

SYNOVIAL FLUID: An Overview

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PBL SEMINAR MBBS III

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- Normal joint is surrounded by a membrane:
 - Synovial membrane (or Synovium) that forms a capsule around the end of the bone;
- Synovial membrane secretes a liquid:
 - Synovial fluid (Synovial : “like egg white”);

What are the functions of Synovial Fluid?

- Several important functions: It serves as:
 - Lubricant,
 - Shock absorber,
 - Nutrient carrier

As a lubricant:

- In healthy joints (healthy cartilage tissue) **Synovial fluid** makes joint slicker than wet ice;

NB:

- Synovial fluid cannot function as a lubricant in joints with poor cartilage caused by inadequate production of **Glucosamine and Chondroitin sulfate which are the building blocks of cartilage;**
- Synovial fluid becomes thin and watery, thus cannot function as a lubricant;

As a shock absorber or hydraulic fluid

- Synovial fluid in contact with cartilage in joints protects the bones from the tremendous impact they would receive when we:
 - Walk Run,
 - Jump,
 - Skip, etc,
- Synovial fluid is a **Dilatent liquid**;
- Synovial fluid has dilatent properties;

What are the characteristics of a Dilatent liquid?

- Dilatent liquids are characterized by the rare quality of becoming thicker and more viscous, when shear (force) is applied to them;

What are the Dilatent properties of Synovial Fluid?

- Synovial fluid in Knees and Hips becomes very viscous at the moment of shear in order to protect the joints; then it thins out again to its normal viscosity instantaneously to resume its lubricating function between shocks;
- Change of state of Synovial fluid occurs over and over again, very rapidly, during vigorous exercise:
 - Sports,
 - Dancing,
 - Walking,
 - Jumping,
 - Skipping, etc;

- This mechanism breaks down, when adequate amount of Glucosamine and Chondroitin (building blocks of cartilage) are not synthesized in the body;
 - Viscosity is reduced, giving thin, watery synovial fluid that fails to function as shock absorber and lubricant;
- Resultant effect is:
 - Pain,
 - Stiffness,
 - Decreased mobility,
- These characterize Osteoarthritis:
 - A condition primarily due to imbalance between rate of destruction and rate of production of cartilage;

Summarise the basic functions of Synovial Fluid

- Lubrication to reduce frictional resistance to joint movement;
- Provide nutrition to articular cartilage;
- Protect the joint structures when subjected to large compressive forces;
- Provide a liquid environment within a narrow pH range;
- Remove various products of metabolism;

State the general composition of Synovial Fluid

- It is a highly viscous fluid that is a Transudate of plasma;
 - Dialysate of blood plasma filtered through semi-permeable walls of blood vessels, with addition of **Hyaluronic Acid**;
 - Hyaluronic acid is one of the high molecular weight compounds called **Glycosaminoglycan (GAG)** produced by synovial cells;
 - Hyaluronic acid makes Synovial fluid viscous

- **Synovial fluid:**
 - Is clear, almost colorless or straw-colored;
 - Has about one-third the amount of protein in blood plasma;
 - Contains only low molecular weight proteins such as Albumin;
 - Does not contain high molecular weight proteins such as Fibrinogen therefore it **does not form Fibrin Clot** when aspirated;
 - Has low Glucose content

What is Hyaluronic Acid?

- Hyaluronic acid:
 - Consist of repeating Disaccharide units of N-Acetylglucosamine and Glucuronic acid;
 - Is a Glycosaminoglycan (GAG) in synovial fluid and cartilage;
 - Is synthesized in synovial membrane and released in synovial fluid;
- Large molecular weight, poly-electrolyte-character, and large volume of water it occupies in solution contribute to the properties of Hyaluronic acid as lubricant and shock absorbent;

State some functions of Hyaluronic acid?

- It acts as lubricant and shock absorber;
- It acts as barrier permitting metabolites to pass through it by diffusion but resist penetration by bacteria and other infectious agents;
- Amount of Hyaluronic acid in cartilage varies, but it is less than 1% of total Glycosaminoglycans (GAG);
- It can be present in a free state, but it is usually found as a part of **Proteoglycan** aggregates in cartilage;

What are **GAG (MUCOPOLYSACCHARIDES)**?

- GAG are un-branched Hetero-polysaccharides made up of repeating disaccharide units in which **one component** is always:
 - **Amino sugar** (D-Glucosamine or D-Galactosamine);
 - The other component is usually **Uronic Acid**;

List the different types of GAG?

- **Seven types of GAG:**
 - Hyaluronic Acid,
 - Chondroitin Sulfate (made up of Chondroitin 4-sulfate and Chondroitin 6-sulfate),
 - Keratan Sulfate I & II,
 - Heparin,
 - Heparan Sulfate,
 - Dermatan Sulfate,

What are Proteoglycans?

- PROTEOGLYCANS are the complex structures formed when GAG are covalently linked to proteins
- GAG are Polysaccharide portions of Proteoglycans

Outline the general structure of Proteoglycans?

- Proteoglycan is a macromolecule made up of protein core to which many GAG chains are attached;
- Proteoglycan consist of 10% protein and 90% GAG;
- Hyaluronic acid is non-covalently bound to Proteoglycan aggregate;
- Glycoproteins stabilize non-covalent association of Proteoglycan subunits with Hyaluronic acids in aggregate;
- In Osteoarthritis there is a characteristic reduction in aggregating Proteoglycans;

What is the general composition of Articular Cartilage?

- Articular cartilage is elastic, fluid-filled, and backed by a relatively impervious layer of calcified cartilage and bone;
- About 80% of this specialized Hyaline cartilage is liquid (two-thirds are in the matrix);
- Collagen forms about half to two-third of the dry weight of cartilage;
- Chondroitin Sulfate (GAG) is in the matrix and comprises one-sixth to one-fourth of the dry weight of articular cartilage;
- Cartilage must remain resilient to act as shock absorber;

- To retain minimal friction cartilage must maintain a smooth and unbroken surface;
- If changes occur in surface, friction increases and a vicious cycle of wear and cartilage destruction ensues;
- Diffusion of nutrients from synovial fluid into articular cartilage is enhanced by the cyclic “kneading” of the cartilage in normal activity;
- Interference with the supply of nutrients may contribute to degenerative joint disease;

Osteoarthritic knees

- Usually contains Synovial fluid with:
 - Increased cell numbers,
 - Increased levels of enzymes,
 - Greater number of particles than normal knee,

List some changes in composition of Synovial fluid in Arthritis?

- Increased protein content;
- Increased number of cells;
- Possible changes in Hyaluronic acid structure;
- In various types of Arthritis, Proteoglycans may act as auto-antigens, thus contributing to the pathologic features of these conditions;
- Amount of Chondroitin sulfate in cartilage diminishes with age, but the amounts of Hyaluronic acid and Keratan sulfate increase;
- These changes may contribute to development of Osteoarthritis;