INTERPLAY OF MATRICES IN CARTILAGE SYNOVIAL FLUID COMBINE UNDER MODERATE AND HIGH LOADINGS

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ABSTRACT

Interplay of the constituents of articular cartilage synovial fluid combine and its role is examined from the biochemical and Theological study on bovine joint. Results show inverse relationship between the changes in the hyaluronic acid and proteoglycan contents of synovial fluid and articular cartilage with the corresponding alterations in the Theological properties of synovial fluid. Study indicates that inter movement fluid solutes across the cartilage and synovial fluid plays important role in the pathophysiology of osteoarthritis.

Keywords : Proteoglycans, Hyaluronic acid, Rheological properties, Osteoarthritis

INTRODUCTION

Risk factors responsible for the genesis of osteoarthrotic disease is not well known. Articular cartilage which is an avascular living tissue depends for its growth, metabolism and nutrition on supplies from surrounding synovial fluid [6,9,14]. In normal cartilage proteoglycans (PGs) component provides compressive ability to load bearing joints and the articular cartilage degradation is prevented by on going PGs biosynthesis which inhibit the onset of osteoarthritis [4]. It has been found that the rate of PGs synthesis in the chondrocytes depends upon the surrounding freely exchangeable pericellular fluid and the hyaluronic acid (HA) in the synovial fluid [10]. Breakdown products of PGs which are smaller than the parent PGs can diffuse freely in and out of the cartilage tissue and into the synovial fluid. Synovial fluid which freely bathes intra-cartilage structures with its solutes and solvents through the process of joint compressive motion consists mainly of HA content that belongs to the family of glycosaminoglycans (GAG) [12]. Synovial fluid also provides lubrication for the frictionless motion of joints and the lubrication mechanism has been found to be influenced by variation in rheological properties of the fluid [5]. Variation in HA contents of the synovial fluid due to pathological processes influence the rheological visco-elastic properties of fluid [7]. Mechanical stresses have been found to produce biochemical changes in load bearing joints. Present study examines the interplay of changes in the proteoglycans content of the cartilage matrix vis-a-vis concentration of HA and the rheological properties of the synovial fluid in freshly amputated bovine knee joints subjected to moderate and high loadings.

MATERIALS AND METHODS

Study has been conducted on two sets of seven pairs of freshly amputated bovine heifers knee joints aged about 1 1/2 - 2 years immediately after the animal were sacrificed in the local slaughter house. The left bovine knee joint specimens were subjected to articulation at 0.75-Hz for two hours where tibia was flexed through an angle of 70° on a specially designed Knee joint articulating machine [8]. A constant loading of 1471.5 N (moderate loading) was applied by the oil sealed hydraulic jack mounted on the top of femoral stump. In the, second set of experiments a load of 2943.0 N was applied on the joint which was subjected to articulation for two hours for studying the high loading effects. The right knee joint of the animal served as control and was placed in vertical stationary position by clamps on a stand for two hours without loading. At first, synovial fluid from the bovine knee joint was aspirated with the help of a aseptic syringe. The fluid was centrifuged at 37000 G for 20 minutes to remove fibrin clots and cell debris which may have entered the fluid during its aspiration and stored in glass bottle at 4°C without any preservative. The joint was opened and tibial condyles load bearing area articular cartilage was scraped from the subchondral bone surface with the help of a sharp scalpel blade and stored in physiological saline soaked filter paper covered petri dish at 4°C for biochemical studies.

Rheological study of synovial fluid : Weissenberg Rheogoniometer was used to measure apparent viscosity \( \eta \), shear rate \( \dot{y} \) and shear stress \( \sigma \) of the normal and load tested synovial fluids.

Biochemical study : HA concentrations in synovial fluid from the control and the load tested bovine knee joints were determined by the method of Tolkdorff et al [11]. The PGs component of the cartilage matrix samples (control and load tested) were extracted by the method of Carney [1] and then the PGs content was estimated by the quantitative dye precipitation technique of Whiteman14.

RESULTS AND DISCUSSION

The results at moderate loading (Fig. 1) showed that the mean value of HA decreased from 0.97 ± 0.06 to 0.48 ± 0.14 mg/ml and the PGs percentage increased from mean value of 7.13 ± 0.80 to 11.13 ± 1.34 of the wet weight of the cartilage. But in high loading HA content in the synovial fluid increased.
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from 1.04 ± 0.09 to 2.39 ± 0.28 mg/ml and the PGs percentage in the cartilage decreased from 7.18 ± 0.68 to 4.04 ± 0.72 of the articular cartilage and HA concentration in synovial fluid of the load tested bovine knee joint is observed.

Role of synovial fluid HA content in joint activities has been postulated to be quite complex and indicates presence of some sort of interplay between the extracellular matrix proteins and GAG conjugates [3]. The porosity of the cartilage tissue (fluid volume/tissue volume) is large estimated pore size ranges from 20 to 65 Å. The HA portion of GAG polymer of synovial fluid has a diameter of around 10 Å. Therefore, size can not account for the flow resistance of solute permeability across the ground substance of the cartilage [2]. Furthermore, joint loading and motion are mainly responsible for the extrusion and intrusion of fluid in the articular cartilage where pressure effects may enhance this process. Abnormal loadings have been found to cause loss of PGs from the articular cartilage and have also been implicated in the etiology of osteoarthritis. Our results have also found decrease in PGs content with shear rate at moderate and high loadings.

The study shows increase in apparent viscosity of synovial fluid with respect to control in case of the synovial fluid expired from the highly loaded knee joint. On the other hand the synovial fluid from moderately loaded knee has shown decrease in the apparent viscosity with respect to control at all shear rates (Fig.2). Our experimental results show inverse variation relationship between HA acid concentration of high load there is an increase in the HA content of the cartilage matrix of highly loaded knee joint that presents a picture of early stages of arthritic degeneration of articular cartilage with increase of HA concentration in the synovial fluid of the joint which is a typical picture of osteoarthritis condition.

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Fig. 1. Variation of cartilage proteoglycans and fluid hyaluronic acid content at moderate and high loadings

Fig. 2. Variation of bovine synovial fluid apparent viscosity with shear rate