Wrist Joint (ellipsoid Joint)

**Saddle joints:**

Articular surfaces are reciprocally concavo-convex. Movements are similar to those permitted by ellipsoid joint with addition of some rotation (conjunct rotation) which accompany
other movements)) around a third axis which occurs independently. Examples of this type of joints are first carpometacarpal joint, sternoclavicular joint, calcaneocuboid joint

Saddle Joint

**Ball and socket joints:**

These are also called spheroidal joints. There articular surfaces include a globular head fitting into a cup shaped socket. Movement occurs around an indefinite number of axes which have common center. Flexion, extension, abduction, adduction, rotation, Circumd uction all occur quite freely. Examples of this type of joints are shoulder joint, hip joint and talo-calcaneonavicular joint.
Ball and Socket Joint (Hip Joint)

MOVEMENT AT SYNOVIAL JOINT

Supination
the action of rotating the forearm so that the palm of the hand is turned up or forward

**Abduction**

moving a bone away from the midline of the body

**Adduction**

the movement of a bone toward the midline of the body

**Pronation**

the action of rotating the forearm so that the palm of the hand is turned down or back

**Blood supply of Synovial Joints:**

The articular and epiphyseal branches given off by the neighboring arteries form a peri-articular arterial plexus. Numerous vessels from this plexus pierce the fibrous capsule and form a rich vascular plexus in the deeper part of the synovial membrane. The blood vessels of the synovial membrane terminate around the articular margins in a fringe of looped anastomoses termed the circulus vasculosus (circulus articularis vasculosus). It supplies the capsule, synovial membrane and the epiphyses. The articular cartilage is avascular.

After epiphyseal fusion in growing long bones the communications between the circulosus vasculosus and the end arteries of the metaphysis are established thus minimizing the chances of osteomyelitis in the metaphysis.

**Lymphatic drainage of synovial joints:**

Lymphatics form a plexus and the subintima of the synovial membrane and drain along the blood vessels to the regional deep nodes.

**Stability of synovial joints:**

The various factors maintaining the stability at a joint are described below in order of their importance;

1. **Muscles:** The tone of different groups of muscles acting on the joint is the most important and indispensable factor in maintaining the stability. Without muscles,
the knee and shoulder would have been unstable and the arches of foot would have collapsed.

2. **Ligaments:** These are important in preventing any over movement and in guarding against sudden accidental stresses. However they do not help against a continuous strain because once stretched, they tend to remain elongated. In this respect the elastic ligaments (ligament flava and the ligaments of the joints of auditory ossicles) are superior to the common type of white fibrous ligaments.

3. **Bones:** They help in maintaining the stability only in firm type of joints like the hip and ankle joints. Otherwise in most of the joints there role is negligible.

**SHOULDER JOINT**

The **shoulder joint** (or **glenohumeral joint**) from Greek *glene*, eyeball, + -oid, ‘form of’, + Latin *humerus*, shoulder) is a multiaxial synovial ball and socket joint and involves articulation between the glenoid cavity of the scapula (shoulder blade) and the head of the humerus (upper arm bone).
Due to the very loose joint capsule that gives a limited interface of the humerus and scapula, it is the most mobile joint of the human body.
The shoulder joint is a ball and socket joint between the scapula and the humerus. However, the socket of the glenoid cavity of the scapula is itself quite shallow and is made deeper by the addition of the glenoid labrum. The glenoid labrum is a ring of cartilaginous fibre attached to
the circumference of the cavity. This ring is continuous with the tendon of the biceps brachii above.

Between the associated muscles of the shoulder is an anatomic space called the axillary space which transmits the subscapular artery and axillary nerve.

**Capsule**

The shoulder joint has a very loose joint capsule known as the articular capsule of the humerus and this can sometimes allow the shoulder to dislocate. The long head of the biceps brachii muscle travels inside the capsule from its attachment to the supraglenoid tubercle of the scapula. Because the tendon of the long head of the biceps brachii is inside the capsule, it requires a tendon sheath to minimize friction.

**Muscles**

The shoulder joint is a muscle-dependent joint as it lacks strong ligaments. The primary stabilizers of the shoulder include the biceps brachii on the anterior side of the arm, and tendons of the rotator cuff; which are fused to all sides of the capsule except the inferior margin. The tendon of the long head of the biceps brachii passes through the bicipital groove on the humerus and inserts on the superior margin of the glenoid cavity to press the head of the humerus against the glenoid cavity. The tendons of the rotator cuff and their respective muscles (supraspinatus, infraspinatus, teres minor, and subscapularis) stabilize and fix the joint. The supraspinatus, infraspinatus and teres minor muscles aid in abduction and external rotation of the shoulder while the subscapularis aids in internal rotation of the humerus.

**Ligaments**

- Superior, middle and inferior glenohumeral ligaments
- Coracohumeral ligament
- Transverse humeral ligament
- Coraco-acromial ligament

**Movements**
• Flexion and extension of the shoulder joint in the (sagittal plane). Flexion is carried out by the anterior fibres of the deltoid, pectoralis major and the coracobrachialis. Extension is carried out by the latissimus dorsi and posterior fibres of the deltoid.

• Abduction and adduction of the shoulder (frontal plane). Abduction is carried out by the deltoid and the supraspinatus in the first 90 degrees. From 90-180 degrees it is the trapezius and the serratus anterior. Adduction is carried out by the pectoralis major, latissimus dorsi, teres major and the subscapularis.

• Horizontal abduction and horizontal adduction of the shoulder (transverse plane)

• Medial and lateral rotation of shoulder (also known as internal and external rotation). Medial rotation is carried out by the anterior fibres of the deltoid, teres major, subscapularis, pectoralis major and the latissimus dorsi. Lateral rotation is carried out by the posterior fibres of the deltoid, infraspinatus and the teres minor.

• Circumduction of the shoulder (a combination of flexion/extension and abduction/adduction).

Clinical significance
The capsule can become inflamed and stiff, with abnormal bands of tissue (adhesions) growing between the joint surfaces, causing pain and restricting movement of the shoulder, a condition known as frozen shoulder or adhesive capsulitis.

A SLAP tear (superior labrum anterior to posterior) is a rupture in the glenoid labrum. SLAP tears are characterized by shoulder pain in specific positions, pain associated with overhead activities such as tennis or overhand throwing sports, and weakness of the shoulder. This type of injury often requires surgical repair.

Anterior dislocation of the glenohumeral joint occurs when the humeral head is displaced in the anterior direction. Anterior shoulder dislocation often is a result of a blow to the shoulder while the arm is in an abducted position. It is not uncommon for the arteries and nerves in the axillary region to be damaged as a result of a shoulder dislocation; which if left untreated can result in weakness, muscle atrophy, or paralysis.

Subacromial bursitis is a painful condition caused by inflammation which often presents a set of symptoms known as subacromial impingement.

**ELBOW JOINT**

In primates, including humans, the elbow joint is the synovial hinge joint between the humerus in the upper arm and the radius and ulna in the forearm which allows the hand to be moved towards and away from the body. The superior radioulnar joint shares joint capsule with the elbow joint but plays no functional role at the elbow. The elbow region includes prominent landmarks such as the olecranon (the bony prominence at the very tip of the elbow), the elbow pit, and the lateral and medial epicondyles. The name for the elbow in Latin is *cubitus*, and so the word cubital is used in some elbow-related terms, as in *cubital nodes* for example.
Capsule of elbow-joint (distended). Anterior and posterior aspects.

The elbow joint and the superior radioulnar joint are enclosed by a single fibrous capsule. The capsule is strengthened by ligaments at the sides but relatively weak in front and behind. On the anterior side the capsule consists mainly of longitudinal fibres. However, some bundles among these fibers run obliquely, thicken and strengthen the capsule, and are referred to as the capsular ligament. Deep fibres of the brachialis muscle insert anteriorly into the capsule and act to pull it and the underlying membrane during flexion in order to prevent them from being pinched.

On the posterior side the capsule is thin and mainly composed of transverse fibres. A few of these fibres stretch across the olecranon fossa without attaching to it and form a transverse band with a free upper border. On the ulnar side, the capsule reaches down to the posterior part of the annular ligament. The posterior capsule is attached to the triceps tendon which prevents the capsule from being pinched during extension.

Synovial membrane

The synovial membrane of the elbow joint is very extensive. On the humerus, it extends up from the articular margins and covers the coronoid and radial fossae anteriorly and the olecrano
n fossa posteriorly. Distally, it is prolonged down to the neck of the radius and the superior radioulnar joint. It is supported by the quadrate ligament below the annular ligament where it also forms a fold which gives the head of the radius freedom of movement. Several synovial folds project into the recesses of the joint. These folds or plicae are remnants of normal embryonic development and can be categorized as either anterior (anterior humeral recess) or posterior (olecranon recess). A crescent-shaped fold is commonly present between the head of the radius and the capitulum of the humerus.

On the humerus there are extrasynovial fat pads adjacent to the three articular fossae. These pads fill the radial and coronoid fossa anteriorly during extension, and the olecranon fossa
posteriorly during flexion. They are displaced when the fossae are occupied by the bony projections of the ulna and radius.

Ligaments

Left elbow-joint

**Left:** anterior and ulnar collateral ligaments
**Right:** posterior and radial collateral ligaments

The elbow, like other joints, has ligaments on either side. These are triangular bands which blend with the joint capsule. They are positioned so that they always lie across the transverse joint axis and are, therefore, always relatively tense and impose strict limitations on abduction, adduction, and axial rotation at the elbow.
The ulnar collateral ligament has its apex on the medial epicondyle. Its anterior band stretches from the anterior side of the medial epicondyle to the medial edge of the coronoid process, while the posterior band stretches from posterior side of the medial epicondyle to the medial side of the olecranon. These two bands are separated by a thinner intermediate part and their distal attachments are united by a transverse band below which the synovial membrane protrudes during joint movements. The anterior band is closely associated with the tendon of the superficial flexor muscles of the forearm, even being the origin of flexor digitorum superficialis. The ulnar nerve crosses the intermediate part as it enters the forearm.

The radial collateral ligament is attached to the lateral epicondyle below the common extensor tendon. Less distinct than the ulnar collateral ligament, this ligament blends with the annular ligament of the radius and its margins are attached near the radial notch of the ulna.

**Muscles**

**Flexion**

There are three main flexor muscles at the elbow:

- **Brachialis** acts exclusively as an elbow flexor and is one of the few muscles in the human body with a single function. It originates low on the anterior side of the humerus and is inserted into the tuberosity of the ulna.

- **Brachioradialis** acts essentially as an elbow flexor but also supinates during extreme pronation and pronates during extreme supination. It originates at the lateral supracondylar ridge distally on the humerus and is inserted distally on the radius at the styloid process.

- **Biceps brachii** is the main elbow flexor but, as a biarticular muscle, also plays important secondary roles as a stabiliser at the shoulder and as a supinator. It originates on the scapula with two tendons: That of the long head on the supraglenoid tubercle just above the shoulder joint and that of the short head on the coracoid process at the top of the scapula. Its main insertion is at the radial tuberosity on the radius.
Brachialis is the main muscle used when the elbow is flexed slowly. During rapid and forceful flexion all three muscles are brought into action assisted by the superficial forearm flexors originating at the medial side of the elbow. The efficiency of the flexor muscles increases dramatically as the elbow is brought into midflexion (flexed 90°) — biceps reaches its angle of maximum efficiency at 80–90° and brachialis at 100–110°.

Active flexion is limited to 145° by the contact between the anterior muscles of the upper arm and forearm, more so because they are hardened by contraction during flexion. Passive flexion (forearm is pushed against the upper arm with flexors relaxed) is limited to 160° by the bony projections on the radius and ulna as they reach to shallow depressions on the humerus; i.e. the head of radius being pressed against the radial fossa and the coronoid process being pressed against the coronoid fossa. Passive flexion is further limited by tension in the posterior capsular ligament and in triceps brachii.

Extension

Elbow extension is simply bringing the forearm back to anatomical position. This action is performed by triceps brachii with a negligible assistance from anconeus. Triceps originates with two heads posteriorly on the humerus and with its long head on the scapula just below the shoulder joint. It is inserted posteriorly on the olecranon.

Triceps is maximally efficient with the elbow flexed 20–30°. As the angle of flexion increases, the position of the olecranon approaches the main axis of the humerus which decreases muscle
efficiency. In full flexion, however, the triceps tendon is "rolled up" on the olecranon as on a pulley which compensates for the loss of efficiency. Because triceps' long head is biarticular (acts on two joints), its efficiency is also dependent on the position of the shoulder.

Extension is limited by the olecranon reaching the olecranon fossa, tension in the anterior ligament, and resistance in flexor muscles. Forced extension results in a rupture in one of the limiting structures: olecranon fracture, torn capsule and ligaments, and, though the muscles are normally left unaffected, a bruised brachial artery.

**Blood supply (cubital anastomosis)**

The anastomosis and deep veins around the elbow-joint

The arteries supplying the joint are derived from an extensive circulatory anastomosis between the brachial artery and its terminal branches. The superior and inferior ulnar collateral branches of the brachial artery and the radial and middle collateral branches of the profunda brachii artery descend from above to reconnect on the joint capsule, where they also connect with the anterior and posterior ulnar recurrent branches of the ulnar artery; the radial recurrent
branch of the radial artery; and the interosseous recurrent branch of the common interosseous
artery.

The blood is brought back by vessels from the radial, ulnar, and brachial veins. There are two
sets of lymphatic nodes at the elbow, normally located above the medial epicondyle — the deep
and superficial cubital nodes (also called epitrochlear nodes). The lymphatic drainage at the
elbow is through the deep nodes at the bifurcation of the brachial artery, the superficial nodes
drain the forearm and the ulnar side of the hand. The efferent lymph vessels from the elbow
proceed to the lateral group of axillary lymph nodes.
Innervation

The elbow is innervated anteriorly by branches from the musculocutaneous, median, and radial nerve, and posteriorly from the ulnar nerve and the branch of the radial nerve to anconeus.

Development during childhood and adolescence

The elbow undergoes dynamic development of ossification centers through infancy and adolescence, with the order of both the appearance and fusion of the apophyseal growth centers being crucial in assessment of the pediatric elbow on radiograph, in order to distinguish a traumatic fracture or apophyseal separation from normal development. The order of appearance can be understood by the mnemonic CRITOE, referring to the capitellum, radial head, internal epicondyle, trochlea, olecranon, and external epicondyle at ages 1, 3, 5, 7, 9 and 11 years. These apophyseal centers then fuse during adolescence, with the internal epicondyle and olecranon fusing last. The ages of fusion are more variable than ossification, but normally occur at 13, 15, 17, 13, 16 and 13 years, respectively. In addition, the presence of a joint effusion can be inferred by the presence of the fat pad sign, a structure that is normally physiologically present, but pathologic when elevated by fluid, and always pathologic when posterior.

PROXIMAL AND RADIOULNAR JOINT

The radioulnar joints are two locations in which the radius and ulna articulate in the forearm:

- **Proximal radioulnar joint**: This is located near the elbow, and is an articulation between the head of the radius, and the radial notch of the ulna.

- **Distal radioulnar joint**: This is located near the wrist, and is an articulation between the ulnar notch of the radius, and the ulnar head.

Both of these joints are classified as pivot joints, responsible for pronation and supination of the forearm.

In this article, we shall look the anatomy and clinical correlations of these joints.
Fig 1.0 – The proximal radioulnar joint, with the annular ligament.

**Proximal Radioulnar Joint**
The proximal radioulnar joint is located immediately distal to the elbow joint, and is enclosed within the same articular capsule. It is formed by an articulation between the head of the radius and the radial notch of the ulna.

The radial head is held in place by the annular radial ligament, which forms a ‘collar’ around the joint. The annular radial ligament is lined with a synovial membrane, reducing friction during movement.

Movement is produced by the head of the radius rotating within the annular ligament. There are two movements possible at this joint; pronation and supination.

- **Pronation:** Produced by the pronator quadratus and pronator teres.
- **Supination:** Produced by the supinator and biceps brachii.

![Articulating surfaces of the proximal radioulnar joint.](teachmeanatomy.com)

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**Distal Radioulnar Joint**

This distal radioulnar joint is located just proximally to the wrist joint. It is an articulation
between the ulnar notch of the radius, and the ulnar head.
In addition to anterior and posterior ligaments strengthening the joint, there is also a fibrocartilageous ligament present, called the **articular disk**. It serves two functions:

- Binds the radius and ulna together, and holds them together during movement at the joint.
- Separates the distal radioulnar joint from the wrist joint.

Like the proximal radioulnar joint, this is a **pivot** joint, allowing for pronation and supination. The ulnar notch of the radius slides anteriorly over the head of the ulnar during such movements.

**Pronation**: Produced by the pronator quadratus and pronator teres

**Supination**: Produced by the supinator and biceps brachii
Fig 1.2 – Articular surfaces of the distal radioulnar and wrist joints.

**Interosseous Membrane**

The interosseous membrane is a sheet of **connective tissue** that joins the radius and ulna together between the radioulnar joints.

It spans the distance between the medial radial border, and the lateral ulnar border. There are small holes in the sheet, as a conduit for the forearm vasculature.

This connective tissue sheet has three major functions:

- **Holds the radius and ulna together** during pronation and supination of the forearm, providing addition stability.

- **Acts as a site of attachment** for muscles in the anterior and posterior compartments of the forearm.

- **Transfers forces** from the radius to the ulna.
WRIST JOINT
The wrist joint (also known as the radiocarpal joint) is a synovial joint in the upper limb, marking the area of transition between the forearm and the hand.
In this article, we shall look at the structures of the wrist joint, the movements of the joint, and the relevant clinical syndromes.

Structures of the Wrist Joint

Articulating Surfaces
The wrist joint is formed by:

- **Distally** – The proximal row of the carpal bones (except the pisiform).
- **Proximally** – The distal end of the radius, and the articular disk (see below).
The ulna is **not part of the wrist joint** – it articulates with the radius, just proximal to the wrist joint, at the distal radioulnar joint. It is prevented from articulating with the carpal bones by a fibrocartilaginous ligament, called the articular disk, which lies over the superior surface of the ulna.

Together, the carpal bones form a **convex** surface, which articulates with the **concave** surface of the radius and articular disk.

Fig 1.0 – Articular surfaces of the wrist joint.

**Vasculature and Innervation**

The wrist joint receives blood from branches of the dorsal and palmar carpal arches, which are derived from the **ulnar** and **radial** arteries.

Innervation to the wrist is delivered by branches of three nerves:

- **Median nerve** – Anterior interosseous branch.
- **Radial nerve** – Posterior interosseous branch.
- **Ulnar nerve** – deep and dorsal branches.

**Stability of the Wrist Joint**

The joint capsule and ligaments contribute to the stability of the wrist.

**Joint capsule:** Like any synovial joint, the capsule is dual layered. The fibrous outer layer attaches to the radius, ulna and the proximal row of the carpal bones. The internal layer is comprised of a synovial membrane, secreting synovial fluid which lubricates the joint.

**Ligaments:** There are four ligaments of note in the wrist joint, one for each side of the joint

- **Palmar radiocarpal** – It is found on the palmar (anterior) side of the hand. It passes from the radius to both rows of carpal bones. Its function, apart from increasing stability, is to ensure that the hand follows the forearm during supination.
• **Dorsal radiocarpal** – It is found on the dorsum (posterior) side of the hand. It passes from the radius to both rows of carpal bones. It contributes to the stability of the wrist, but also ensures that the hand follows the forearm during pronation.

• **Ulnar collateral** – Runs from the ulnar styloid process to the triquetrum and pisiform. Works in union with the other collateral ligament to prevent excessive lateral joint displacement.

• **Radial collateral** – Runs from the radial styloid process to the scaphoid and trapezium. Works in union with the other collateral ligament to prevent excessive lateral joint displacement.

Fig 1.1 – Palmar view of the ligaments of the wrist joint.

**Movements of the Wrist Joint**

The wrist is an **ellipsoid** type synovial joint, allowing for movement along two axes. This means
that flexion, extension, adduction and abduction can all occur at the wrist joint.

All the movements of the wrist are performed by the muscles of the forearm.

**Flexion** – Produced mainly by the flexor carpi ulnaris, flexor carpi radialis, with assistance from the flexor digitorum superficialis.

**Extension** – Produced mainly by the extensor carpi radialis longus and brevis, and extensor carpi ulnaris, with assistance from the extensor digitorum.

**Adduction** – Produced by the extensor carpi ulnaris and flexor carpi ulnaris

**Abduction** – Produced by the abductor pollicis longus, flexor carpi radialis, extensor carpi radialis longus and brevis.

**JOINT OF THE HANDS AND FINGERS**

**THE HAND JOINTS**
The intercarpal joints are synovial joints formed between the individual bones of the proximal row of the carpal bones, between the individual bones of the distal row of carpal bones, and between the proximal and distal rows (the midcarpal joint). Does that seem confusing? These joints don’t have much movement, just a small amount of gliding between the bones.

The carpometacarpal joints are synovial joints between the distal carpal bones and the metacarpals, and the intermetacarpal joints are between the metacarpals. The carpometacarpal joint of the thumb is a saddle-shaped joint between the trapezium and the base of the first metacarpal. The joints have a synovial membrane surrounded by fibrous joint capsules. They’re supported by anterior, posterior, and interosseous (between bone ligaments. The thumb joint can extend, flex, abduct, adduct, and circumduct. The fifth metacarpal joint is fairly mobile, but the rest don’t have much movement.

THE FINGER JOINTS
The joints of the fingers include the metacarpophalangeal joints and the interphalangeal joints. They’re all synovial joints with synovial membranes and fibrous joint capsules.

- **Metacarpophalangeal joints:** Connecting the proximal phalanges to the metacarpals are condyloid joints with strong palmar and collateral ligaments that allow
for movement in different directions (flexion, extension, abduction, adduction, circumduction). You may recognize them as your knuckles.

- **Interphalangeal joints**: These hinge joints allow flexion and extension. They join the heads of the phalanges with the bases of the next distal phalanges. Each finger (digits two through five) has one proximal interphalangeal joint and one distal interphalangeal joint. The thumb has only one interphalangeal joint.
The hip is the body’s second largest weight-bearing joint (after the knee). It is a ball and socket joint at the juncture of the leg and pelvis. The rounded head of the femur (thighbone) forms the ball, which fits into the acetabulum (a cup-shaped socket in the pelvis). Ligaments connect the ball to the socket and usually provide tremendous stability to the joint. The hip joint is normally very sturdy because of the fit between the femoral head and acetabulum as well as strong ligaments and muscles at the joint.

All of the various components of the hip mechanism assist in the mobility of the joint. Damage to any single component can negatively affect range of motion and ability to bear weight on the joint. Orthopedic degeneration or trauma – those conditions affecting the bones in the hip joint – can necessitate total hip replacement, partial hip replacement or hip resurfacing.

Bones of the hip joint
Normal Hip Joint vs. Arthritic Hip Joint

The femur is the upper leg bone or thigh. It is the largest bone in the body. At the top of the femur is a rounded protrusion which articulates with the pelvis. This portion is referred to as the head of the femur, or femoral head.

There are two other protrusions near the top of the femur, known as the greater and lesser trochanters. The muscles involved in hip motion are attached to the joint at these trochanters.

The acetabulum is a concave area in the pelvis, into which the femoral head fits. The pelvis is a girdle of bones, connected at the front by cartilage pad, called the pubis, and at the back by the lowest four fused vertebrae (the sacrum). The sacro-iliac joints are located where the sacrum meets the pelvis.

The bone surfaces of the femoral head and acetabulum have a smooth durable layer of articular cartilage that cushions the ends of the bones and allows for smooth movement.

Hip joint capsule or socket

![Diagram of Hip Joint](image_courtesy_of_Smith_Nephew)

You may hear your hip surgeon refer to the capsule or socket, when describing the structure of the hip joint. The joint capsule is a thick ligamentous structure surrounding the entire joint. Inside the capsule, the surfaces of the hip joint are covered by a thin tissue called the synovial membrane. This membrane nourishes and lubricates the joint.
Ligaments

As noted above, the stability of the hip joint is directly related to its muscles and ligaments. The most notable ligaments in the hip joint are:

- **Iliofemoral ligament**, which connects the pelvis to the femur at the front of the joint. It keeps the hip from hyper-extension
- **Pubofemoral ligament**, which attaches the most forward part of the pelvis known as the pubis to the femur
- **Ischiofemoral ligament**, which attaches to the ischium (the lowest part of the pelvis) and between the two trochanters of the femur.

Labrum
The labrum is a circular layer of cartilage which surrounds the outer part of the acetabulum effectively making the socket deeper to provide more stability for the joint. Labrum tears are not an uncommon hip injury.

Muscle Groups
The various muscles which attach to or cover the hip joint generate the hip’s movement.

- **Gluteals**: The gluteals are the muscles in your buttocks. The gluteals (gluteus maximus, gluteus minimus and gluteus medius) are the three muscles attached to back of the pelvis and insert into the greater trochanter of the femur.

- **Quadriceps**: The four quadricep muscles (vastus lateralis, medialis, intermedius and rectus femoris) are located at the front of the femur. All four attach to the top of the tibia. The rectus femoris originates at the front of the ilium. The three other quads attach around the greater trochanter of the femur and just below it.

- **Iliopsoas**: This is the primary hip flexor muscle. The three parts of the iliopsoas attach the lower part of the spine and pelvis, then cross the joint and insert into the lesser trochanter of the femur.

- **Hamstrings**: The three muscles at the back of the thigh are called the hamstrings. All three attach to the lowest part of the pelvis.

- **Groin muscles**: The groin or adductor muscles attach to the pubis and run down the inside of the thigh.

**KNEE JOINT**
The knee joint is a bicondylar type **synovial** joint, which mainly allows for flexion and extension (and a small degree of medial and lateral rotation). It is formed by articulations between the patella, femur and tibia.

In this article, we shall examine the anatomy of the knee joint – its articulating surfaces, ligaments and neurovascular supply.
Fig 1.0 – A broad overview of the bony structures of the knee joint.

**Articulating Surfaces**

Fig 1.1 – More detailed view of the bony surfaces. The inferior surface of the femur and superior surface of the tibia is shown.

The knee joint consists of two articulations (see fig. 1.1):

- **Tibiofemoral** – The medial and lateral condyles of the femur articulating with the tibia.
• **Patellofemoral** – The anterior and distal part of the femur articulating with the patella.

The tibiofemoral joint is the **weight-bearing** joint of the knee.

The patellofemoral joint allows the tendon of the **quadriceps femoris** (the main extensor of the knee) to be inserted directly over the knee, increasing the **efficiency** of the muscle. Both joint surfaces are lined with **hyaline** cartilage, and enclosed within a single joint cavity. The patella is formed inside the tendon of the quadriceps femoris; its presence minimises wear and tear on the tendon.
Neurovasculature

The blood supply to the knee joint is through the genicular anastomoses around the knee, which are supplied by the genicular branches of the femoral and popliteal arteries. The nerve supply, according to Hilton’s law, is by the nerves which supply the muscles which cross the joint. These are the femoral, tibial and common fibular nerves.

Menisci

The medial and lateral menisci are fibrocartilage structures in the knee that serve two functions:

- To deepen the articular surface of the tibia, thus increasing stability of the joint.

- To act as shock absorbers.

They are C shaped, and attached at both ends to the intercondylar area of the tibia. In addition to the intercondylar attachment, the medial meniscus is fixed to the tibial collateral ligament and the joint capsule. Any damage to the tibial collateral ligament results in tearing of the medial meniscus.

The lateral meniscus is smaller and does not have any extra attachments, rendering it fairly mobile.
Fig 1.2 – Posterior view of the knee joint, with the joint capsule removed. Note the close relationship of the tibial collateral ligament, and the medial meniscus
Fig 1.3 – The menisci of the knee joint. Superior surface of the tibia

Bursae

A bursa is synovial fluid filled sac, found between moving structures in a joint – with the aim of reducing wear and tear on those structures. There are four bursae found in the knee joint.

- **Suprapatella bursa** – This is an extension of the synovial cavity of the knee, located between the quadriceps femoris and the femur.

- **Prepatella bursa** – Found between the apex of the patella and the skin.

- **Infrapatella bursa** – Split into deep and superficial. The deep bursa lies between the tibia and the patella ligament. The superficial lies between the patella ligament and the skin.

- **Semimembranosus bursa** – Located posteriorly in the knee joint, between the semimembranosus muscle and the medial head of the gastrocnemius.
Fig 1.4 – Sagittal view of the knee joint, showing the major bursae.
Ligaments

The major ligaments in the knee joint are:

1. **Patellar ligament** – A continuation of the quadriceps femoris tendon distal to the patella. It attaches to the tibial tuberosity.

2. **Collateral ligaments** – These are two strap-like ligaments. They act to stabilise the hinge motion of the knee, preventing any medial or lateral movement.

   - **Tibial (medial) collateral ligament** – A wide and flat ligament, found on the medial side of the joint. Proximally, it attaches to the medial epicondyle of the femur distally it attaches to the medial surface of the tibia.

   - **Fibular (lateral) collateral ligament** – Thinner and rounder than the tibial collateral, this attaches proximally to the lateral epicondyle of the femur, distally it attaches to a depression on the lateral surface of the fibular head.

3. **Cruciate Ligaments** – These two ligament connect the femur and the tibia. In doing so, they cross each other, hence the term ‘cruciate’ (Latin for like a cross)

   - **Anterior cruciate ligament** – attaches at the anterior intercondylar region of the tibia and ascends posteriorly to attach to the femur, in the intercondylar fossa. It prevents anterior dislocation of the tibia onto the femur.

   - **Posterior cruciate ligament** – attaches at the posterior intercondylar region of the tibia, and ascends anteriorly to attach to the femur in the intercondylar fossa. It prevents posterior dislocation of the tibia onto the femur.
Fig 1.5 – The major ligaments of the knee joint: Green – patella ligament, Red – collateral ligaments, Dark blue – anterior cruciate ligament, Light blue – posterior cruciate ligament

Movements

There are four main movements that the knee joint permits:

- **Extension**: Produced by the quadriceps femoris, which inserts into the tibial tuberosity.
• **Flexion**: Produced by the hamstrings, gracilis, sartorius and popliteus.

• **Lateral rotation**: Produced by the biceps femoris.

• **Medial rotation**: Produced by five muscles; semimembranosus, semitendinosus, gracilis, sartorius and popliteus.

*NB: Lateral and medial rotation can only occur when the knee is flexed (if the knee is not flexed, the medial/lateral rotation occurs at the hip joint).*

**ANKLE JOINT**

The ankle joint (or talocrural joint) is a synovial joint located in the lower limb. It is formed by the bones of the leg and the foot – the tibia, fibula and talus. Functionally, it is a **hinge type** joint, permitting dorsiflexion and plantarflexion of the foot. In this article, we shall look at the applied anatomy of the ankle joint; the articulating surfaces, ligaments, movements, and any clinical correlations.

**Articulating Surfaces**

The ankle joint is formed by three bones; the **tibia** and **fibula** of the leg, and the **talus** of the foot:

- The tibia and fibula are bound together by strong tibiofibular ligaments, producing a bracket shaped socket, which is covered in hyaline cartilage. This socket is known as a **mortise**.

- The **body** of the talus fits snugly into the mortise formed by the bones of the leg.
The articulating part of the talus is wedge shaped. It is wider anteriorly, and thinner posteriorly. During dorsiflexion, the anterior part of the bone is held in the mortise, and the joint is more stable (vice versa for plantarflexion).

![X-ray of a normal ankle joint. Note the bracket shaped socket formed by the tibia and fibula.](Image)

[CC-BY-NC-ND 4.0]
Fig 1.1 – Superior view of the tarsal bones of the foot. Note the wedge shape of the talus.

**Ligaments**

There are two sets of ligaments, which originate from each malleolus. The **medial ligament** (or deltoid ligament) is attached to the medial malleolus. It consists of four separate ligaments, which fan out from the malleolus, attaching to the talus, calcaneus and navicular bones. The primary action of the medial ligament is to resist over-eversion of the foot.

The **lateral ligament** originates from the lateral malleolus. It resists over-inversion of the foot. It is comprised of three distinct and separate ligaments:

- Anterior talofibular: Spans between the lateral malleolus and lateral aspect of the talus.
- Posterior talofibular: Spans between the lateral malleolus and the posterior aspect of the talus.
- Calcaneofibular: Spans between the lateral malleolus and the calcaneus.

**JOINT OF THE FOOT AND TOES**
The foot contains a number of joints, but two important joints are the subtalar and transverse tarsal joints. These two joints allow you to invert and evert the foot.

- **Subtalar joint**: This joint is the posterior joint formed between the talus and the calcaneus. It’s a synovial joint, and it’s stabilized by medial, lateral, and interosseous talocalcaneal ligaments.
- **Transverse tarsal joint**: The transverse tarsal joint is actually a combination of the following two joints:
  - **Talocalcaneonavicular joint**: This synovial joint is formed between the talus and the calcaneus and the navicular bones. It’s stabilized by the plantar calcaneonavicular ligament.
  - **Calcaneocuboid joint**: Another synovial joint, this one is formed between the front of the calcaneus and the posterior surface of the cuboid bone. It’s stabilized by the bifurcated ligament on the top, the long plantar ligament on the bottom, and the short plantar ligament, which is deep to (located underneath) the long plantar ligament.

The remaining joints of the foot allow for a little movement of the foot and toes:

- **Cuneonavicular joint**: This synovial joint is formed between the navicular bone and the three cuneiform bones. It is supported by dorsal and plantar cuneonavicular ligaments. It allows for some gliding movement.

- **Cuboideonavicular joint**: This fibrous joint is between the cuboid and navicular bones. It’s supported by dorsal, plantar, and interosseous ligaments.

- **Tarsometatarsal joints**: These synovial joints are formed between the tarsal bones
and the bases of the metatarsal bones. These joints are strengthened by dorsal, plantar, and interosseus ligaments.

- **Intermetatarsal joints:** These synovial joints involve the bases of the metatarsal bones. All these joints are strengthened by dorsal, plantar, and interosseus ligaments.

- **Metatarsophalangeal joints:** These synovial joints are between the heads of the metatarsal bones and the bases of the proximal phalanges. They’re supported by plantar
and collateral ligaments. They allow you to flex and extend your toes as well as move them apart and closer together.

- **Interphalangeal joints:** These joints connect the phalanges. They’re synovial joints strengthened by collateral and plantar ligaments, and they let you flex and extend your toes.

**DISEASE OF SKELETAL SYSTEM**

- **Arthritis**

Arthritis exists in two main forms.

**Osteoarthritis** is the wear and tear our bones and joints experience over time. Obesity is an important factor that can accelerate osteoarthritis, especially of the knees and hips. All joints are lined with cartilage to provide cushioning and synovial fluid to help lubricate the joint through a range of motion. Over time, these tissues break down and wear away leading to bone spur formation, joint narrowing, inflammation and pain. Severe osteoarthritis management consists of pain control and at times steroid joint injections can provide temporary relief. Advanced cases are treated with joint replacement.

**Autoimmune arthritis** occurs when the body attacks itself and damages joints. Rheumatoid arthritis is one example and over time, results in severe joint destruction and chronic debilitation. Treatments are geared toward managing pain and modulating the immune system to limit further destruction.
2. Osteoporosis

As bone mineral density decreases, bones lose their integral strength. Age, hormone status and diet all play a vital role in osteoporosis. Bones become progressively weak and are prone to fractures with minor trauma.

1. Rickets/ Osteomalacia

Rickets is caused from a severe deficiency of calcium, vitamin D and phosphate. Bones soften and become weak losing their normal shape. Bone pain, muscle cramps and skeletal deformities occur.

1. Tendinitis
Overuse or injury of the tendons results in inflammation and pain. Tendons connect muscle to bone and facilitate movement. Commonly affected areas include the knee, elbow, wrist and Achilles’ tendon. Treatment includes rest, ice and modifying activities until the pain and inflammation resolve.
1. **Clubfoot**

Clubfoot is a birth defect resulting one or both feet pointing inward and downward. This makes learning to walk difficult and specialized orthopedic therapy or surgery is often required. The medical term for this condition is **talipes equinovarus**.

6. **Bursitis**

The bursa are specialized sacs of fluid found around our joints. They provide cushioning between the joints and nearby muscle, tendon and ligaments. The well-known condition of ‘water on the knee’ is an example of prepatellar bursitis. This condition causes pain, swelling and mild redness. Treatment includes avoiding pressure on the area, OTC medications such as ibuprofen and rest.

7. **Spina Bifida**
This birth related condition results in incomplete closure of the vertebra around the spinal canal. Many people have a mild form and do not even know it. More severe forms...
are accompanied by nerve defects, difficulty walking at problems with bowel and bladder function.

8. Leukemia

White blood cells are produced in part by the bone marrow. A variety of blood cancers are generally termed leukemia. The onset is generally insidious and until a critical mass of abnormal cells occurs, most people are without symptoms. Early warning signs include: bone pain, excess fatigue, easy bruising, night sweats, unexplained weight loss and bleeding gums.

9. Bone Cancer

Tumors can arise in bones in a similar fashion as other solid organ cancers. Bone cancer can occur as a primary type of cancer or can be a sign of an advanced cancer located elsewhere in the body that has spread (metastasized) to the bones. Primary bone cancers include osteosarcoma and Ewing’s. Metastatic cancer examples include lung, breast and prostate.

10. Other Causes

Osteogenesis imperfecta is a spectrum of bone disorders ranging from mild to severe and
life threatening. People with this condition are prone to fractures with minor trauma. The most severe form usually results in death in-utero. Persons with this disorder may have blue appearing sclera (the white part of the eye has a bluish tint).

**Osteopetrosis** is a rare bone disorder where the bones literally become petrified and are literally dissolve and break.
**Paget's disease** leads to the bones to break down faster than they rebuild. Normally this process is kept in balance, but the accelerated breakdown occurring in Paget's results in fragile bones with an increased risk of fracture.

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