Biomechanics of Joints and Orthopaedic Implants
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Lecture: 06
Shoulder and Elbow Joints

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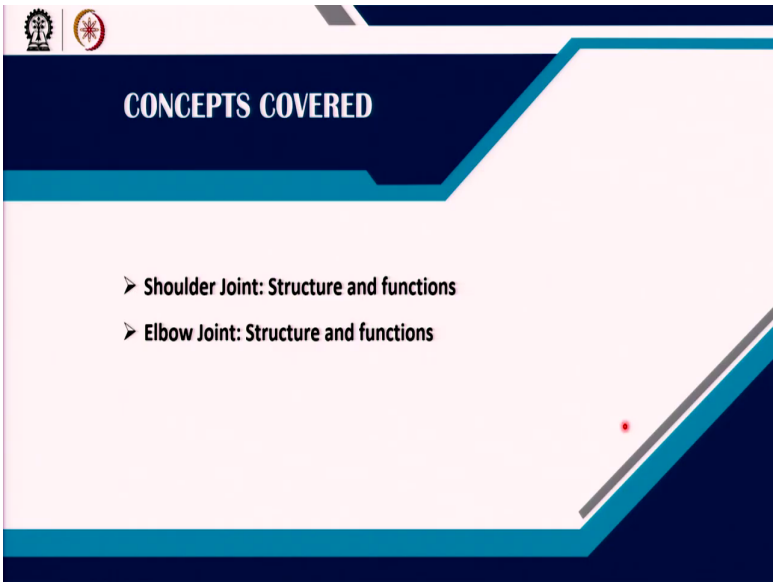

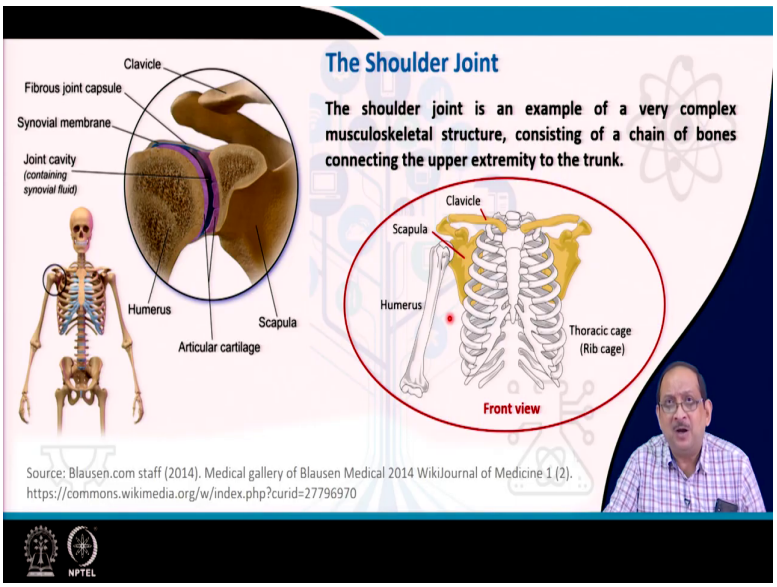

Good morning. Welcome to the lecture on shoulder and elbow joints. Now, in this lecture, we will be covering the structure and functions of the shoulder joint and the elbow joint separately. Now, the shoulder joint is an example of a very complex musculoskeletal structure consisting of a chain of bones connecting the upper extremity of the trunk.

As you can see here, the shoulder joint is formed by a chain of bones - humerus, scapular, clavicle, as well as the thoracic cage. The scapula is gliding over the thoracic cage when we are raising or moving our arms. When we are lifting our arm, the scapula is gliding over the thoracic cage.

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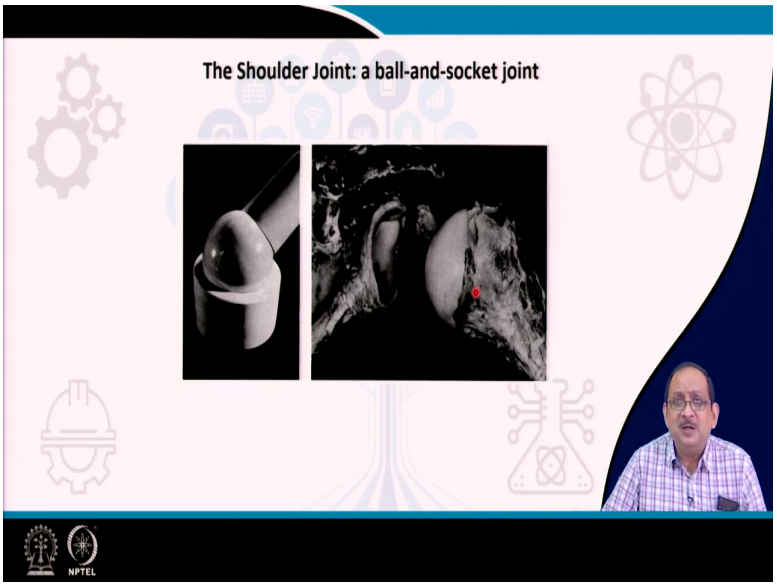

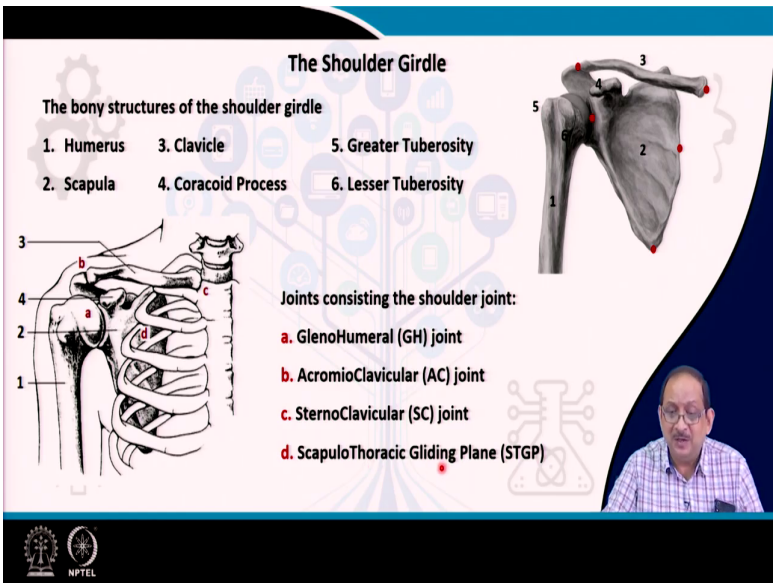

Now, the shoulder joint is classically a ball and socket joint. As discussed in the earlier lecture, a ball and socket joint gives us rotation around different axis. So, the shoulder joint is a highly mobile joint with a large range of motion. The bony structures of the shoulder girdle, as we call it, consists of the humerus, the scapula or the shoulder blade, the clavicle or the collarbone, and the coracoid process, which is a bony structure located on top of the scapula.

The other bony structures are greater tuberosity and lesser tuberosity on the humeral head. Now, the joints that constitute the shoulder joints through the shoulder joint are Glenohumeral joint due to articulation of the humeral head with the glenoid cavity. The acromioclavicular joint, so acromion is a bony structure, and it forms an acromioclavicular joint, joint formed by the connection of the clavicle with the acromion that is known as the acromioclavicular joint.

The sternoclavicular joint is the joint formed by the sternum and the other end of the clavicle. So, one end of the clavicle forms the acromioclavicular joint given by b here, and the other end of the clavicle forms the sternoclavicular joint with the sternum. And the fourth is not really a joint but a gliding plane, which is known as the scapula thoracic gliding plane. But since, it is a connection between the thoracic cage or rib cage with the scapula, so we call it a scapulothoracic gliding plane.

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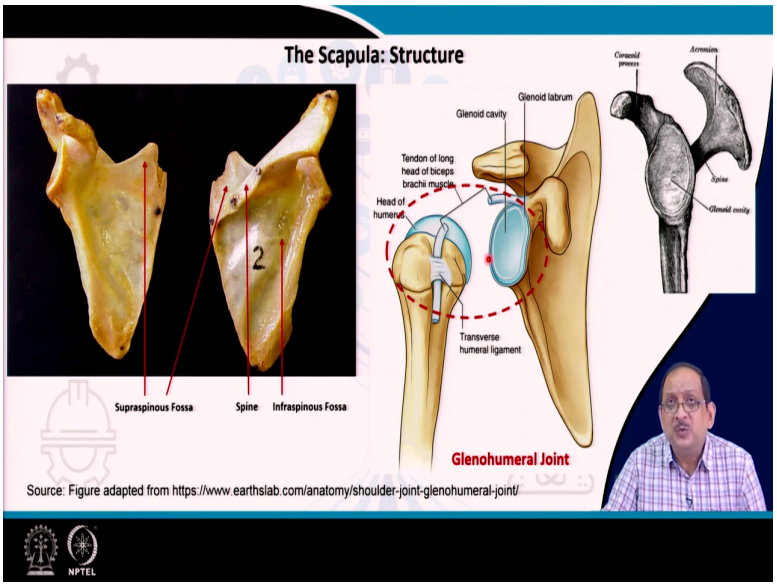

Now, let us consider the structure of the scapula, which is very, very complex. As you can see, the scapula is formed of some solid bony ridges and some solid bony structures. So, we have a glenoid, then a lateral border; we have this on the back of the scapular spine, which are solid bony ridges. However, it is also formed by thin laminated structures which are called fossa area.

So, you have supraspinous fossa, which is located above the scapular spine, and the infraspinatus fossa which is located lower to the scapular spine. If we take a side view, it can be seen that the structure of the scapula is almost like the branching of a tree. Hence, it is a very complex structure, and it gives us a large range of motion. It is a very, very mobile joint, and the mobility comes primarily from the glenohumeral joint, which is formed due to the articulation of the humeral head with the glenoid cavity.

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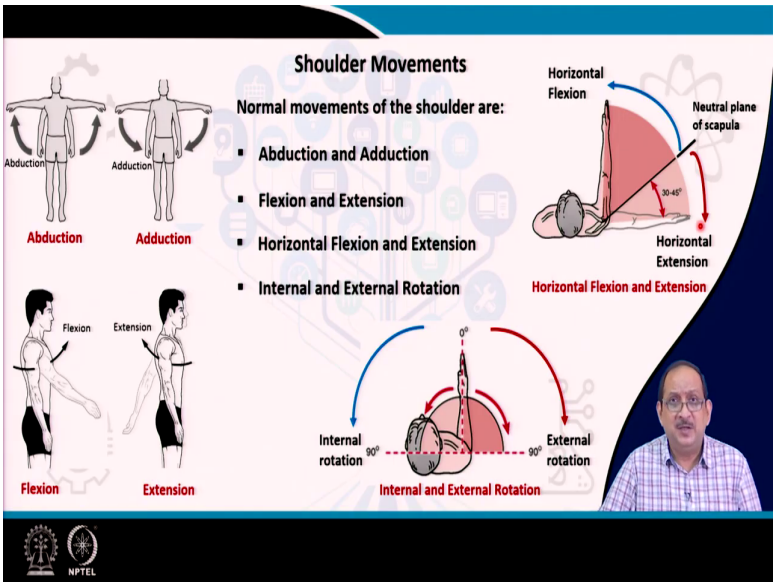

Now, let us consider the normal movements of the shoulder. As I remarked earlier, that the shoulder offers the largest range of movements in the human body. So, the normal movements are abduction and adduction, which is raising the arm and lowering the arm. Raising the arm is abduction. So you are moving away from the midline of the body as you are raising your arm. Lowering your arm is adduction.

Flexion extension is moving your hand forward and backward, forward is flexion, and backward is extension. In the horizontal plane, the movement flexion and extension can also be executed. So, when it is in the horizontal plane, we say that the movements are horizontal flexion and horizontal extension. Apart from these, the other rotation of the shoulder are the external and internal rotations. So, the internal rotation corresponds to the movement of the arm inwards towards the midline of the body. And away from the midline of the body is external rotation.

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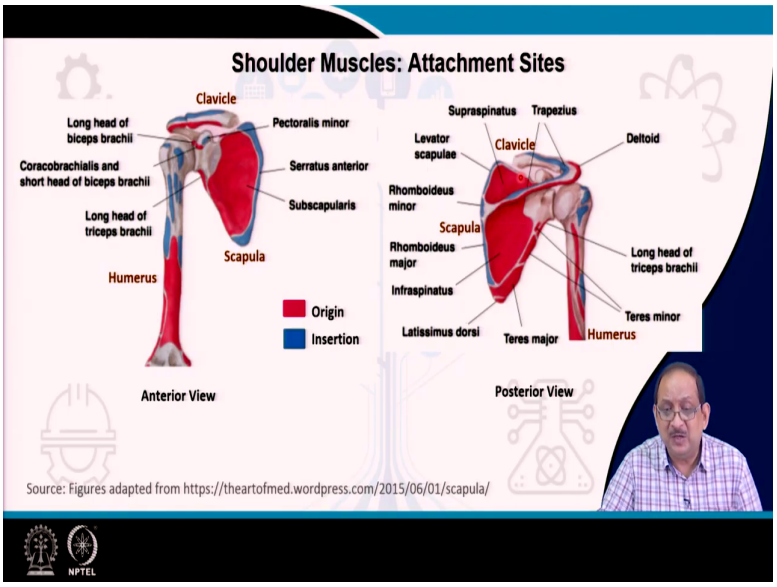

There are a large number of muscles that are in the shoulder joint. So, we can see the origin, which is marked by red color and the insertion of the different muscles in the shoulder. So, these muscles either have origin or insertion on the humerus, scapula, or clavicle that constitutes the shoulder joints. The attachment site of all the muscles in the shoulder is shown in the anterior view and posterior view of this slide.

The important muscles that are acting on the shoulders are also shown, which are deltoid, trapezius, supraspinatus, infraspinatus, teres major, teres minor, rhomboideus, and latissimus dorsi. We have the long head of triceps, the short head of biceps, and the long head of biceps as well. There is also the pectoralis minor and the serrate muscle serratus anterior, as well as subscapularis. The subscapularis located in the anterior side of the scapula, whereas the infraspinatus and supraspinatus are located on the backside of the scapula - one on the infraspinatus fossa, the other attached on the supraspinous fossa.

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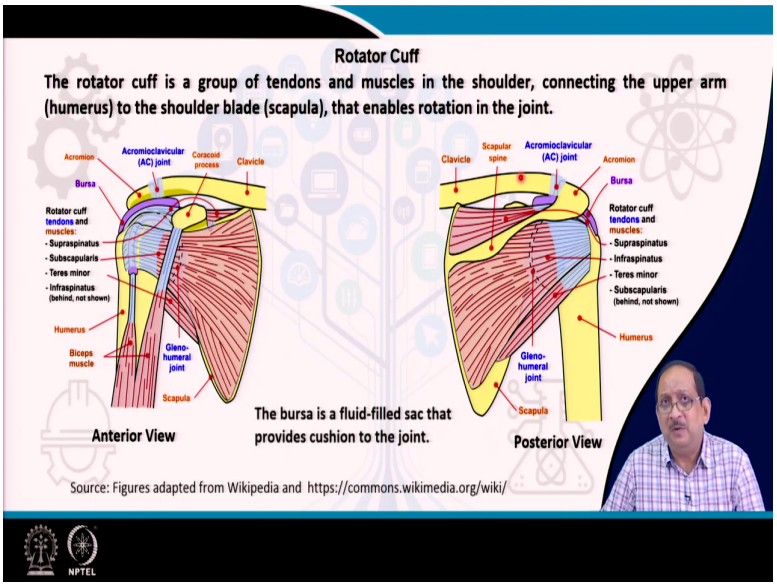

The rotator cuff group of muscles in the shoulder is connecting the upper arm to the shoulder blade, and the primary function of the rotator cuff is to enable rotation in the joint. Now, as you can see here, the rotator cuff group of muscles are four muscles, and the location and the attachment sites of this muscle are specifically plotted in this slide, both the anterior and posterior view.

So, we have the supraspinatus and infraspinatus, which are located on either side of the fossa. We have subscapularis in the front that is shown in the anterior view. And the fourth muscle is the teres minor, the location of which is shown here. Now, within this whole structure of the shoulder, there is a fluid-filled sac that is located near the glenohumeral joint towards the superior side of the glenohumeral joint. This fluid-filled sac is known as the bursa, which provides a cushion to the glenohumeral joint.

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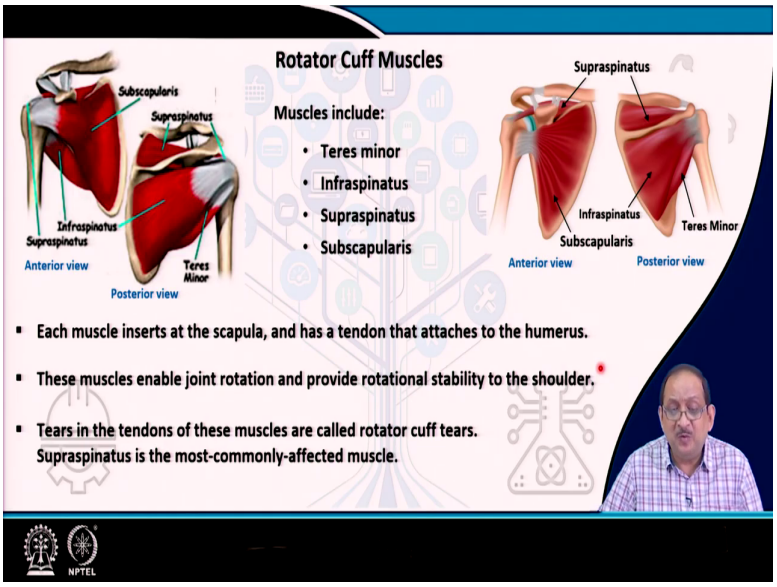

As indicated earlier, the muscles of the rotator cuff are the teres minor, infraspinatus, supraspinatus, and subscapularis. As clearly shown in the figures on either side, each of these muscles inserts at the scapula and has a tendon that attaches to the humerus. So, the rotator cuff muscle connects the humerus and scapula.

These muscles enable joint rotation and provide rotational stability to the shoulder. Tears in the tendons of these muscles are commonly known as rotator cuff tears. The supraspinatus is the most commonly affected muscle within the group of rotator cuff muscles.

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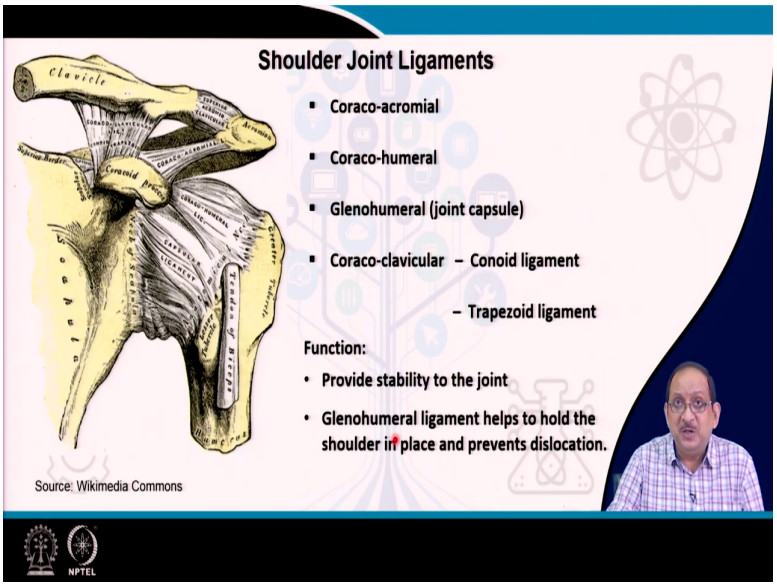

The shoulder ligaments can be listed as Coraco-acromial ligament, the Coraco-humeral ligament, glenohumeral ligament, and the Coraco-clavicular ligament. Now, as you can see in the figure, the Coraco-acromial ligament is the ligament that connects the coracoid process with the acromial. So, these are two bony structures originating from the scapula, but they are located within distance apart between the two. So, the Coraco-acromial ligament connects the acromion with the coracoid process.

The Coraco-humeral ligament connects the coracoid process with the humerus. The glenohumeral ligaments are a part of the joint capsule, the glenohumeral joint capsule. Sub capsular ligament and the Coraco-clavicular ligaments are the ligaments that connect the clavicle with the coracoid process.

There are two ligaments, one is the conoid ligament, and another is the trapezoid ligament. These two are grouped under the Coraco-clavicular ligaments. The primary function of these ligaments is to provide stability to the joint. In particular, the glenohumeral ligament helps to hold the shoulder in place and prevents it from dislocation.

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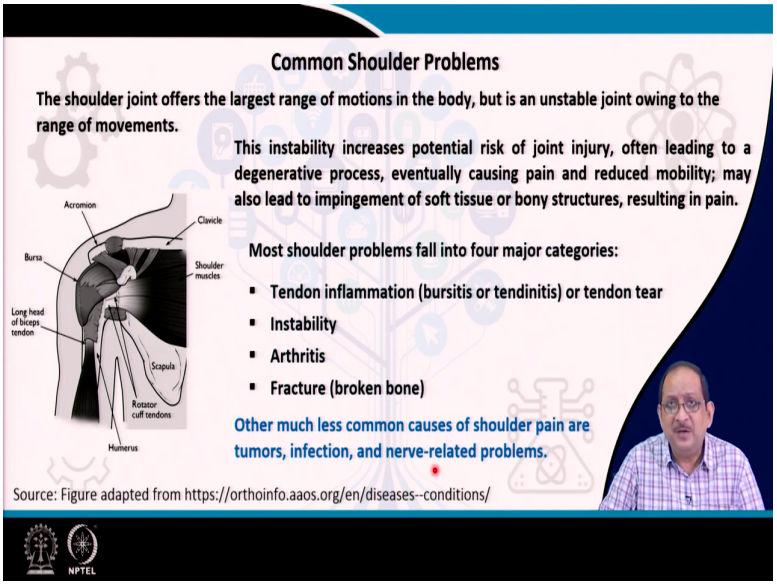

Let us come to the common problems in the shoulder joint. As indicated earlier, the shoulder joint offers the largest range of motion in the human body. However, it is an unstable joint owing to the large range of movements. This instability increases the potential risk of joint injury, often leading to degenerative processes, eventually causing pain and reduced mobility. It may also lead to impingement of the soft tissue or bony structures, resulting in pain.

Most shoulder problems fall under the four major categories. The first is tendon inflammation or tendon tear. The second is instability. The third is the common bone degenerative disease that is arthritis, and the fourth is bone fracture. Other much less common causes of shoulder pain are tumours, infection, and nerve-related problems.

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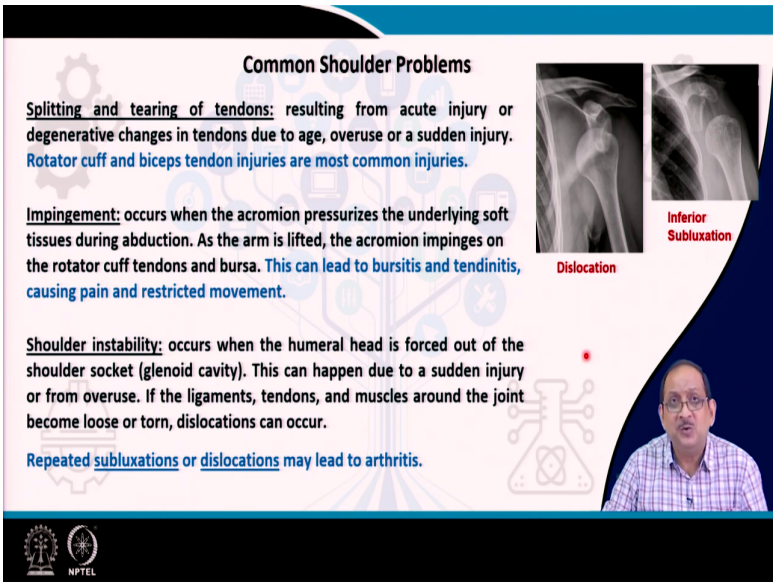

Now, let us discuss a little bit more in detail the problems of the shoulder which were indicated earlier. The splitting and tearing of the tendons is one important problem that results from acute injury or degenerative changes in tendons due to age, overuse, or a sudden injury. Rotator cuff and biceps tendon injuries are the most common injuries under this category. Impingement occurs when the acromion pressurizes the underlying soft tissue during abduction.

So, as the arm is lifted, the acromion impinges on the rotator cuff tendons and bursa. This leads to bursitis and tendonitis, causing pain and restrictive movement. The third, also quite common, is shoulder instability. The shoulder instability occurs when the humeral head is forced out of the glenoid cavity or the shoulder cavity. So, this can happen due to sudden injury or from overuse.

In case the ligaments, tendons, and muscles surrounding the joint cavity become loose or torn, dislocation can occur. Now, repeated subluxation and dislocation as shown in these two figures; the dislocation you can see very clearly that the humeral head has come out of the socket in the anterior posterior direction. It has come out anteriorly whereas, in the inferior

subluxation, the humeral head has come out and fallen down towards the inferior direction. That is inferior subluxation. So, repeated occurrence of the subluxations or dislocations may lead to arthritis.

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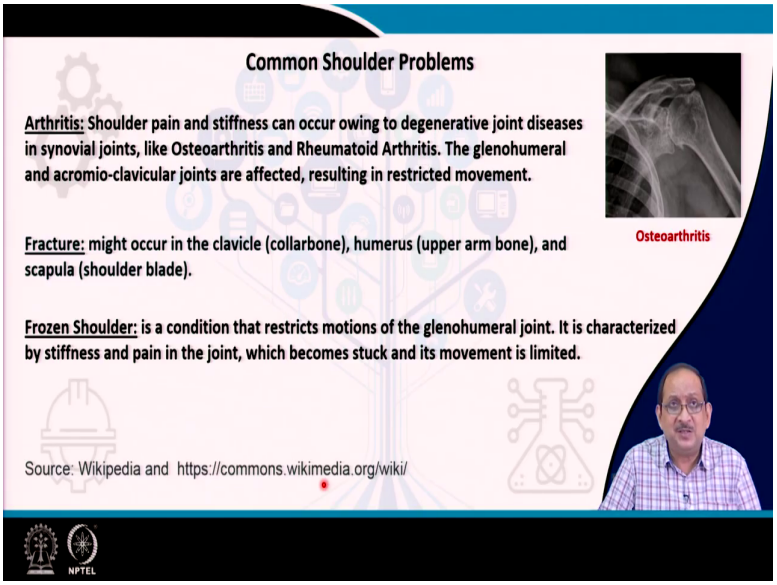

The shoulder arthritis is a degenerative joint disease common in all synovial joints. So, the shoulder is not an exception; it is accompanied by shoulder pain and stiffness. Common arthritis that is affecting the shoulder joint is osteoarthritis and rheumatoid arthritis. The glenohumeral and the acromial clavicular joints are generally affected, resulting in restricted movement of the shoulder joint.

Fracture can happen in clavicle (the collarbone), humerus (the upper arm bone), the humerus bone, and the scapula (the shoulder blade) due to different reasons. But the fracture is mostly due to fall or traumatic injuries. The frozen shoulder is sometimes quite common in patients; it is a condition that restricts motions of the glenohumeral joint.

It is characterized by stiffness in the joint and accompanied by pain. The shoulder becomes stuck with very limited movements, which can be designated as a state of frozen or stuck. So, this condition that restricts the motion of the glenohumeral joint to a great extent is known as the frozen shoulder.

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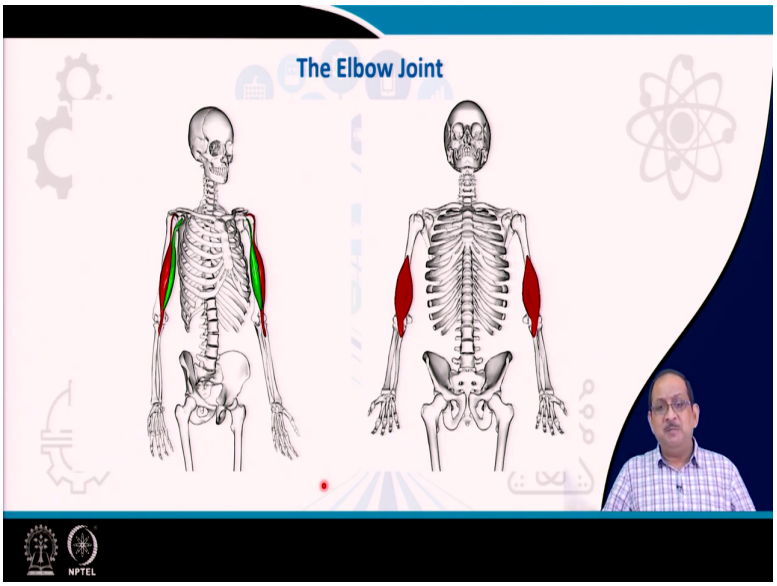

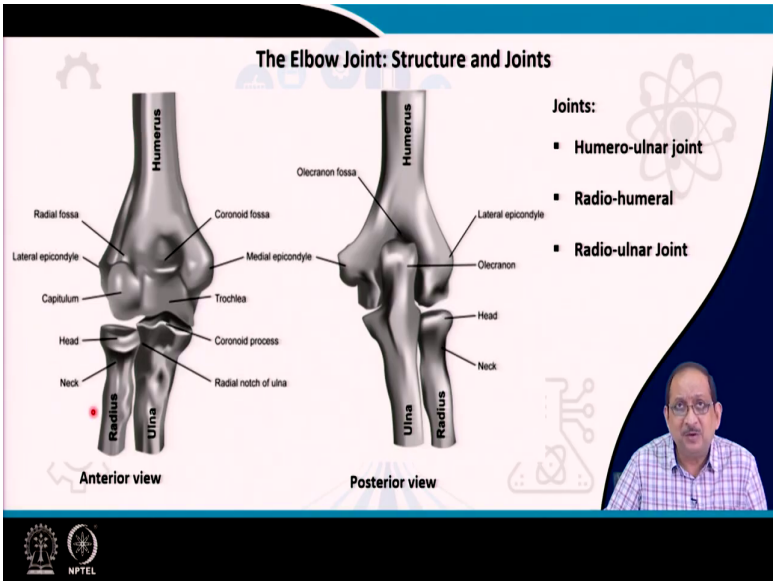

Let us now come to the second part of the lecture on the elbow joint. The elbow joint consists of three main bones .i.e. the humerus, the radius, and the ulnar. And the joints that are formed due to articulation of these bones are the humero-ulnar joint, the radio-humeral joint, and the radio-ulnar joint. The anterior and posterior view of the structure of the elbow joint is clearly presented in this slide.

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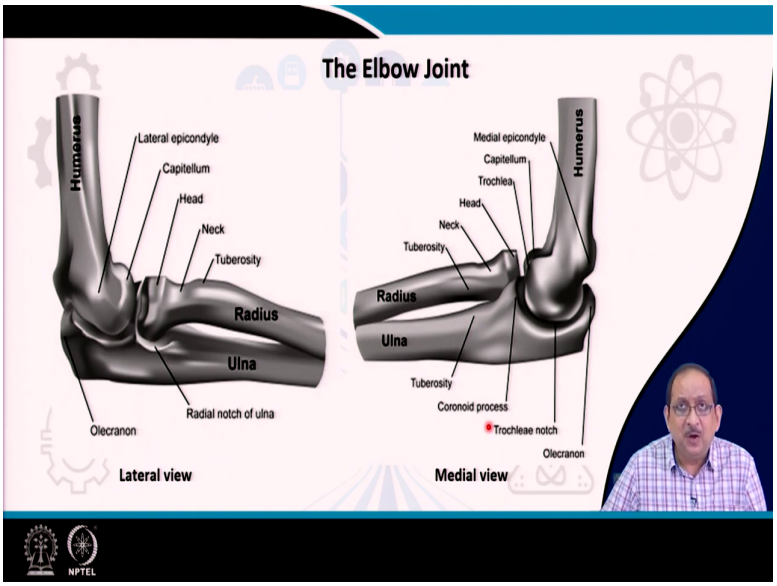

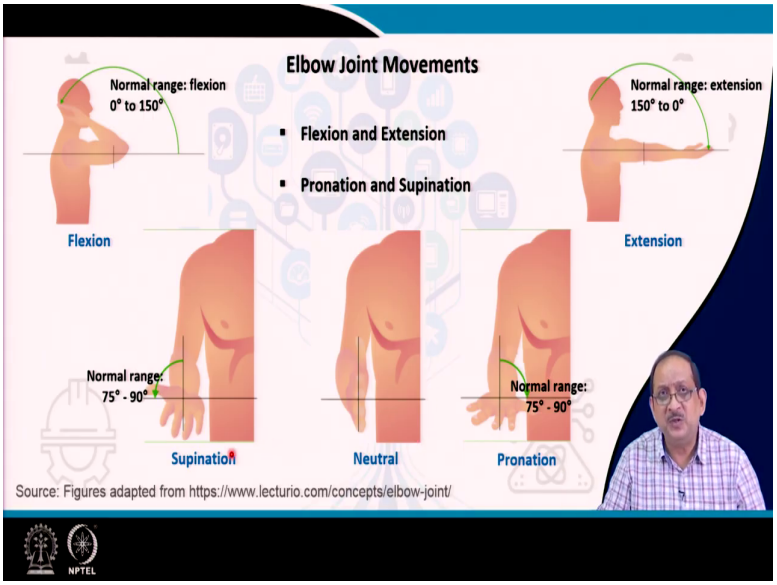

A lateral and a medial view of the elbow joint is also presented in this slide. Now, let us consider the movements of the elbow joint. Elbow also has a range of movements. The flexion and extension are the two primary movements, opposite in nature. So, we have a normal range of flexion of around 150 degrees, and normal range of extension is just the opposite, again around 150 degrees.

We have some specialized movement of the elbow joint in the form of rotation of the arm. So, either it is supination or pronation. So, if we consider the arm in as the neutral position, this position is neutral position; opening the palm is supination. So, we have normal range of 75

to 90 degrees; closing the arm in the opposite direction is pronation as indicated here. So, these are opposite rotational movement in the elbow presented here in the slide.

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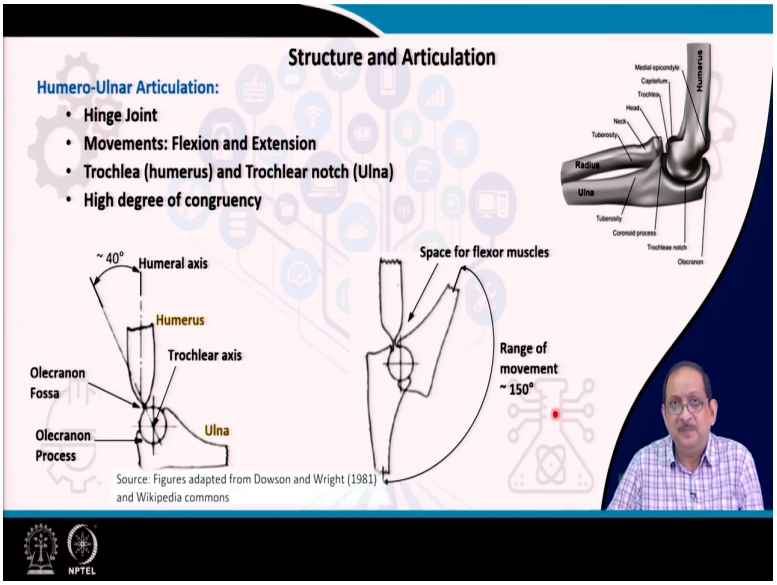

Now, let us look into the structure and the articulation of the bony parts, bony structures within the elbow joint. Now, the first articulation that needs to be addressed is the humero-ulnar articulation. So, it is an articulation between the humerus bone and the ulnar, and this articulation resembles a hinge joint, and the primary movements that are offered by this joint or articulation are flexion and extension.

So, if I look into the structure, we see that the Trochlea, which is a bony structure in the humerus, articulates in the Trochlea notch, which is located within the ulnar. So, the Trochlea of the humerus is articulating within the Trochlea notch of the ulnar, giving rise to humero-ulnar articulation. This joint has a high degree of congruency. So, the flexor movement offered by this joint can range up to 150 degrees.

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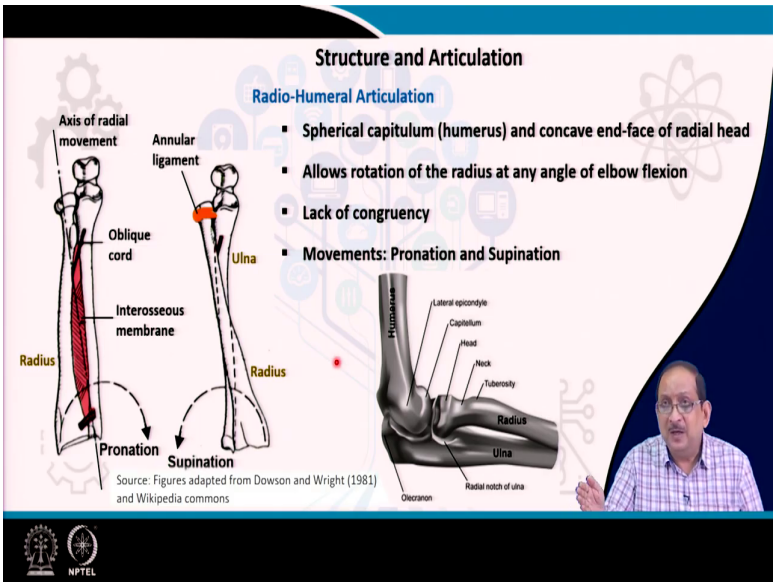

The next articulation is the radio-humeral articulation. So, the articulation is between the spherical capitulum of the humerus and the concave end face of the radial head. So, we have the radial head located towards the proximal part of the radius, and there is a concave end face of the radial head that articulates with the capitulum here.

Here is the capitulum and the radial head, spherical capitulum of the humerus is articulating with the concave end-face of the radial head, giving rise to radio-humeral articulation. It allows rotation of the radius at any angle of the elbow flexion. So, this radio humeral articulation is allowing rotation of the radius at any angle of the elbow flexion. However, this articulation lacks congruency in the structure. The movements offered by this articulation are pronation and supination. The movements of moving the palm outward and inward are discussed earlier.

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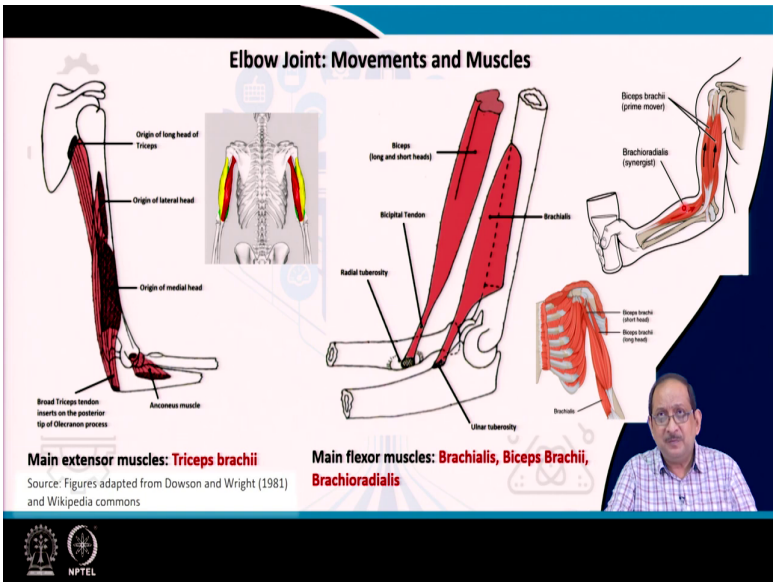

Now, let us look into the details of the movements and the corresponding muscles connected to these movements. We can see here the main extensor muscles; the muscles that are responsible for movement extension of the elbow is the triceps brachii. And the origin and insertion of these triceps are shown in the figure. The main flexor muscles are brachialis. Bicep brachii, and brachioradialis. So, we have Bicep brachii, brachialis here, and brachioradialis that is causing the flexion movement.

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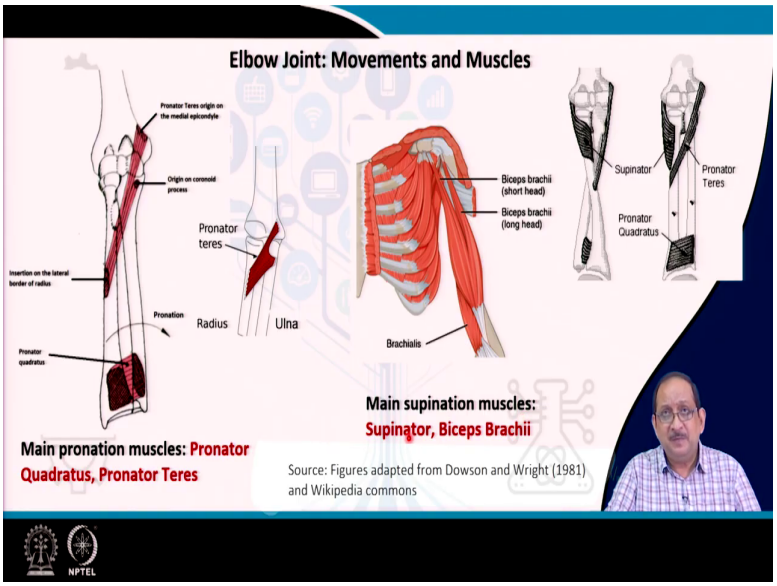

The other movements are pronation and supination, as discussed earlier. The main muscles responsible for pronation are pronator, quadratus located here, and the pronator teres located

more towards the medial epicondyle of the humerus and the proximal part of radius. The muscles responsible for supination are the supinator, as you can see here, and the biceps brachii.

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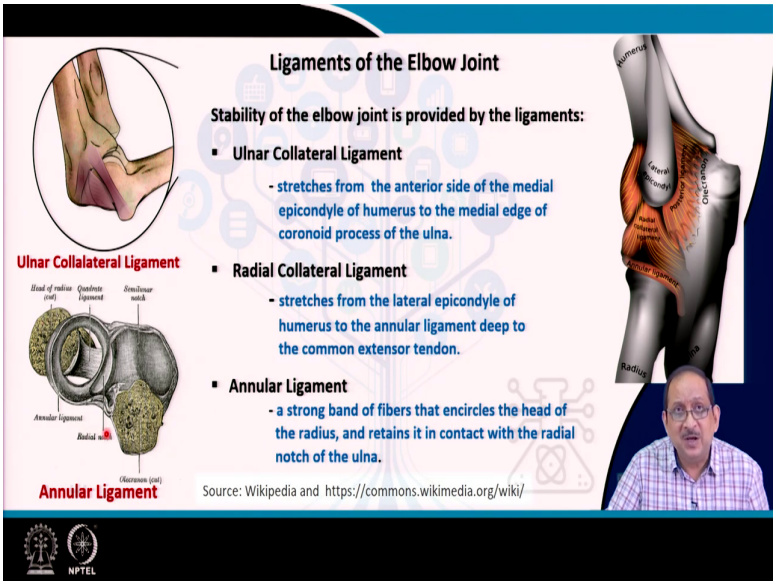

The ligaments, as usual, offer stability to the elbow joint. And the main three ligaments that constitute the elbow joint are the ulnar-collateral ligament, the radial-collateral ligament, and the annular ligament. The ulnar collateral ligament is also known as medial collateral ligament, and it stretches from the anterior side of the medial epicondyle of the humerus to the medial edge of the coronoid process of the ulna. So, this is a very important ligament of the elbow joint.

The radial collateral ligament, on the other hand, stretches from the lateral epicondyle. So, it is stretching from here, the lateral epicondyle of the humerus, to the annular ligament, deep to the common extensor tendon. So, from the lateral epicondyle of the humerus to the annular ligament deep to the common extensor tendon. Whereas the annular ligament is a strong band of fibers that encircle the head of the radius and retains it in contact with the radial notch of the ulna. So, it is a circular type band of fibers connecting radial notch of the ulna.

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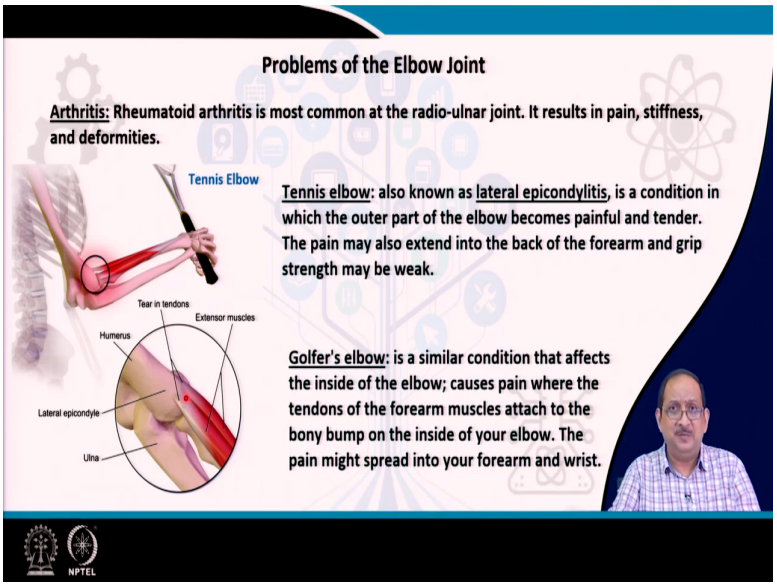

The problems of the elbow joint can be listed here. Similar to other synovial joints, arthritis is a common problem in the elbow joint. Rheumatoid arthritis is the most common in the radio-ulnar joint, which results in pain, stiffness, and deformities. The tennis elbow, also known as lateral epicondylitis, is a condition in which the outer part of the elbow becomes painful.

The outer part of the elbow is painful and tender, the pain may also extend into the back of the forearm, and the grip strength in this condition may be very weak. Now, Golfer's elbow is a somewhat similar condition that affects the inside of the elbow. It causes pain, where the tendon of the forearm muscles is attached to the bony bump on the inside of the elbow. The pain might spread into your forearm and wrist.

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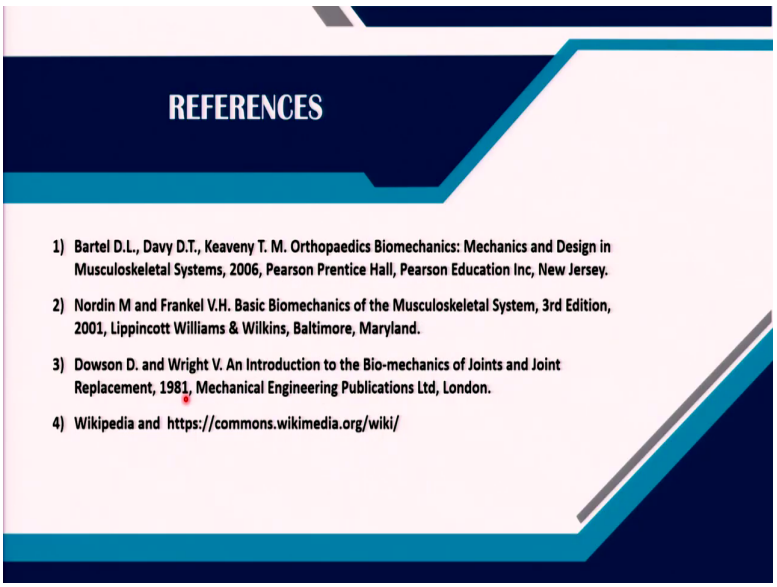

The lecture is based on some references, which are listed here. I thank you for listening.