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Textbook of General Anatomy

With

Systemic Anatomy
Radiological Anatomy
Dissection of Cadaver (Introduction)
Case Scenarios &
Clinical Applications

V Subhadra Devi

JAYPEE

Textbook of
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V Subhadra Devi MS (Anatomy)
Professor and Head
Department of Anatomy
Sri Padmavathi Medical College for Women (SPMC-W)
Sri Venkateswara Institute of Medical Sciences (SVIMS) University
Ex Vice Principal (Academic), Professor and Head
Department of Anatomy
Sri Venkateswara Medical College
Tirupati, Andhra Pradesh, India

JAYPEE BROTHERS MEDICAL PUBLISHERS
The Health Sciences Publisher
New Delhi | London | Panama

Preface

The prerequisite for understanding the patient is the strong basic fundamental concepts in the medical curriculum followed by its clinical application. Integration of basic and clinical sciences leads to contextual learning, active rather than passive involvement in the process of learning, which in turn, improves problem-solving skills of medical professionals, which is the single best approach to alleviate the suffering in the diseased.

The *Textbook of General Anatomy* is conceived with a strong belief to inspire the new entrants into the portals of medicine about the importance of learning basic skills, knowledge and attitude before they embark on reading the important branch of medicine the anatomy, that requires in-depth region-wise knowledge and skills.

This book provides basic knowledge required for understanding the dissection of cadaver and study of various regions of the body adopting integrated approach. This book was prepared as per the syllabus of anatomy recommended by the Medical Council of India (MCI) and other medical-related boards in Asia.

All possible care was taken to ensure that the information provided facilitates understanding of importance of each of the systems in the body and their clinical relevance to motivate the students of medicine on the importance of basics and its application in practicing the profession.

A simple language, easy-to-understand illustrations, flowcharts, tables and presentation in boxes are the unique adoptions in this book to drive the new age generation of students to make it student friendly. These are highly useful for the readers to recall and for competitive examination preparation.

The additional components that are included in this book to enrich the knowledge of readers is the gross anatomical, developmental, microscopic, radiological and clinical case insights in the form of author's own images, personal collections and collection from several clinicians/practitioners.

This book can be used as a self-study guide by students of medical, dental and allied health courses to understand the basic concepts of human anatomy.

As this is a single person's effort, there is every possibility of omissions and commissions that needs the feedback from the anatomists, medical and allied specialists of all generations and above all the students for whose benefit writing of this book is envisioned.

V Subhadra Devi

Contents

6 CHAPTER

Introduction to Arthrology/Joints

Learning Objectives

- Definition of joint
- Classification of different types of joints with examples
- General features of a synovial joint
- Bursa
- Clinical case with anatomical explanation

Definition

A joint or articulation is a connection or a junction between two or more bones or cartilages to permit movement.

- All the 206 bones of the body with the *exception* of hyoid bone in the neck are connected to at least one other bone.
- Study of joints is called *arthrology* (Greek arthron = joint) or *syndesmology* (Greek syndesmo = fastening or joining).
- A joint can also be called an *articulation* (Latin articulatio = connecting) or an *articulus*.
- Some joints are merely bonds of union between different bones and do not allow movement. Joints of the skull (sutures) belong to this category.
- Some joints allow slight movement (intervertebral discs), while some others (shoulder) allow great freedom of movement.
- The number of joints in a child is more than that of adult. As growth proceeds some of the bones fuse together, e.g. ilium, ischium, and pubis fuse to form hip bone; the two halves of frontal bone and that of mandible fuse; the five sacral vertebrae fuse to form single sacrum; and the four coccygeal vertebrae fuse to form single coccyx.

Articulating parts in different bones:

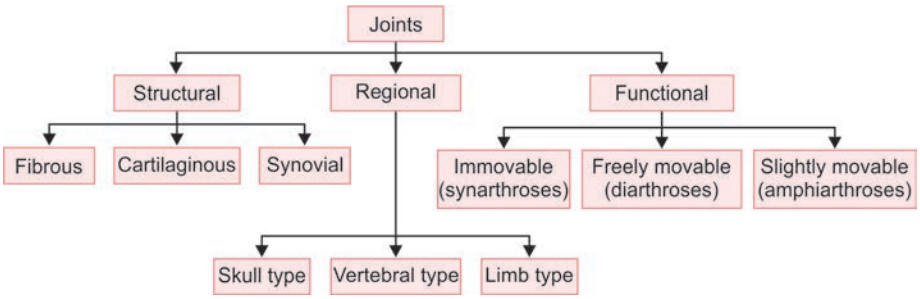
- Long bones articulate at their ends
- Flat bones articulate at margins
- Short or irregular bones articulate at their articular surfaces.

Classification of Joints

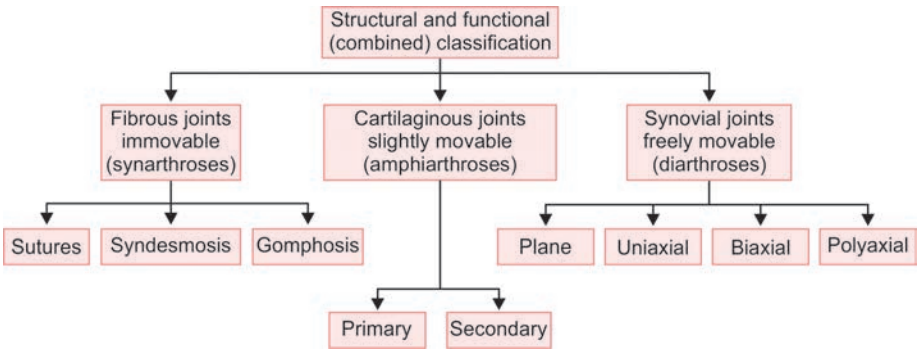
Joints are classified based on structure, region, and function (Flowcharts 6.1 to 6.3).

- *Structural:* Depending on the type of material binding articulating bones
- *Regional:* Depending on location
- *Functional:* Depending on the range of movement
- *Combined:* Combination of structure and function.

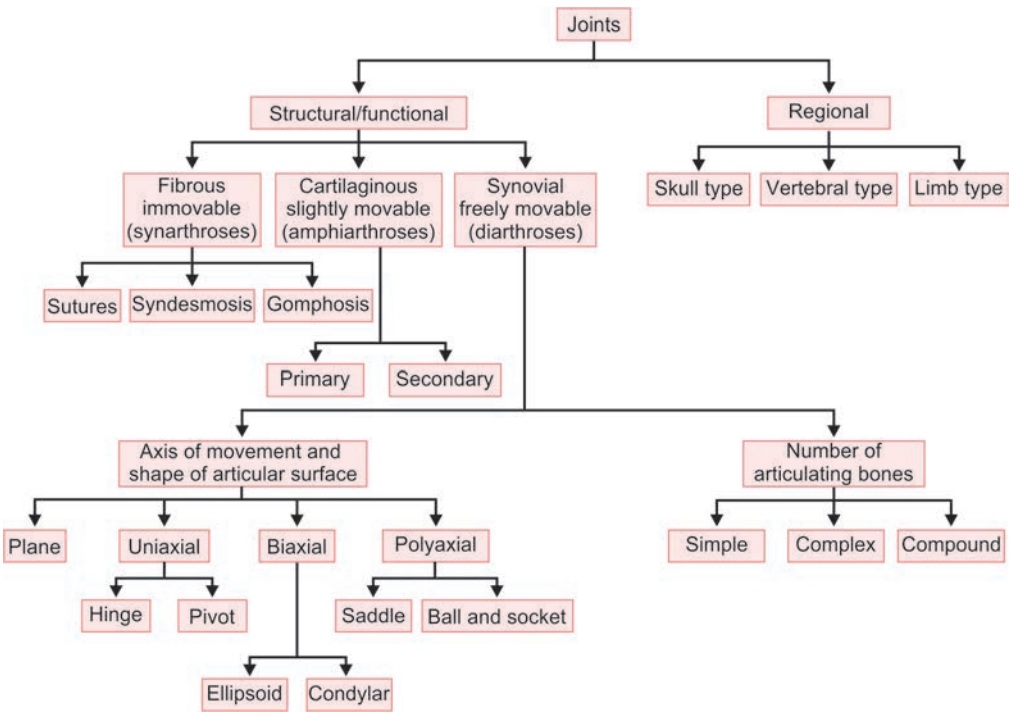
Flowchart 6.1: Broad classification of joints.



Flowchart 6.2: Combined (structural and functional) classification of joints.



Flowchart 6.3: Combined classification of joints and subtypes.



Subdivision of each with type, its specific identification features with examples was presented in Table 6.1 and Figures 6.1A to C.

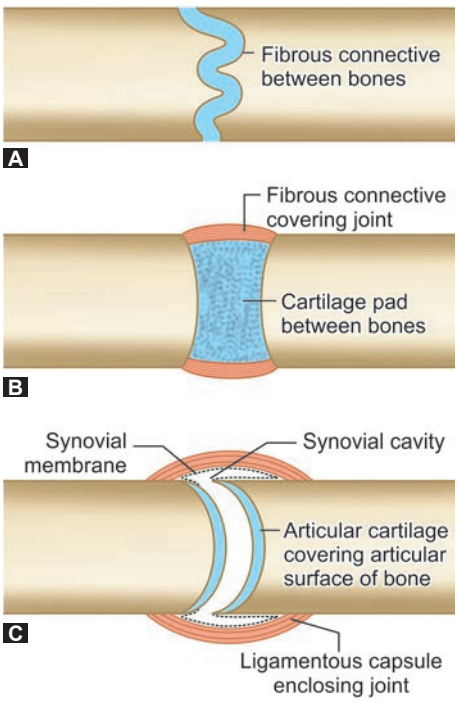
Fibrous Joints (Flowcharts 6.2 and 6.3 and Figs. 6.1A to C)

Features

- These are immovable/fixed joints, i.e. *synarthroses*.
- Articular surfaces are joined by fibrous tissue.

Table 6.1: Classification of joints.

A. Structural classification		
Fibrous joints	*Cartilaginous joints*	*Synovial joints*
❑ Fibrous tissue will be binding the articulating ends ❑ It is a solid joint without joint cavity ❑ These joints provide *stability with no movement* ❑ They are protective in function. ❑ Example—joints between bones of skull (sutures)	❑ The intervening tissue between the articulating ends is either a hyaline cartilage or a fibrocartilage ❑ These joints lack a joint cavity ❑ *It has limited mobility* ❑ Examples—intervertebral disc, pubic symphysis	❑ Articulating surfaces of bones are not united directly ❑ A membrane lined cavity filled with lubricating fluid encloses the bones and allows free movement ❑ Cartilage with synovial membrane enclosing a joint cavity is present ❑ These joints allow a wide range of movement ❑ Mobility is greater but stability is less ❑ These are the most common joints of the body ❑ Examples—hip joint, shoulder joint, knee joint, and sternoclavicular joint
B. Regional classification		
Skull type	*Vertebral type*	*Limb type*
No mobility but stable	Limited mobility but very secure and stable	Mobile but not very secure
C. Functional classification		
Synarthroses	*Amphiarthroses*	*Diarthroses*
❑ *Immovable joints*: No mobility ❑ Example—sutures of skull	❑ *Slightly movable joints*: Some degree of mobility. Hence, called amphi (two-sided) arthroses because it is neither completely mobile nor completely immobile ❑ Example—intervertebral discs	❑ *Freely movable joints*: Maximum degree (wide range) of mobility ❑ The name "diarthroses" is frequently applied to the synovial type of joint, where the movements are free and the participating bones are separated from each other, qualifying the adjective "two" ❑ Examples—shoulder, hip, and knee joints
D. Combination of structure and function		
Fibrous and immovable (synarthroses)	*Cartilaginous and slightly movable (amphiathroses)*	*Synovial and freely movable (diarthroses)*



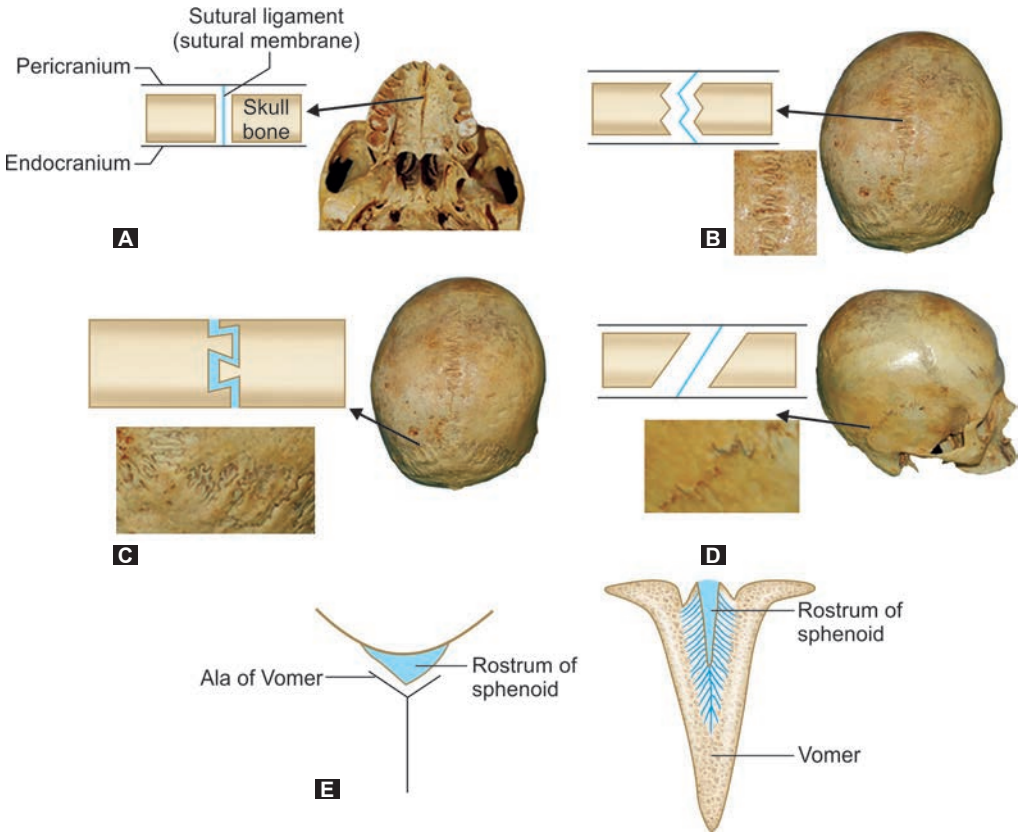
Figs. 6.1A to C: Classification of joints. (A) Synarthrosis—fibrous joint; (B) Amphiarthrosis—cartilaginous joint; (C) Diarthrosis—synovial joint.

- The edges of bones are dove-tailed into one another.
- It lacks a joint cavity.

The fibrous joints are further classified into various subtypes with each having specific features.

Subtypes of Fibrous Joints

- *Sutures (synostosis) (Fig. 6.2)*:
  - Latin Sutura, derived from suo = a sewing or a seam. This type of joint is found only in the skull.
    - *Synostosis:* Obliteration of suture leads to union of the articulating bones by bone tissue itself. This is called synostosis (syn + osteo = joining by bone). When a suture obliterates, *synostosis* occurs first on the deeper aspect of the suture (internal or endocranial aspect) and gradually extends on to the superficial (external or pericranial) aspect. Complete obliteration occurs much later in life.
  - Fibrous tissue connects the bones as *sutural ligament* (thin connective tissue layer).
  - Majority are seen between bones that ossify in membrane.
  - These gradually ossify with advancing age.
  - These are immovable.
  - Seen between skull bones, e.g. sagittal and coronal sutures.
  - In a growing child they exhibit little mobility.
  - *Types:* Depending on shape of articulating surfaces and articular margins:
    - *Plane suture:* The articulating margins are plane and united by sutural ligament, e.g. joint between palatine processes of two maxillae (Fig. 6.2A).
    - *Serrate suture:* Saw-toothed appearance of bone edges, e.g. sagittal suture of skull (Fig. 6.2B).
    - *Squamous suture:* Edges of bones overlap, e.g. suture between parietal and squamous parts of temporal bone (Fig. 6.2C).
    - *Denticulate suture:* The margins are like teeth, e.g. lambdoid suture (Fig. 6.2D).
    - *Schindylesis (wedge and groove suture):* Edge of one bone fits into the groove of the other bone, e.g. joint between rostrum of sphenoid and upper margin of vomer (Fig. 6.2E).
- *Syndesmosis (Fig. 6.3)*:
  - *Greek—Syndesmos* = ligament.
  - Surfaces of bones are united by fibrous connection, most commonly



Figs. 6.2A to E: Fibrous joint—sutures: (A) Plane suture (Palatine process of two maxilla); (B) Serrate suture (Sagittal suture); (C) Denticulate suture (Lambdoid suture); (D) Squamous suture (Between parietal and squamous part of temporal bone); (E) Schindylesis (Wedge and groove suture).

Fig. 6.3: Fibrous joint—syndesmosis.

by interosseous ligaments that persist throughout life. It is also represented by slender fibrous cord or aponeurotic membrane.

- Slight degree of movement is possible depending on the distance between bones and degree of flexibility of uniting fibrous tissue.
- For example, interosseous membrane between forearm bones and leg bones, inferior tibiofibular joint; ligamenta flava (ligaments between spines of vertebrae); and posterior part of sacroiliac joint.

- *Gomphosis/peg and socket joint (Fig. 6.4)*:
  - Gomphos = bolt, Osis = condition.
  - A peg-shaped process gets inserted into a socket and is united by fibrous tissue.
  - For example, articulation of roots of teeth into alveolar sockets anchored by *periodontal ligament.*
  - This type of arrangement does not allow movement of tooth. If movement is allowed it is pathological and results in loosening of tooth.

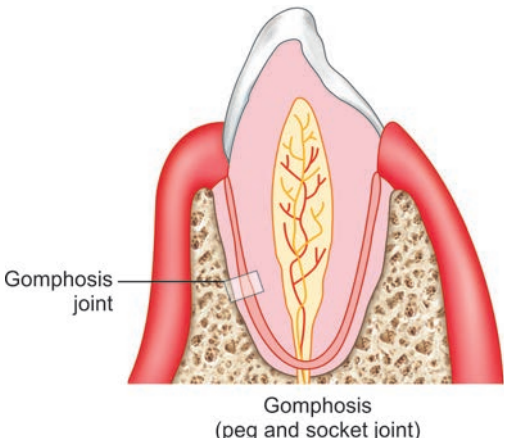


Fig. 6.4: Fibrous joint—gomphosis.

Fontanel (Fig. 6.5)

- In the newborn and in infants the connective tissue between bones of skull is much wider especially in the skull cap, i.e. between sagittal, coronal, squamous, and lambdoid sutures. These are called fontanels.
- During the time of parturition (delivery of the fetus) the fontanel provides flexibility for the delivery of the fetal head to pass through birth canal by overlapping of bones of vault or skull cap.
- After birth these fontanel allow expansion of skull with enlargement of brain.
- The fontanel decrease in width during 1st year after birth when the skull bones are enlarging and it becomes the suture.
- At some sutures, the connective tissue will ossify and be converted into bone.

Cartilaginous Joints (Flowcharts 6.1 to 6.3 and Fig. 6.1)

Features

- These are slightly movable joints, i.e. amphiarthroses.

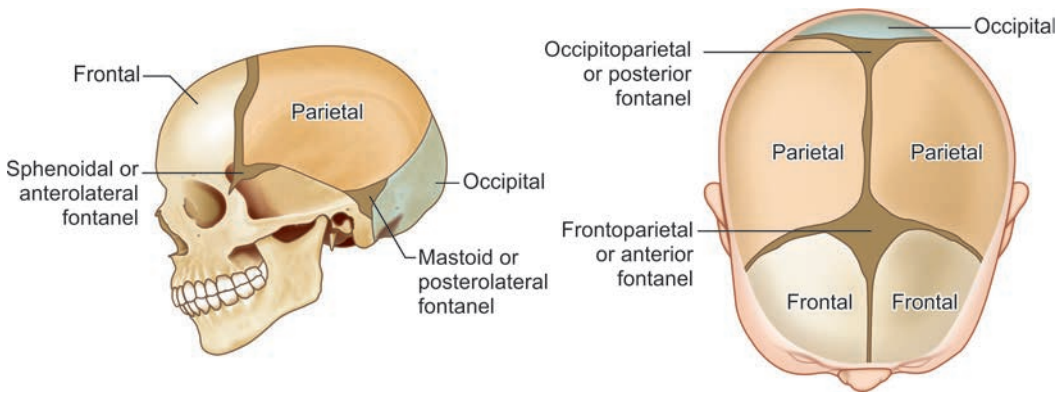


Fig. 6.5: Fontanel.

- Cartilage is present between articulating surfaces.
- Fibrous capsule holds the bones and cartilage in place.

The cartilaginous joints are further classified into various subtypes with each having specific features.

Classification and Features of Subtypes with Examples

- *Primary cartilaginous joints*: *Synchondroses/hyaline cartilaginous joints (Fig. 6.6).*
  - It is temporary. At a certain age cartilaginous plate is replaced by bone, i.e. it is ossified leading to synostosis.
  - Bones are lined by a plate of hyaline cartilage.
  - Primarily designed for bone growth.
  - All primary cartilaginous joints are quite immovable.
  - They are very strong.
  - *Examples:*
    - *Joints between epiphysis and diaphysis of a growing long bones*: It is replaced by bone when growth in length of diaphysis is completed. It is a temporary synchondrosis.
    - *Joint between basiocciput and basisphenoid:* Synchondrosis is converted to synostosis around 25 years of age.
    - *First chondrosternal joint:* Articulation between costal cartilage of 1st rib and manubrium.
    - Anterior ends of 11 pairs of ribs with their costal cartilages.
- *Secondary cartilaginous joints: Fibrocartilaginous/symphyses (Fig. 6.7).*
  - These joints are permanent and persist throughout life, *except* symphysis menti which is temporary.
  - Articular surfaces are covered by a thin layer of hyaline cartilage and united by a disc of fibrocartilage/fibrous tissue.
  - Typically they occur in the median plane of the body. Hence, they are also called *midline joints.*
  - These permits limited movements due to compressive fibrocartilage.
  - *Examples:*
    - Intervertebral discs between the bodies of vertebra
    - Manubriosternal joint
    - Symphysis pubis

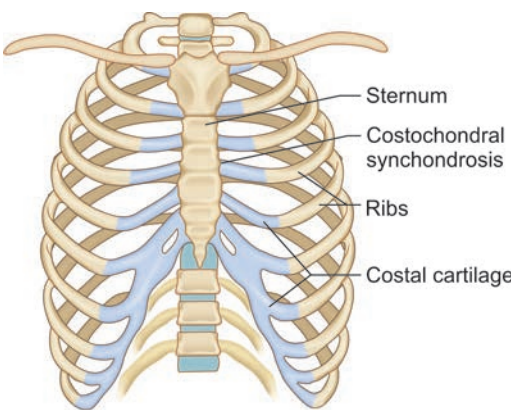


Fig. 6.6: Cartilaginous (primary) joint—synchondroses.

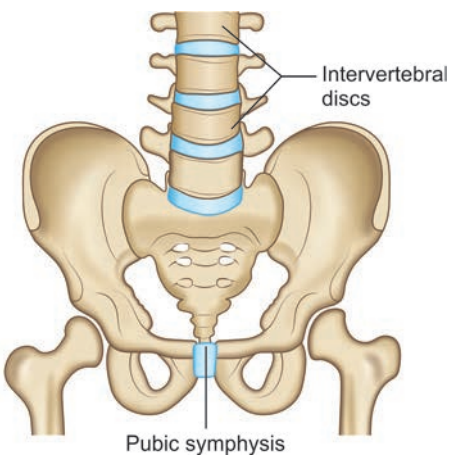


Fig. 6.7: Cartilaginous (secondary) joint—symphysis.

- Symphysis menti. This is the only symphysis devoid of fibrocartilage.

Synovial Joints

Features

- These are freely movable joints, i.e. *diarthroses*. Wide range of movement is possible.
- Most of the joints of appendicular skeleton belong to this group.
- Articular surfaces are covered by cartilage.
- Ligaments hold the bones together.
- Joint cavity is present and it contains synovial fluid.
- Joint cavity is enveloped by articular capsule which consists of an outer fibrous capsule and an inner synovial membrane.
- Sometimes the joint cavity is divided completely or incompletely by articular disc or meniscus of fibrocartilage.
- Movements of joints vary from a simple gliding to a wide range.
- Factors contributing for the stability of the joint are:
  - Bony contour
  - Ligaments
  - Muscles
  - *Atmospheric pressure:* Negligible factor.
- Synovial joints are important in the field of health sciences, i.e. in medicine, nursing, physiotherapy, sports medicine, and massage therapies.

Description of General Structure of Synovial Joint

The basic structure of synovial joint can be described under Figure 6.8.

Articulating Bones

- The articulating surfaces are called male and female surfaces.

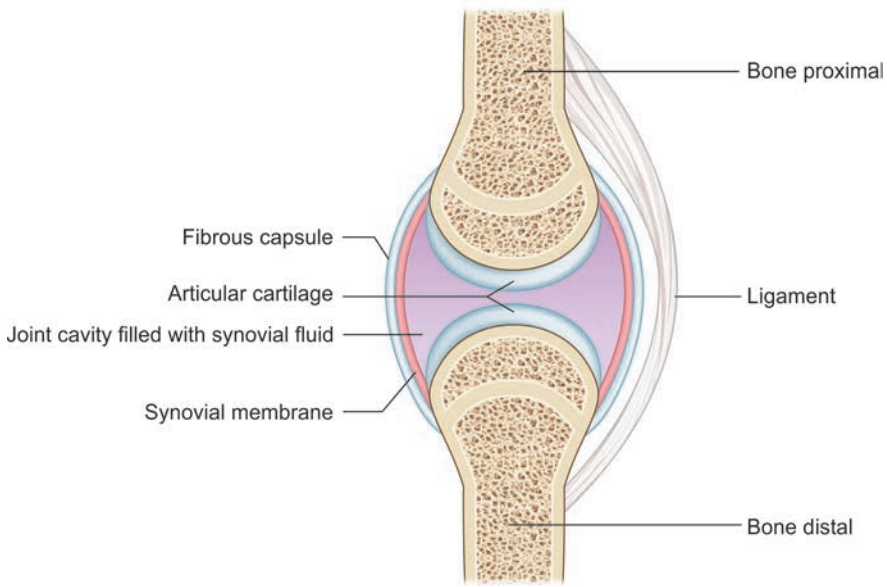


Fig. 6.8: Synovial joint—general structure.

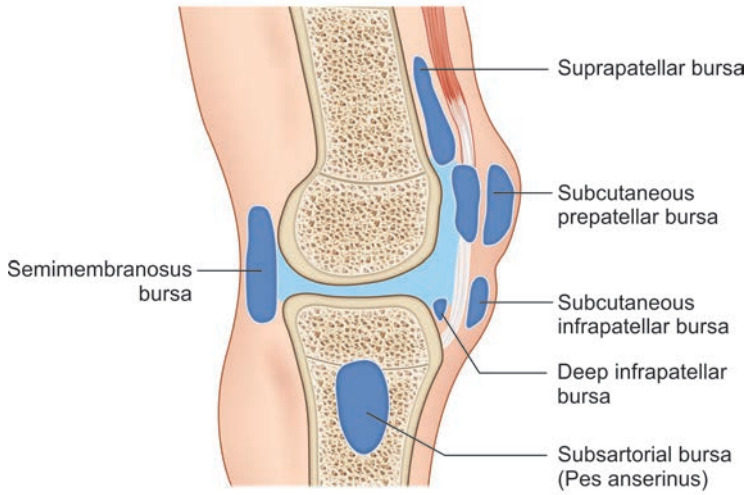


Fig. 6.9: Bursae around knee.

- The bursae are present in almost all major joints of the body.
- There are four types of bursa:
  1. *Synovial bursa*: Majority of the bursae are synovial, e.g. knee joint, and shoulder joint.
  2. *Adventitious bursa*: This bursa develops if any surface of the body is subjected to repeated stress. They are called accidental bursa, e.g. bunion.
     - *Bunion* is a deformity of great toe. The bursa at the metatarsophalangeal joint of big toe is swollen and the head of first metatarsal tilts to a side and a large bump is seen.
  3. *Subcutaneous bursa*: It is located between the skin and the bony prominence near the joint. For example, *Olecranon bursa (students elbow), prepatellar bursa* (housemaids bursa), *superficial infrapatellar bursa, and Achilles bursa*.
     - *Students elbow* (Olecranon bursa)—located between the loose skin of the elbow and the ulna. When inflamed there will be pain, swelling, and redness of elbow with restriction of movement. If infected, the bursa will open and the pus gets drained.
     - *Prepatellar bursa* (housemaids bursa)
  4. *Subtendinous bursa*: It is present between the tendon and bone or between adjacent tendons or between tendon and ligament. They are seen in the limbs, e.g. retrocalcaneal bursa. It is present from birth.
  5. *Submuscular bursa*: It is seen between muscles, e.g. greater trochanteric bursa, iliopsoas bursa, medial and lateral gastrocnemius bursae, and subpopliteal bursae.

Different types of bursae in the body, their location, and type are presented in Table. 6.2.

Classification of synovial joints (Flowchart 6.3): A. Based on number of articulating bones: Presented in Table 6.3.

Table 6.2: Location of various bursae and their clinical importance.

Name of bursa	*Location*	*Type*	*Clinical importance*
Ulnar bursa	Begins at wrist and ends at the middle of palm	Subtendinous	Horse shoe abscess results from infection of radial or ulnar bursa
Radial bursa	Extends from wrist crease to distal phalanx of thumb	Subtendinous	
Subpopliteal bursa	Between the lateral condyle of the femur and the popliteus muscle	Submuscular	
Iliopsoas bursa	Between the front of the hip joint and the iliopsoas muscle (flexor of hip)	Submuscular	Largest bursa in the body Iliopsoas bursitis—pain at the front of the hip radiating down to the knee or even into the buttocks
Greater trochanteric bursa	Superficial to greater trochanter of femur	Submuscular	Inflammation of this bursa is the common cause of hip pain
Medial gastrocnemius	Between the medial head of the gastrocnemius and the capsule of knee joint	Subtendinous	
Lateral gastrocnemius	Between lateral head of the gastrocnemius and the capsule of knee joint	Subtendinous	
Anserine bursa	Between the medial (tibial) collateral ligament and the tendons of the sartorius, gracilis, and semitendinosus (i.e. the pes anserinus)	Submuscular	Inflammation of the bursa due to constant friction because of certain positions, constant movement, certain diseases
Bunion	At the metatarsophalangeal joint of big toe	Adventitious bursa	Inflammation pushes the big toe against next toe. The surface skin is red.
Acromial bursa	Between the acromion process and the skin	Subcutaneous	
Subacromial bursa	Between the acromion process and supraspinatus muscle	Submuscular	
Subcoracoid bursa	Between the tendon of coracobrachialis and subscapularis muscles	Submuscular	
Subtendinous bursa of subscapularis	Between the neck of scapula and subscapularis muscle	Subtendinous	
Intertubercular bursa	Between the tendon of biceps brachii and the intertubercular sulcus of the humerus	Submuscular	
Retrocalcaneal bursa	Between Achilles tendon and calcaneus	Subtendinous	
Achilles bursa	Between Achilles tendon and the skin in the lower part of the ankle toward the heel	Subcutaneous	

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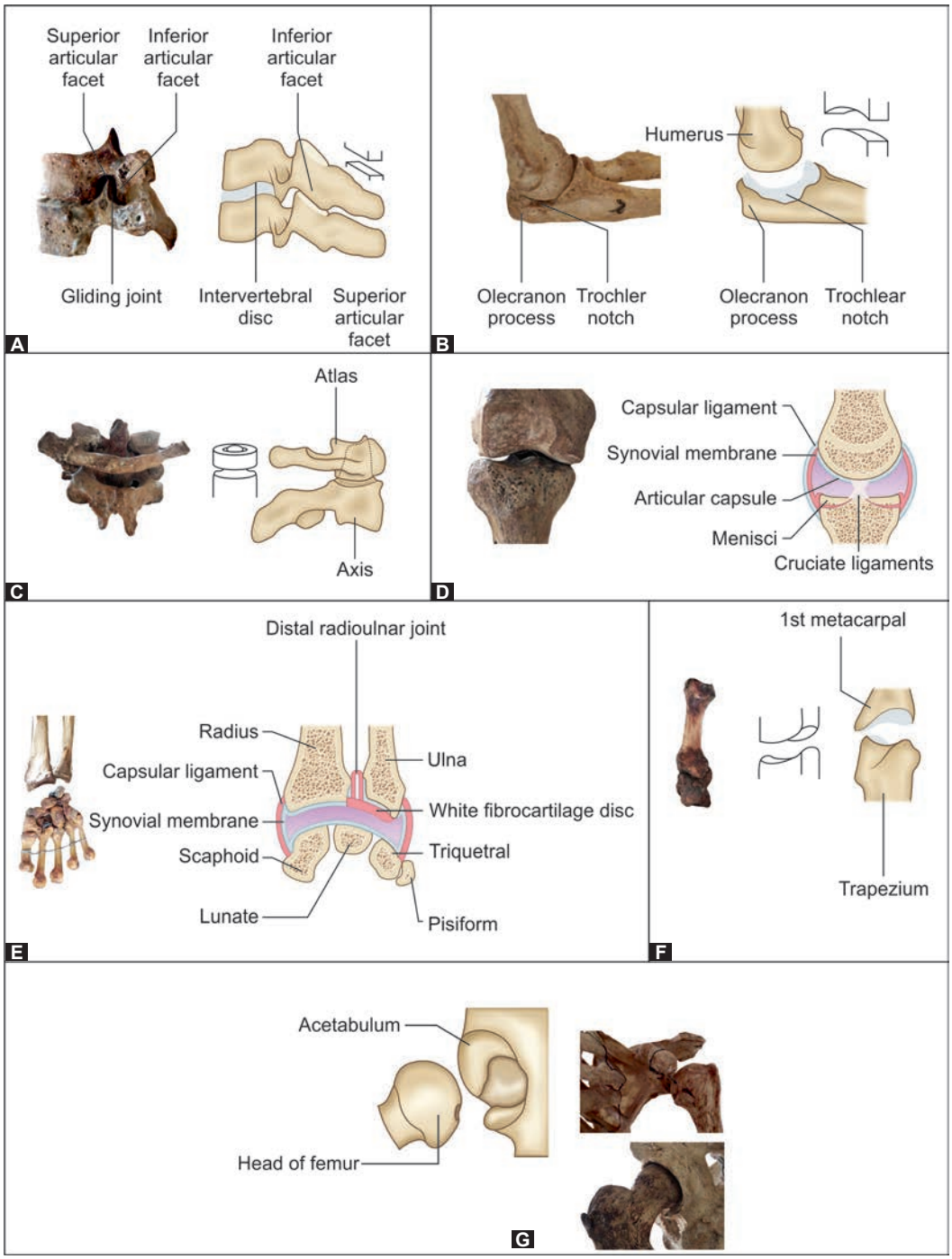

Figs. 6.10A to G: Synovial joint—subtypes; (A) Planner or gliding joint; (B) Hinge joint; (C) Pivot joint; (D) Condylar joint; (E) Ellipsoid joint; (F) Saddle joint; (G) Ball and socket joint.

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Medial and lateral excursions: Side to side chewing movements of mandible from and toward midline
Opposition: Movement of thumb that brings tip of thumb in contact with the tip of other finger
Lateral flexion: Bending the neck or body toward the right or left side
Rotation: Movement of a bone around its long axis (shoulder joint, proximal radioulnar joint, and hip joint) or along its central axis (atlantoaxial joint) or twisting of vertebral column (summation of small movements between adjacent vertebrae)

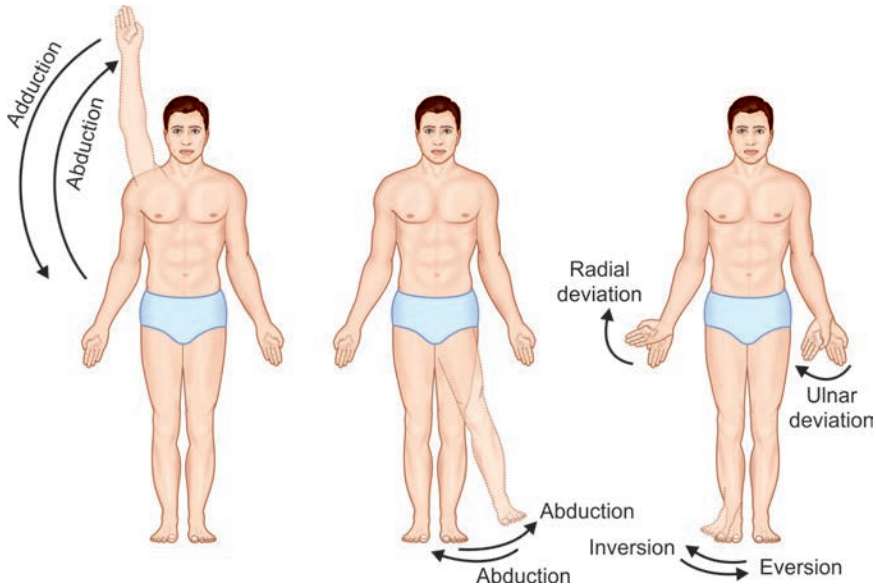
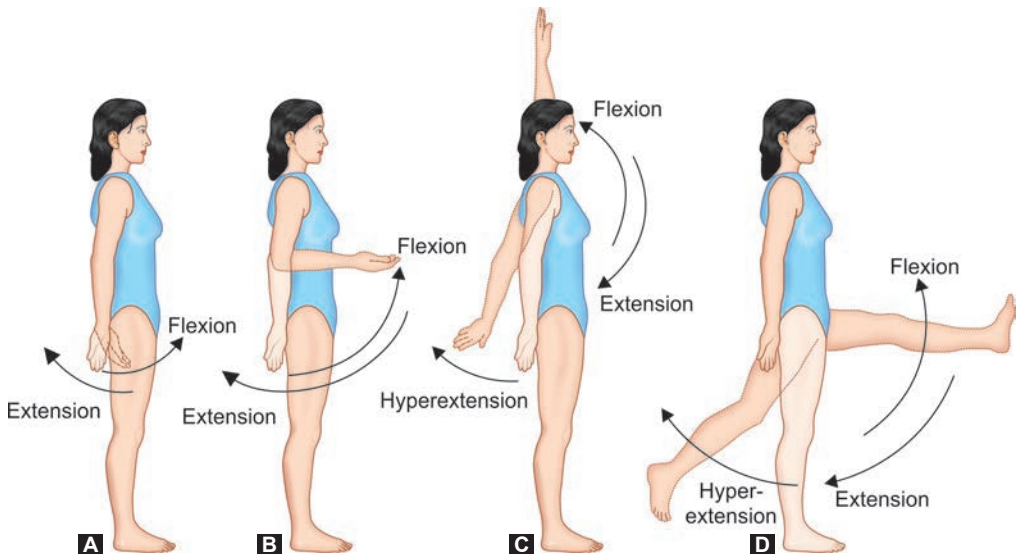


Fig. 6.12: Limbs—paired movements.



Figs. 6.13A to D: Limbs—paired movements: (A) Movements at wrist; (B) Movements at elbow; (C) Movements at shoulder; (D) Movements at hip.

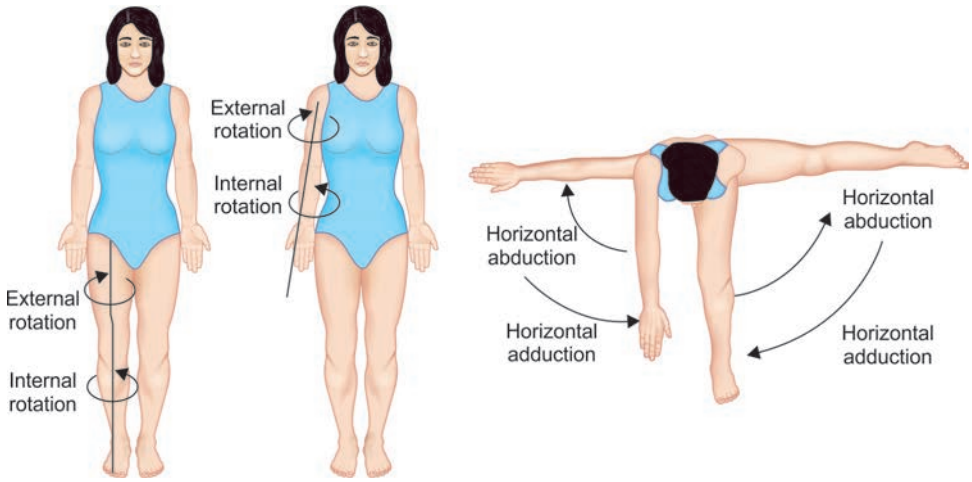


Fig. 6.14: Limbs—paired movements.

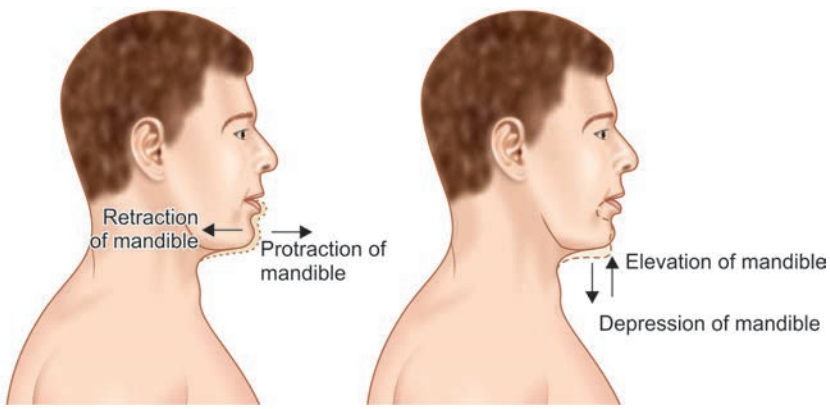


Fig. 6.15: Mandible—paired movements.

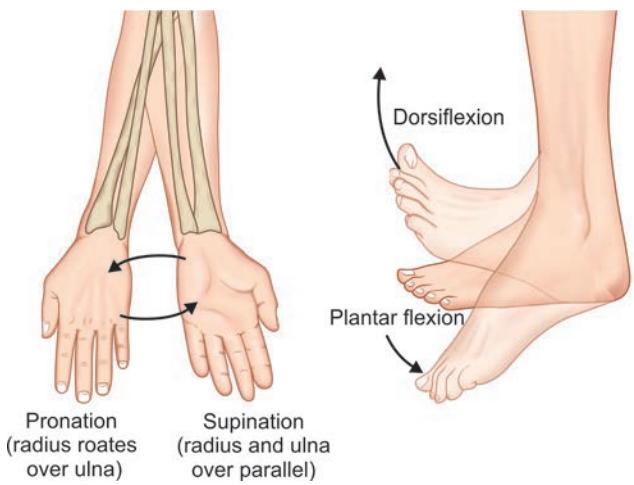


Fig. 6.16: Forearm and ankle—paired movements.

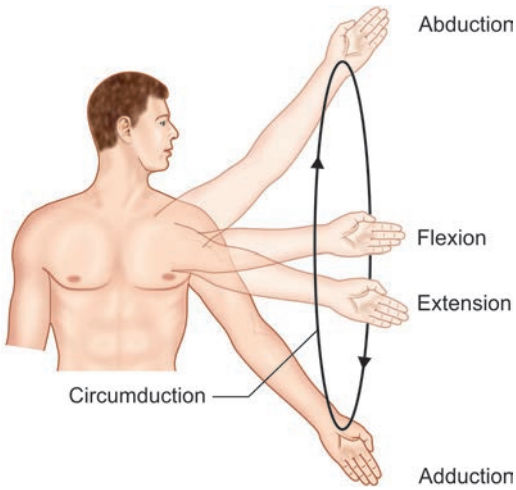


Fig. 6.17: Shoulder—circumduction movement.

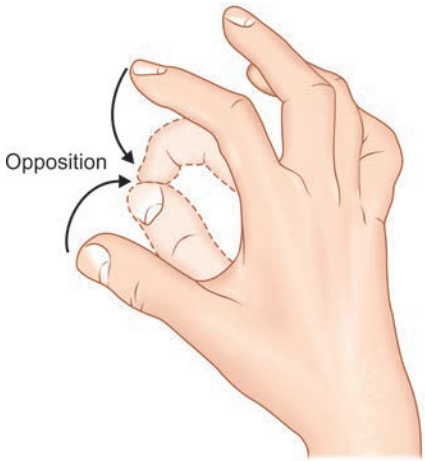


Fig. 6.18: Thumb—opposition movement.

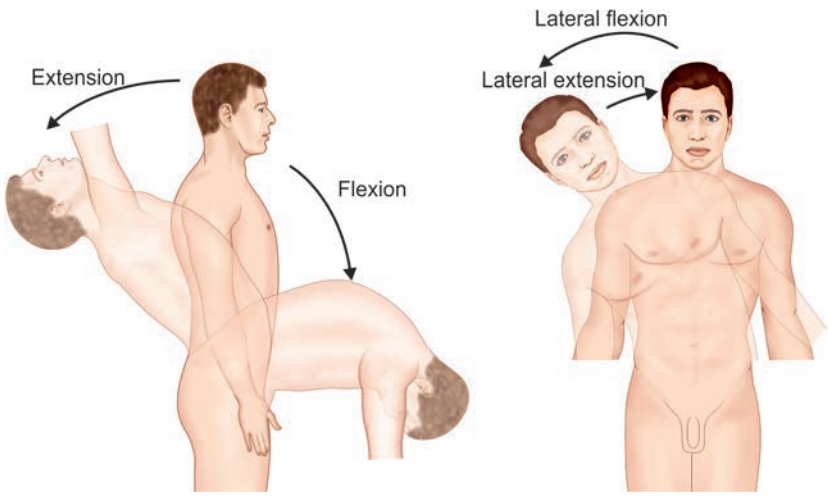


Fig. 6.19: Movements of trunk and neck.

Clinical Application of Joints

- *Arthritis* is inflammation of joint. There are about 100 different types of arthritis. The most common conditions, rheumatoid arthritis or osteoarthritis (old age), psoriatic arthritis and gout. The involved joints are swollen, painful, and with restricted movement.
- *Arthroscopy* is the procedure used for visualization of joint cavity and treating joint problems. A fiber-optic video camera is passed through a small incision into the joint cavity. The image is transmitted to the video-monitor.

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Contd…

- *Arthroplasty* is an orthopedic surgical procedure where the articular surface of a joint is replaced or remodeled to restore the function of the joint, e.g. total hip replacement, and total knee replacement.
- *Sprain*: Tear of a ligament causes severe pain due to fluid effusion in the ligament and joint. There will not be any dislocation.
- *Dislocation and subluxation*: Dislocation is loss of contact between the two articulating bones. If the contact is retained it is called subluxation. The common cause for dislocation is trauma and can cause pain, loss of function and deformity. The dislocation is diagnosed by X-ray.
- *Neuropathic joint*: It is caused by leprosy, tabes dorsalis and the joints show painless swelling and bone destruction.
- *Osteotomy* is a surgical procedure whereby a bone is cut to shorten or lengthen it or change its alignment if it has healed in an abnormal fashion following a fracture. It is also used to correct deformities of the limb, i.e. coxa vara and valga (deformity of hip), genu valgum (knock knee) and genu varum (bowed legs).

Anatomical Basis for Clinical Condition

Case Scenario

Problem: A sports person had a fall on outstretched arms and comes to the orthopedic surgeon with pain and swelling of the shoulder and restricted movement. It was diagnosed as dislocation of shoulder joint.

Questions:

1. What is the difference between fracture, dislocation, subluxation, and sprain in a shoulder joint?
2. What investigation is required to rule out fracture?
3. What treatment will be advised by the doctor?
4. Why is the shoulder more prone for dislocation?

Anatomical explanation:

1. Dislocation is complete disruption of a joint. It occurs when the two bones are out of place at the joint connecting them. Subluxation is partial dislocation followed by relocation. Fracture is a break in the bone. Dislocation can be associated with a fracture of the bone. A sprain is due to the tear of the ligament.
2. An X-ray of shoulder to be done to rule out fracture.
3. Surgical reduction to be followed by immobilization of the joint. After immobilization exercise for strengthening the joint to be advised.
4. The shoulder joint is a ball and socket joint formed by larger head of humerus and a smaller glenoid cavity of scapula. The range of mobility is more than the stability in the shoulder joint. Hence, it is more prone for dislocation.

Questions

1. Describe the general features of synovial joints.
2. Describe the features of fibrous joints and classify them with examples.
3. Classify synovial joints with examples.
4. Differences between symphysis and synchondrosis.
5. Bursa
6. What do you understand by axes of movement and degrees of freedom? Give examples.

☞ Key Concept

Take Home Message—Joints

- A joint is the connection between two or more bones or cartilages to permit movement.
- Long bones articulate at their ends, flat bones at margins and short or irregular bones at their articular surfaces.
- Joints are classified based on their structure and function into synarthroses (fibrous and immovable), amphiarthroses (cartilaginous and slightly movable) and diarthroses (synovial and freely movable).
- Fontanels are unossified fibrous tissue between the bones of vault of skull in fetus and in the infant.
- In a fibrous joint the articulating bones are connected by modification of fibrous tissue, i.e. ligament or interosseous membrane.
- Primary cartilaginous joints are temporary. Secondary cartilaginous joints are midline joints.
- The eight important components of a synovial joint are articulating bones, articulating cartilage, articular capsule, articular disc, joint capsule, accessory ligaments, synovial fluid, and bursa.
- Bursae are small fluid-filled, closed, synovial membrane lined sacs located between bone and muscle or tendon or ligament at the sites of friction and the fluid is called synovial fluid.
- There are five types of bursa—(1) synovial, (2) subcutaneous, (3) subtendinous, (4) submuscular, and (5) adventitious.
- Most of the joints of appendicular skeleton are synovial and are important in the field of medicine.
- The factors contributing to stability of synovial joint are contour of bones, ligaments, muscles, and atmospheric pressure.
- The three axes through which movement takes place in a synovial joint are sagittal, frontal and vertical with each at the intersection of two fundamental planes of the body.
- Depending on the number of axes through which movement of bone takes place the synovial joints are classified as uniaxial with one degree of freedom, biaxial with two degrees of freedom, and multiaxial with three degrees of freedom.