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The health seen through the structural hierarchies of collagen: from disease to regeneration

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In recent decades the extracellular matrix (ECM) has aroused growing interest in biomedical and regenerative fields. It is a complex network made by different macromolecules, in which the main component is the type I collagen, a fibril-forming protein characterized by a tissue-specific morphology. Its hierarchical structure, with specific functional domains, supplies bio-physical support to cells attachment, tissue growth and re-modeling. The multi-level structure possesses a specific arrangement from the molecular order, up to supramolecular scale. In particular it is organized in triple helices assembled in fibrils and fibers, in accordance with a liquid crystalline arrangement at nanoscale, a quasi hexagonal packing observed in corneal tissue.[1]
To deeply understand the role of its physiologic features and with the aim to exploit them for biomaterial fabrication useful in regenerative medicine, we investigated type I collagen with both Wide (WAXS) and Small (SAXS) Angle X ray Scattering techniques, of collagen powders and flakes obtained after its extraction from natural tissues and of engineered biomaterial during each step of fabrication process. Both X rays techniques have revealed how manufacturing protocols deeply affect the structural characteristic, both atomic (WAXS) and nanoscale (SAXS), of the biomaterial itself, thus its function, becoming fundamental tools to screen the suitable protocols, according to the tissue to regenerate. [2,3,4,5]
As collagen structure modifications can be related to specific disease prognosis, we also used scanning SAXS and WAXS microscopies for diagnosis, inspecting the structural features in aneurysms biopsies, and in diabetes minimal models.
Precisely, in aneurysms, mapping biopsies allowed to detect and co-localize the nanometric structure of several organic components of the tissues (type I collagen, myofilament and elastin) as well as to identify crystalline phases of pathological micro calcifications.[6] In diabetes, analyses were conducted on decellularized bovine pericardia biotissues, soaked with different sugars (D-glucose, D-galactose, D-ribose) at increasing concentrations (0, 2.5, 5, 10, 20 and 40 mg/ml), and incubated at 37℃ for 3, 14, 30 and 90 days, to identify the sites of glycation and speed of glycation due to glucose/galactose and ribose.[7,8,9]

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