Morphogenesis of the Joint Capsule and its Blood-Vascular Bed

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With 12 Figures in the Text

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Introduction

The joint capsule appears to be a rather complicated organ whose constituents — the fibrous and synovial membranes — possess different structures and different functional significance. The fibrous membrane performs principally the mechanical role, forming a certain round ligament in each joint. To such function of the external membrane of the joint capsule corresponds its coarse-fibrous structure, whose degree of development is directly correlated with the conditions of the mechanical load in every part of the joint. In parts undergoing the constant tension the fibrous layer of the capsule forms dense thickenings, due to the great concentration of fibres, running parallel to one another. These thickenings in certain regions of the joint are known to be formed as independent bundles indicated usually as ligaments. The function of connecting the joint ends of articulating bones in the fibrous layer of the joint capsule seems to be so evident, that it was taken as a basis for determining the whole complex of formations concentrated in the joint capsule by giving to it a common term — bursal or capsular ligament (ligamentum capsulare).

The internal layer of the joint capsule is of quite a different structure. It produces the synovia and ensures its continuous interchange, thus creating conditions for the normal work of the joint. The activity of the synovial coat determines probably the direction of the differentiation and the conditions of some tissues of the joint (articular cartilage). On the other hand, the functional conditions of the joint, the intensity of its work and even the nature and size of mobility in the articulation essentially affect the morphological pattern of the synovial coat. Therefore, possessing a common morphological and functional identity of the synovial membrane in the joints of different types, its separate regions even within the same joint have essential structural characteristics which were a subject of investigation for many researchers.

W. LUBOSCH (1910) and E. PAYR (1918) considered the synovial membrane as little differentiated cartilaginous tissue. This opinion, however, was not agreed by morphologists as nobody, besides LUBOSCH, could find either morphological or functional identity of the cartilage and of the synovial coat.

The histological structure of synovial membranes was described in details in articles of R. LANGZERT (1867), H. TILMANS (1875, 1876), B. HAGEN-TOORN (1883), J. HAMMAR (1894), S. I. SICHERKUNOV (1940), D. DAVIES (1945), J. LANG (1959), I. A. IMERLISHTVI (1960, 1961) and others. The most comprehensive study of the joint synovial membrane was made by I. P. KALLISTOV (1946, 1958). The
results of the investigations of the fibrous construction and reactive structures of the synovial membrane of the knee-joint, which were carried out in comparative-anatomical, age- and functional aspects, are represented by Kallistov in his doctoral dissertation. Proper attention was also drawn to these data in the monograph of M. A. Baron, dealing with the reactive structures of internal membranes (1949).

Of particular interest for investigators among other structures of the synovial membrane are its processes, extending into the joint cavity and, for their shape, identified as plicae and villi. These derivatives of the synovial membranes in joints were first described by A. Kölliker (1867) and were for a long time considered to be nonvascular. From that time on, a lot of diverse opinions have been advanced concerning the structure and causes of the appearance of the synovial villi. Some authors (Tillmans, Hammar) considered them only as proliferative formations appearing in the joint tissues in response to a certain excitation or even to some inflammatory process. Others (Hagen-Torn) believed that the appearance of villi is associated with the degree of intraarticular pressure, and some (D. Kling, 1936) regarded the number of villi and the character of their distribution over the surface of the synovial membrane of the joint as species specific features, remaining unaltered after birth. J. Key (1925) stated that the number of villi in each joint is directly proportional to the size of the joint itself.

However, already Hagen-Torn recorded that there exists a direct connection between the synovial villi and the blood vessels of underlying tissues, and that the predominating number of villi are being arranged in the joint in the regions of the synovial membrane containing the densest blood-vascular networks. Hagen-Torn referred the appearance of the first villi in ontogenesis to the prenatal development when there begin the active movements in the foetal joints which, according to the author, contribute to the change of the intraarticular pressure. Thus, the power of intraarticular pressure was considered by Hagen-Torn as an immediate cause of the development of synovial villi.

Kallistov regards the synovial villi as reactive structures arising in response to the dynamic load in the joint. In intrauterine life the appearance of the villi (after Kallistov's data as well as after Hagen-Torn's ones) coincides with the beginning of active joint movements. In the postnatal ontogenesis of animals and man, as well as in the comparative-anatomical mammalian series, the number of synovial villi and plicae in the joint are directly correlated with its dynamic conditions. The increase of mobility in the joint in each case results not only in the augmentation of the number of synovial villi but also in the complexity of their form. And on the contrary, with the more or less long immobilization of the joint or limitation of the joint mobility, correlated with the occupation of man, the synovial villi in any stage of their development will undergo a reverse development, so that with the renewal of the joint activity they may appear again in the number equivalent to the dynamic load.

In the experiment, a mechanical irritating agent (glass beads), having been introduced into the joint cavity, induces the reaction of the synovial coat in the same manner by increasing the number of villi and complicating their form. Basing on these data, Kallistov arrived at the conclusion that the appearance