MOLECULAR STRUCTURE OF THE NATIVE TYPE II COLLAGEN FIBRIL

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INTRODUCTION

The fibrous collagens are amongst the most important structural proteins known to man. They are ubiquitous in animals and form the structural basis of various organ tissues as well as skin, bones, cartilage, and ligaments.
In addition to their biomechanical properties and functions, these fibrous supramolecular assemblies contain numerous ligand binding sites for non–collagen molecules involved in fibrillogenesis and tissue digestion that occur at key life stages in all mammals, as well as in normal growth and repair (1,2).
Understanding how collagen imparts strength to the fabric of connective tissues, as well as its role in regulation of the (dynamic) organization of the extracellular matrix (ECM), requires knowledge of how collagen monomers are organized in the tissues native state.

EXPERIMENTAL

The natural crystalline structure of collagen fibrils in some tissues allows the use of fiber diffraction methods for the study of its structure. This alternative biophysical method has the potential to give structural information about collagen type II with minimum interference from sample preparation and may give the opportunity to produce a relatively detailed three-dimensional visualization of the fibrils sub-structure. Lamprey notochord has more ordered assemblies of collagen type II fibrils and therefore was the best choice for these experiments.

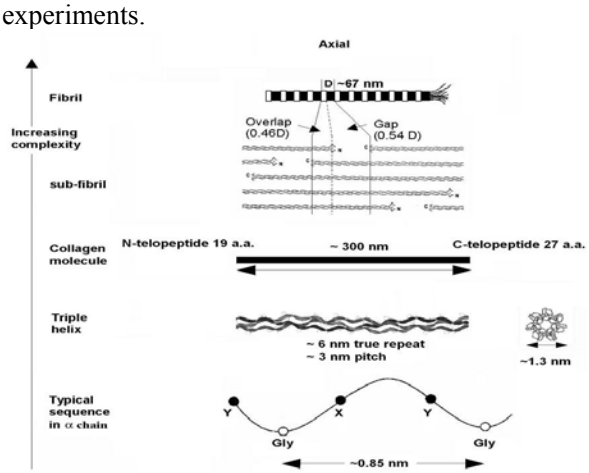

Figure 1. Hierarchy of collagen type II structure.

The complementary techniques used in this study include: fiber diffraction (small and wide angle X-ray diffraction experiments were performed at BioCAT, APS, ANL), single crystal crystallography, Atomic Force Microscopy (AFM), Electron Microscopy (EM) and molecular visualization / computational methods.

RESULTS

Fiber diffraction studies revealed the parameters of collagen type II fibrils from lamprey notochord, which are the same as collagen type II fibrils in mammalian tissues (30 nm in diameter), and the periodicity of 67 nm as in collagen type I fibrils (1,2). Data analysis also showed very specific conformation of collagen type II telopeptides, which is crucial for fibrillogenesis and organization of collagen type II tissues, such as articular cartilage.
Microscopic techniques proved the similarity of collagen type II fibrils in lamprey notochord and mammalian tissues (bovine articular cartilage).

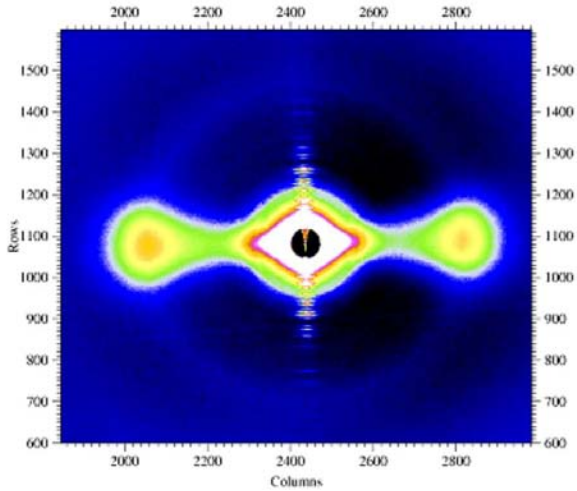

Figure 2. Collagen type II diffraction pattern with 15-Å resolution (WAX).

REFERENCES

1. "Collagen fibril architecture, domain organization, and triple-helical conformation govern its proteolysis." Shiamalee Perumal, Olga Antipova, and Joseph P. R. O. Orgel. PNAS (2008), 105: 2824 – 2829.
2. "Candidate cell and matrix interaction domains on the collagen fibril, the predominant protein of vertebrates." Shawn M Sweeney, Joseph P Orgel, Andrzej Fertala, Jon D McAuliffe, Kevin R Turner, Gloria A Di Lullo, Steven Chen, Olga Antipova, Shiamalee Perumal, Leena Ala-Kokko, Antonella Forlino, Wayne A Cabral, Aileen M Barnes, Joan C Marini, James D San Antonio. JBC (2008), 283: 21187 - 21197.