Express the Mechanical Behaviour of each Valve Leaflet Specimen

Burno Sherman*

Department of Biological Sciences, Korea Advanced Institute of Science and Technology, Republic of Korea

***Corresponding author:** Email: Sherman_b@gmail.com

Citation: Sherman B (2022) Express the Mechanical Behaviour of each Valve Leaflet Specimen. Electronic J Biol, 18(4): 1-2

Received date: March 10, 2022, Manuscript No. IPEJBIO-22-13399; **Editor assigned date:** March 13, 2022, PreQC No. IPEJBIO-22-13399 (PQ); **Reviewed date:** March 27, 2022, QC No. IPEJBIO-22-13399; **Revised date:** March 30, 2022, Manuscript No. IPEJBIO-22-13399 (R); **Published date:** April 10, 2022, DOI: 10.36648/1860-3122.18.4.018

Description

Scales have been a key form of protection for fish for hundreds of millions of years. Although most commonly found in fish and reptiles, scales may also be found in mammals: The pangolin is covered in keratinous scales. Additionally, ancient Romans produced armour named lorica squamata, in which individual iron or bronze scales were sewn to a fabric backing. Although it comes at an additional weight penalty in comparison with other armours, such as logical hamate (chain mail), its effectiveness in battle made it an important defence for Roman legionnaires.

Mechanical Behaviour

In order to express the mechanical behaviour of each valve leaflet specimen in terms of physically meaningful parameters, we used a recently developed Mesoscale Structural Constitutive Model (MSSCM) for MV leaflet tissues. In brief, the total stress in the leaflet in this solid mixture model was assumed to be the weighted linear sum of the stresses borne by the underlying collagen fibre network, elastin fibre network and the remainder of the tissue matrix, with each stress being scaled by the mass fraction of its corresponding phase. The matrix phase has been shown to have very low tensile stiffness and thus to contribute very little to the mechanical behaviour of the total tissue. Therefore, in this study, we neglected the matrix phase and instead attributed all the stress in the tissue to the collagen and elastin fibre networks.

As implied by the name, the inspiration for the lorica squamata was likely drawn from a biological scale: Squama means scales in Latin. Natural scales are becoming the subject of intense investigation because of potential bioinspired applications. The most studied fish scales may be categorized into four types: placoid, cosmoid, ganoid and elasmoid. Placoid scales, which are commonly found on sharks, are denticles that feature a flattened rectangular base plate. They are embedded in the fish body and have spines that project from the posterior surface. Similar to teeth, these scales have a pulp core surrounded by a bone-like material (dentine) and an enamel-like outer layer (vitrodentine). Cosmoid scales likely evolved from the fusion of placoid scales, although a tissue complex known as cosmine takes the place of the pulpal core. Ganoid scales are rigid and jointed articulating scales consisting of a thin mineral surface layer made of hydroxyapatite, called ganoine, atop a bony foundation. Elasmoid scales evolved from the thinning of ganoid scales and consist of two subcategories: ctenoid and cycloid. Each consists of a bony mineralized surface layer and a fibrillary plate beneath, which is mostly collagen. Ctenoid scales have spines, which are bony growths distinct from the body of the scale, while the cycloid scales are smooth.

Primary Hallmark of Biological Tissues

A primary hallmark of biological tissues that distinguishes them from abiotic structures is their ability to actively adapt to mechanical, chemical, electrical and thermal cues from their surroundings. In tissues that respond largely to mechanical stimuli, altered loading can trigger a strategic blend of Extracellular Matrix (ECM) synthesis, degradation and remodelling, producing adaptive changes in mechanical properties that lead to restored function. While valvular tissues are known to remodel in response to various pathological and non-pathological conditions, few studies have elucidated the mechanisms through which heart valve tissues grow and remodel. Most investigations of valvular remodelling also focus on disease conditions and are therefore potentially influenced by factors specific to the pathology of interest. As a result, very little is known about how heart valves grow and remodel purely in response to altered loading. Such information is important not only for our general understanding of heart valve pathophysiology, but also to serve as the basis for improved methods of valvular repair and replacement.

The objective of this study was thus to develop a better understanding of the valvular growth and remodelling process, using the MV pregnancy response as a model system for normal heart valve tissues. Specifically, we sought to draw connections between changes in tissue mechanical properties, composition, and structure and MV Interstitial Cell (MVIC) geometry. Using these results, we began an effort to elucidate the mechanisms through which heart valves are able to adapt under persistent altered loading conditions in vivo. In particular, we wanted to determine if there is a specific homeostatic endpoint that the MV tissue system attempts to re-establish, similar to vascular tissues. To link the observed structural and morphological information, we used a recently developed comprehensive structural constitutive model specialized for the MV. Moreover, we linked tissue-level and cellular changes by quantifying how MVIC geometry changes throughout pregnancy. This additional focus on MVIC geometry was based in part on the role of MVICs (particularly their induced deformations over the cardiac cycle) in MV tissue maintenance. Because both the LV and MV are otherwise healthy throughout pregnancy, our results provided insights into how valvular tissues adapt without the confounding pathological factors that must be considered in other diseased systems.

It revealed materials design principles present in the penetration resistance of the ganoid scales of polypterus senegalus, a small fish that reaches only approximately 200 g in mass and 20 cm in length. Its scales have multiple layers, each with unique properties, deformation mechanisms, and a specialized manner in which cracking and failure occur in order to absorb energy and protect the fish.

Atractosteus spatula, or alligator gar, is another fish with a ganoid-type scale and is the subject of our research. As one of the largest freshwater fish in North America, large gars may reach 140 kg in mass and 3 m in length. Owing to attacks by other gars (self-predation) and alligators, the scales of this fish are required to perform exceptionally as armour. Its scales resist the powerful ambush attack of its predators and interface in a way that allows the fish to maintain flexibility and motion in spite of the scales' individual rigidity.