**TERM PAPER**

**ON**

**SOFT TISSUE MECHANICS (STM)**

**PREPARED BY**

**PEPPLE IBIM OBIEDIMA**

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**SUBMITTED TO**

**DR. IGE EBENEZER**

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**INTRODUCTION**

Tissue is a group cell or fluid that work together to a common function, the tissue in turn combine together to form an organ, the tissues are of various types

Soft tissues are very common in the human body such as the skin, the brain, gastro-intestinal system, muscles, etc. Soft tissue refers to tissues that connect, support, or surround other structures and organs of the body. They include muscles, tendons, ligaments, fascia, nerves, fibrous tissues, fat, blood vessels, and etc. Soft tissues also give shape and structure to the human body, protect the organs, move fluids (blood), store energy and so on.

Soft tissue mechanics is a part of biomechanics that deals majorly on fundamental ideas and material models from nonlinear elasticity and visco-elasticity.

**SOFT TISSUE IN HUMAN BODY**

There are of many types in the human body; fat, fibrous tissue, nerves, vessels, muscles etc.

1. Nerves: they control all the body functions and movements. It is made up of 2 main types of cells (neurons and glial cells); neurons send messages (as electrical impulses) from one part of the body to another while the glial cells support the nerves cells. Nervous tissue is also called nervous tissue or neural tissue.
2. Fibrous Tissue: these are connective tissue made up of rope-like parts called fibers; the fibers help move the body parts and keep them strong and stable. They are found in the walls of blood vessels and surrounds many organs.
3. Vessels: blood vessels are long, elastic hollow tubes that are found throughout the body (arteries, veins and capillaries) while lymph vessels are small tubes that run throughout the body; they contain lymph fluid to collect and carry waste products, damaged cells and germs from the body’s tissue.
4. Fat: this is a soft tissue made up of fat cells that tightly packed together, it is commonly found under the skin of the hips, waist, abdomen, it also surrounds organs, the body also uses it for energy.
5. Muscle: this soft tissue contain protein filament of actin and myosin that slide past one another which produce contraction that changes both the length and shape of the cell, the main function of the muscle is to produce force and motion. There are 3 types of muscle: smooth muscle, skeletal muscle and cardiac muscle.
	* 1. Smooth muscles are involuntary muscles, they also allow organs to expand and contract. They are found in the walls of the body’s hollow organs (stomach, intestine, bladder, and uterus).
		2. Skeletal muscles are voluntary muscles and are found in muscles that attach to bones. This muscle allows us to stand upright and allows us move different parts of our body.
		3. Cardiac muscles form the walls of the heart and allow us to pump blood, they are also involuntary muscles.

Figure 1 below shows the various positions of the soft tissues in the human body.



**Figure 1: Anatomical Model showing Various Soft Tissues (source: uofmhealth.org)**

**COLLAGEN AS A FIBROUS PROTEIN AND BASIC STRUCTURAL ELEMENT OF STM**

Collagen is a strong, insoluble, extensible and chemically inert animal protein; it is one of the most plentiful proteins inn mammals, it is responsible for structural support in connective tissue, muscle and skin; it is also responsible for skin elasticity. Collagen is a major insoluble fibrous protein in the extracellular matrix and in the connective tissues collagen gives strength to bones, teeth, cartilage, tendon, blood vessels and intervertebral discs [1]. The consensus amino acid sequence of collagen is (-Gly-Pro-Hyp-)n, where Hyp is 4-hydroxyproline. Each triple-helix associates into a right-handed superhelix called a microfibril. Each microfibril is interdigitated with its neighboring microfibrils. Collagen is heavily modified and cross-linked (at Lys and His), depending on the tissue type.

Collagen comprises of one-third of total protein, 28 diffeerent types of collagen composed of at least 46 distinct polypeptide chains and have been identified in vertebrates and many other proteins contain collagenous domains. The categories of collagen include the classical fibrillar and network-forming collagens, the FACITs (fibril-associated collagens with interrupted triple helices), MACITs (membrane-associated collagens with interrupted triple helices), and MULTIPLEXINs (multiple triple-helix domains and interruptions). Collagen is a macromolecule with length of about 280 nm. Collagen molecules are linked to each other by covalent bonds building collagen fibrils. Depending on the primary function and the requirement of strength of the tissue the diameter of collagen fibrils varies.

**STRESS-STRAIN RELATIONSHIP IN COLLAGEN BIOMATERIALS**

Stress and strain measurements are used in biomaterials, using mechanical methods, in order to determine other mechanical properties of the materials.

Stress-strain relationships of soft tissues are classified by 3 regions. At low stress there is a region of relatively low elastic modulus in which large extensions may occur for small increases in tension. At high stresses, below the ultimate strength of the tissue, there is a region of high elastic modulus in which extensions are much smaller for a given stress increment. The elastic properties in both these regions are approximately linear and it is possible in principle to derive a value of an elastic modulus from the slope of the stress–strain response in either of these quasi–linear regions. Viidik (1987) has termed the slope of the high stress region the elastic stiffness to distinguish it from the elastic property of the tissue in the region at low stress. In the middle region there is a constant change in gradient of the stress–strain relationship. For some tissues either or both of the quasi–linear regions are absent; for others the change from low to high modulus occurs over a relatively small range of applied stress (Yamada, 1973). [3]

A typical stress–strain curve is J-shaped, where the initial “softer” response is due to entropic elastic deformation and the latter stiffer response correlates with molecular deformation (changes in internal energy), which is followed by plastic deformation and rupture of the material. The typical curves for collagen exhibit a classic J-shape with a small entropic response (typically below strains of about 3%) and a substantial molecular stretching component.[4]

**CARTILAGE AND ITS APPLICATION IN ARTICULATING JOINTS**

Cartilage is a connective tissue found in many regions of the body including: the elbows, knees and ankles. There are 3 types of cartilages:

1. Hyaline; found in the ribs, nose, larynx, trachea

ii) Elastic; found in the external ear, epiglottis and larynx

iii) Fibro; found in the invertebral discs, joint capsules, ligaments.

Articulation is from the latin word “articuloris” meaning “jointed” which means anatomical joints. It is formed of fibrous connective tissue and cartilage.

Cartilage is a group of tissues produced by chondrocytes that is characterized by a relative lack of vascularity and consists of cells surrounded by a specialized extracellular matrix composed predominantly of type II collagen and proteoglycan.

**MECHANICAL TESTING PROCEDURES FOR SOFT TISSUES**

Mechanical testing reveals the properties of a material under dynamic or static force, to ensure the materials are suitable for their intended applications.

Mechanical testing can be used to establish the compressive, tensile, bending, or shear properties of a tissue. Skin is highly anisotropic, viscoelastic and nearly incompressible; skin is tested using uniaxial tensile methodologies, where a suitably shaped strip of skin is gripped at both ends and stretched while the load and the extension are recorded

Soft tissues such as cartilage have been traditionally tested using compression testing. To understand the compressive tensile properties of a tissue, young modulus is typically calculated by analyzing the linear portion of the stress-strain curve, indicating the resistance to compression or tension. There are many testing procedure to assess tissue mechanics, which has made it difficult to interpret or compare results and many mechanical methods focus on characterizing the mechanical properties of the tissue by testing the specimen to destruction.[2]

**CONCLUSION**

Soft Tissue Mechanics (STM) is a vast area in biomechanics with various subdivisions and gives the understanding of the mechanics of the various soft tissues in the body.

**REFRENCES**

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| [1]  | M. D. Lisa and K. W. Fred, "Molecular assembly and mechanical properties of the extracellular matrix: A fibrous protein perspective," *Biochimica et Biophysica Acta (BBA) - Molecular Basis of Disease,* pp. 866-875, 2013.  |

[2] G. Michelle, P. Yaami, S. Alexandar, E. b. Peter and S. Mattheew, "Biomechanical Characterization of Human Soft Tissues Using Indentation and Tensile Testing," *Journal of Visualized Experiments,* 2016.

[3] Meyer, M. Processing of collagen based biomaterials and the resulting materials properties. *BioMed Eng OnLine* **18,** 24 (2019).

[4] Michelle Griffin, Yaami Premakumar, Alexander Seifalian, Peter Edward Butler, Matthew Szarko, [Biomechanical Characterization of Human Soft Tissues Using Indentation and Tensile Testing](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5226394/) (118): 54872. Published online 2016 Dec 13. doi: 10.3791/54872