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ON CHANGES IN THE CHLORINE CONTENT
OF PATELLAR CARTILAGE AND INTER-
VERTEBRAL DISCS ASSOCIATED WITH
DEGENERATION

BY

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When discussing degeneration in cartilage there are two main causes to consider: one is the mechanical factor, wearing away of the cartilage, the other the chemical changes or metabolic disturbances. Certainly, in any particular case, there may be a combination of both factors. If one looks at the problem in another way and, for example, compares the joint with a motor, one finds that the reason why a certain part wears out before the rest depends both on the greater strain to which it is subjected and on the fact that its material is less durable. However, from the clinical standpoint the latter aspect is the more profitable to study. The mechanical element is rather outside the scope of therapeutics. One cannot alter the fact that the surfaces of the patella are subjected to severe strain or that there is greater strain on the lower than the upper intervertebral discs. On the other hand, if one could discover what metabolic and nutritional factors affect the cartilage's resistance to mechanical wear, the problem would be one step nearer to its solution.

Amongst investigations into the nutrition and chemistry of cartilage there is one, that of *Rous and Beattie* (1929), which seems of considerable interest in this connection. These workers showed that, in animals, cartilage, tendons and connective tissue, in contrast to other tissues, lacked a buffering

mechanism. When dilute acids or alkalis were infused into the animals the pH of these tissues altered according to the solution, while other tissues maintained their pH until the animal died. Since we know that throughout man's life there is a more or less marked tendency to acidosis one can imagine that, although the blood with its effective buffering mechanism is not affected, yet tissues which lack such a mechanism, such as cartilage, might be changed in their chemical structure by prolonged periods of acidosis. When there is acidosis of the blood (or, more correctly, latent acidosis, since the pH is not altered) certain ionic shifts take place. The alkali reserve is reduced by expiration of carbonic acid, and the bicarbonate ions are replaced by the acid radicals. At the same time the chloride ions pass from the plasma into the red blood cells where the excess chloride is bound to the proteins (*Feldman and Ulanowskaja*). It has also been shown experimentally (*dell'Aqua*) that as well as this ionic shift in the blood chloride ions pass out into the tissues. How the chloride is bound in the tissues has not been discovered. It is generally assumed that tissue cells, in contrast to red blood cells, remain chloride-free. One can imagine, in view of *Rous* and *Beattie's* findings of the lack of buffering mechanisms in connective tissue, tendons and cartilage, and of the fact that these tissues have relatively few cells, that the passage of chlorides in acidosis would take place into just these tissues.

With this working hypothesis in mind I studied the chlorine content of patellar cartilage and intervertebral discs using both healthy and degenerated specimens. The patellar cartilage was taken from post-mortem specimens, and divided into normal, pre-malacic, malacic and osteo-arthritic groups. By pre-malacic was meant cartilage which was macroscopically normal but which was removed from the vicinity of a malacic area. For the intervertebral discs nucleus pulposus was taken from post-mortem cases and prolapsed discs from operations. The following values for the chlorine content were obtained:

Specimen	Numbers	% Cl in fresh tissue	% Cl in dried tissue
Nucleus pulposus	35	0.23	1.32
Prolapsed discs	35	0.52	2.47
Patellar cartilage:			
normal	16	0.32	1.46
pre-malacic	25	0.60	2.48
malacic	25	0.53	2.66
osteo-arthritic	20	0.52	2.24

The figures show that there is a marked increase, up to 100 %, in the chlorine content in degeneration. It is noteworthy that this chemical change is already present in the pre-malacial stage, and that the chemical changes precede the degeneration. What is the significance of these findings and how is the increased chlorine content bound? The water content of these tissues is between 75 and 80 % and the chloride content of this amount, assuming it is about the same as in extracellular fluids, will be about 0.25 %. These figures are the maximum possible for chloride in diffusible form. Since the figures calculated in this way are only a half or a third of the actual figures the greater part of the chlorine in degenerated tissue must be in an undissociated form. But, as no insoluble chlorides are known to exist in the body, the excess chlorine must presumably be bound to the tissue proteins. Thus one reaches the conclusion that in degeneration chlorine is incorporated in the cartilage protein, chondroitin, as a non-diffusible protein compound, or, in other words, there is a latent acidosis in degenerated cartilage. If these conditions occurred in the blood, the alkali reserve would have reached 0 with an increase in chloride of 25 %, so that in degenerative cartilage, where there is an increase of up to 100 %, the acidosis must be considered very marked. These findings explain *Hirsch's* observation that the content of chondroitin sulphuric acid in patellar cartilage is reduced at an early stage of degeneration. From a chemical point of view it is natural that chondroitin sulphuric acid which is a weak

acid would be displaced from cartilage when the chloride content increases.

To summarise, in my opinion the process of cartilage degeneration is as follows:—

acidosis in the body fluids

passage of chloride into non-buffered tissues, including cartilage.

displacement of chondroitin sulphuric acid, and with it reduced resistance of the cartilage to mechanical wear and tear.

degeneration of those parts of the cartilage which are most subjected to mechanical wear and tear.

SUMMARY

By examining the chloride content in normal and degenerated cartilage it was found that the degenerated cartilage contained considerably more chloride. The significance of this is discussed.

RESUME

En examinant la teneur en chlorure de cartilages normaux et dégénérés, on a trouvé que le cartilage dégénéré contient beaucoup plus de chlorure. La signification de cette trouvaille est discutée.

ZUSAMMENFASSUNG

Bei einer Untersuchung des Chloridgehalts in normalem und degeneriertem Knorpel wurde festgestellt, dass der degenerierte Knorpel bedeutend mehr Chlorid enthielt. Die Bedeutung dieses Fundes wird erörtert.

LITERATURE

Rous and Beattie: J. Exp. Med. 44, 1926, 435.

Feldman and Ulanowskaja: Act. med. Scand. 87, 1935, 65.

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