Mechanical characteristics of connective tissue

Connective tissue serves as a mechanical support for the body, it also ensures metabolism and energy reserve and represents regeneration potential for other tissues as well.

We distinguish between three types of connective tissue: ligament, cartilage and bone.

Musculosceletal load

In general, all types of binders have the same two building blocks: cells and their intercellular matrix.

Mechanical characteristics of ligaments

Ligaments consists mainly of fibroblasts, collagen (reticular) fibers, elastic fibers and amorphous intercellular mass .

Collagen fibers:

It has the greatest mass in the tissue. depending on the type of ligament they run either parallel or are slightly wavy. Its main physical properties are **flexibility** and **tensile strength**. They participate in the construction of tendons and ligaments, where both high strength and flexibility are needed. They extend by 8-10% of their basic length and withstand loads of up to 50 N/mm^2.

The source of the strength of collagen fibers is the specific structure of tropocollagen, which is rich in two unusual amino acids in the body: hydroxyproline and hydroxylysine. Hydroxyproline easily forms cross-links between molecules and thus increases its strength. The surrounding environment, the extracellular metrix, also has an influence.

The strength and elasticity is also caused by the periodic banding of microfibrils, which is based on the alternation of tropocollagen molecules, which have a certain length and alternate in a step-like manner in the microfibrils.

Elastic fibers:

They are found less in the ligament and mostly form a complement of collagen fibers. They are not as solid (they can withstand a tension of only 2-3 N/mm 2), but are very elastic (they can be extended up to 200% of their original length).

Reticular fibers:

reticular fibers are rich in type 3 collagen and form networks. their biomechanical properties that conterbute to the locomotor system of the tissue is yet unknown.

intercellular mass:

It is a colorless jelly-like solution produced by fibroblasts , which fills the space between cells and fibers. From a biochemical point of view, we are talking about a complex compound of so-called proteoglycans, which consist of polysaccharides and mainly hyaluronic acid . It weighs a huge amount of water, can increase its volume up to a thousand times, and even a small amount of it causes the gelatinous consistency of the intercellular mass and its viscosity. The characteristic results from the function - stabilization of the entire fiber structure. In addition, proteoglycans enable the metabolism of fibroblasts . The concentration of hyaluronic acid also causes the lubricating ability of the synovial fluid.

Intercellular mass	
	biomechenical properties
collagen fibers	flexibility and tensile strength (elongation of 8-10% and can withstand a load of 50 N/mm 2)
elastic fibers	very elastic (they can elongate by up to 200% and withstand a stress of only 2-3 N/mm 2)
intercellular matrix	stabilization of the entire fiber structure.

Collagen ligament:

- Thin collagenous tissue:

  It creates fine, three-dimensional networks of fibers that have low mechanical resistance and, together with the intercellular mass, enable the smooth movement of muscle fibers and respond with flexibly to changes in the volume of organs.

- Stiff collagen fiber:

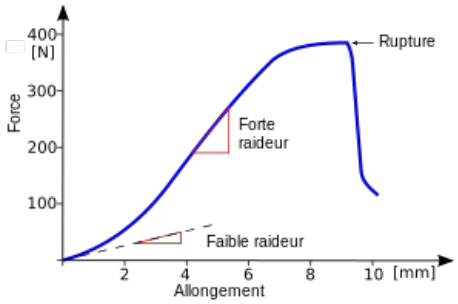
Disorganized: a compact network of strong collagen fibers supplemented by elastic fibers, characterized by mechanical resistance, it is one of the fibrous layer of the skin.
Arranged: the dominant type of ligament in the locomotor system, forming tendons (aponeuroses), ligaments, and joint capsules.

TENDONS

tendons are strings of stiff, organized ligaments, which attach muscles to bone and thus mediate the flexible transfer of muscle power to the skeleton system. They consist of parallel running collagen fibers separated by a small amount of amorphous intercellular mass and with a small admixture (up to 5%) of elastic fibers. They represent a passive moving and supporting system, their tensile strength is logically based on the strength of collagen fibers.

VASES

They have a similar structure to that of tendons, but they do not have such a regular arrangement and the occurrence of fibroblasts is uneven. The content of elastic fibers should be around 4-5% (larger amounts were found in the ligamenta flava, which have up to 71% elastic fibers). They strengthen and fix the movement system in the body.



Ligament elasticity threshold

Mechanical characteristics of cartilage

Cartilage is a connective tissue that consists of chondrocytes , collagen and elastic fibers, and amorphous intercellular material . Unlike the ligament, it is avascular and not innervated, but is surrounded by a layer of perichondrium , which contains blood vessels and nerves.

From a biomechanical point of view, it is a very heterogeneous mixture - the maximum tensile strength is only 5% compared to bone, and elasticity is dependent on hydration (from a physical point of view, it is comparable to a sponge). The last-mentioned property is especially important for articular cartilage and intervertebral discs, when during loading, water is pushed out relatively quickly in the initial phase and the shape changes, but in the next phase, the higher rigidity of the fibrous component prevents further deformation. Cartilage is divided into hyaline , elastic and fibrous .

Cartilage		
	Properties	**locations**
HYALINE	smooth, fragile, hard	articular cartilage; the skeleton of the larynx, trachea and bronchi; the basis of the fetal skeleton
ELASTIC	flexible, pliable	the wall of the bronchi, the cartilage of the larynx, the base of the pinna and the external auditory canal
FIBRO	Mechanical resistance in tension, compression and torsion	mainly intervertebral plates, pubic symphysys, cartilaginous plates in the joints (disci, minsci)

resources

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