operation cases was unusually cheerful and the need for post-operative drugs was much reduced.

The method would appear to be of value in controlling pain following operations on the chest, upper abdomen, loin, and ano-rectal region: it may also prove of value in the treatment of fractured ribs. It would appear to be less effective when obesity makes accurate placing of the solution difficult, and is contra-indicated in the presence of infection.

On theoretical grounds one would expect a reduction in secondary complications due to inhibition of the cough reflex and retention of urine, but our series is too small for the forming of any conclusions on this point.

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COLLAGEN/CHONDROITIN SULPHATE RATIO OF HUMAN ARTICULAR CARTILAGE RELATED TO FUNCTION

BY

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In a study of the physical and biochemical changes which accompany the ageing of hyaline articular cartilage a preliminary examination of the two main components, collagen and chondroitin sulphate, showed a very different ratio in some joints compared with others. This is, I suggest, related to mechanical function, since weight-bearing and non-weight-bearing areas of articular cartilage differ significantly in collagen and chondroitin sulphate content, whether comparison is made between joints or between different areas within the same joint.

Material and Methods

The material was taken within one hour of necropsy from adult patients whose articular cartilage showed no macroscopic evidence of senile change. Slices about 1 mm. thick were removed from the whole of the articular surface of the head of the humerus and the lower end of the humeral femur: an aliquot was taken for analysis.

For comparison of weight-bearing and non-weight-bearing areas within an individual knee-joint, slices were taken from the following sites: (a) patellar surface of the femur, (b) the middle (weight-bearing) thirds of both femoral condyles, and (c) the posterior (non-weight-bearing) thirds of both condyles. These samples were compared with cartilage from (d) the centre of the medial surface (non-weight-bearing) of the humeral head, and from (e) the superior (weight-bearing) surface of the head of the femur.

The cartilage slices were dried in acetone and then over sulphuric acid to constant weight. Determination of the hydroxyproline content was made according to the method

of Neuman and Logan (1950a), and collagen values were obtained by multiplying the hydroxyproline figures by 7.5 (Neuman and Logan, 1950b).

Chondroitin sulphate was determined by estimation of hexosamine after hydrolysis according to the method of Elson and Morgan (1933). The factor for conversion of hexosamine to chondroitin sulphate is approximately 4 (Einbinder and Schubert, 1950).

Results

Table I gives the results of five typical estimations. It is evident that the chondroitin sulphate content of knee cartilage is greater than that of the shoulder, but that the reverse holds for collagen.

TABLE I.—*Collagen and Chondroitin Sulphate Content of Healthy Articular Cartilage: Comparison of Knee and Shoulder (% of Dry Weight)*

Case	Age	Collagen		Chondroitin Sulphate		Collagen/Chondroitin Sulphate Ratio	
		Knee	Shoulder	Knee	Shoulder	Knee	Shoulder
1	38	66.0	75.0	22.4	14.4	2.9	5.2
2	49	52.5	69.8	20.8	16.4	2.5	4.3
3	55	63.0	74.3	22.8	17.2	2.8	4.3
4	60	59.3	67.5	19.6	14.8	3.0	4.6
5	66	51.0	69.8	22.0	15.6	2.3	4.5

Table II shows that if comparison be made between joints (or between different areas within the same joint) the content of chondroitin sulphate is greater and the collagen less in weight-bearing articular cartilage than in cartilage which bears no weight.

TABLE II.—*Collagen and Chondroitin Sulphate Content of Weight-bearing and Non-weight-bearing Articular Cartilage (% of Dry Weight) in Man Aged 55*

Joint	Site	Collagen	Chondroitin Sulphate	Collagen/Chondroitin Sulphate Ratio
Weight-bearing: Knee (articular surface of femur)	Medial condyle (middle third)	47.3	24.8	1.9
	Lateral condyle (middle third)	50.3	24.0	2.1
	Patellar surface	49.5	23.6	2.1
Hip	Head of femur	50.3	23.6	2.1
Non-weight bearing: Knee (articular surface of femur)	Medial condyle (posterior third)	57.8	18.8	3.1
	Lateral condyle (posterior third)	59.3	16.0	3.7
Shoulder	Head of humerus	66.0	16.8	3.9

Although, strictly speaking, the patellar articular surface of the femur is not weight-bearing, it is an area subject to marked shearing action, and its composition resembles that of weight-bearing cartilage.

Discussion

The importance of mechanical function in determining the composition of articular cartilage is illustrated by the results shown above: the greater resilience needed in weight-bearing areas is provided by a higher polysaccharide content.

It is well known that the earliest degenerative changes in the knee occur on the middle third of the articular surface of the medial femoral condyle and on the femoral patellar surface. It is conceivable that the susceptibility to degeneration of weight-bearing or stressed sites is related to the special structural adaptation to function revealed by the above analysis. It is hoped in future work to test this hypothesis.

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