Comparison of mechanical properties of modern polymer composites used for bone tissue regeneration

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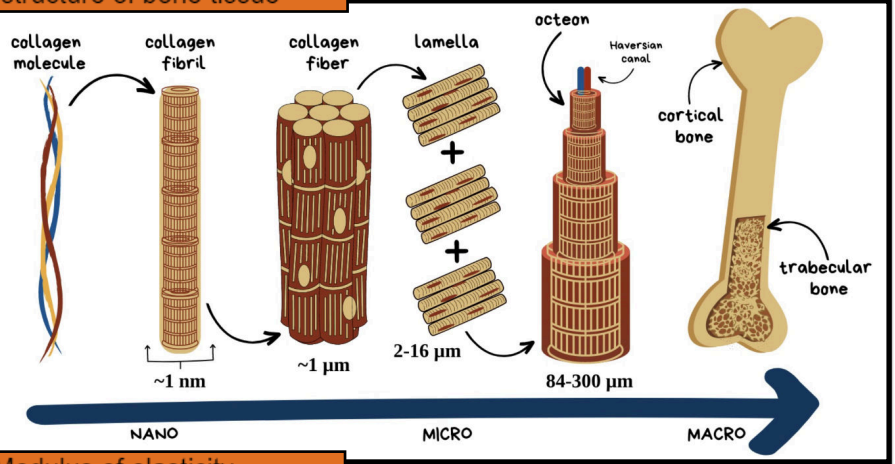
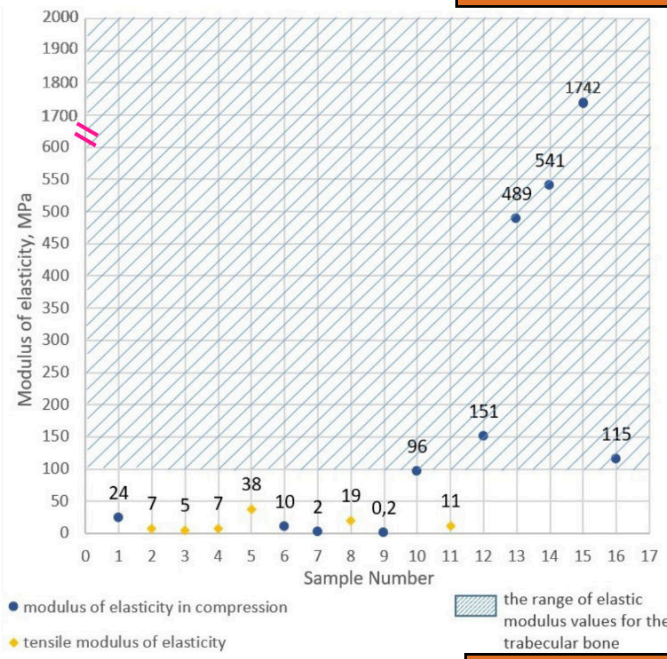
The structure of bone tissue

The bone frame is a three-dimensional temporary mechanical structure that mimics the extracellular matrix (ECM) of bone tissue and creates favorable conditions for the processes of bone remodeling and regeneration. The ideal three-dimensional scaffold consists of a biocompatible, biodegradable material with mechanical properties similar to the tissue in which it will be implanted. In native bone hydroxyapatite crystals form a structure and provide the compression resistance, collagen creates tensile strength and bending resistance. The reconstruction of the physical structures and functions of protein, mineral and cellular components of bone is the goal for developers creating materials for bone tissue engineering.

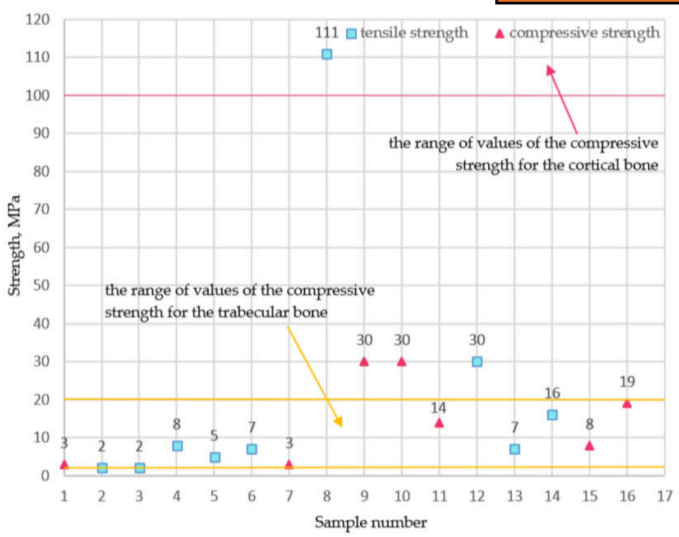


Modulus of elasticity



Samples of composites of three-dimensional frameworks:
1 - diopside/hardistonite/polycaprolactone fumarate
2 - poly(lactic-co-glycolic acid)
3 - poly(lactide-co-glycolide)/TiO_2 nanoparticles
4 - thermoplastic starch/ethylene vinyl alcohol/forsterite
5 - clinoptilolite/poly(ε-caprolactone)-poly(ethylene glycol)-poly(ε-caprolactone)
6 - gelatin/plasma with growth factors (PRGF)/bioactive 45s5 glass nanoparticles doped with lithium
7 - poly-e-caprolactone
8 - polycaprolactone/layered double hydroxide
9 - poly-L-lactic acid
10 - cellulose/poly-L-lactic acid/hydroxyapatite
11 - chitosan/silicon dioxide/calcium β-glycerophosphate/sodium β-glycerophosphate pentahydrate/hydroxyapatite
12 - dopamine/alginate/chitosan/hydroxyapatite
13 - polylactic acid/polyvinyl alcohol/hyaluronic acid
14 - collagen/β-tricalcium phosphate/strontium oxide
15 - (sodium alginate)-g-(hydroxyapatite-silicon oxide-silica)
16 - poly-e-caprolactone/polyaniline/barium titanate

Strength



Samples of composites of three-dimensional scaffolds:
1 - gelatin/plasma with growth factors (PRGF)/ bioactive 45s5 glass nanoparticles doped with lithium
2 - poly-e-caprolactone
3 - poly-e-caprolactone/layered double hydroxide,
4 - PCL(P) + 15BG,
5 - poly-e-caprolactone/polyaniline/barium titanate
6 - polylactic acid/polyvinyl alcohol/ hyaluronic acid
7 - diopside/hardistonite/polycaporolactone fumarate
8 - zinc substituted hydroxyapatite/silk fiber/methylcellulose
9 - poly(lactic-co-glycolic acid)
10 - poly(lactic-co-glycolic acid)/TiO_2
11 - (sodium alginate)-g-(nHAp-SiO-GO) (GO - silica)
12 - thermoplastic starch/ethylene vinyl alcohol/forsterite
13 - polyurethane
14 - polyurethane/amla oil
15 - pentaerythrittriacrylate-co-trimethylolpropane tris(3-mercaptopropionate) (PETA-co-TMPTMP)
16 - PETA-co-TMPTMP/ГА.

Conclusions

Thus, there is very little work on obtaining composites corresponding to the mechanical properties of the cortical bone. Depending on the level of strength and elasticity of the material, the scope of its application and the form in which it can be used are selected. These can be gels, films or three-dimensional scaffold. The development of composites for bone tissue regeneration is a promising direction necessary for society, however, before the successful implementation of such products, a number of issues need to be resolved from the selection of optimal and safe material to certification, clinical trials and production.