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THE STRUCTURE OF THE COLLAGEN OF THE TEMPORO-MANDIBULAR DISC IN MAN

by

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The articular disc is usually described as a plate of fibrocartilage which during intrauterine life develops from the connective tissue connecting the perichondrium of the condyle and the periosteum of the temporal bone. The disc does not, however, show the usual fibrocartilaginous character of other articular discs. This *Orban* (1957) viewed as a functional adaptation to the high mobility of the disc. He likened the disc rather to a ligament, the collagenous fibres being parallel and densely packed. It has also been stated that the disc is an extension of the fibrous part of the lateral pterygoid muscle (*Symons,* 1952). *Rees* (1954) described the disc as consisting of four transverse bands and considered the upper fibroelastic stratum of the disc to represent the discomalleolar band of the foetus; this band suggests the continuation of the lateral pterygoid muscle, which runs through the petrotympanic fissure and is attached to the malleus.

The collagenous fibres run parallel in the narrow central portion, but are less regular in the posterior part (*Lubosch,* 1906). That the fibre bundles course perpendicular to the surface in the deeper layers and parallel to the surface in the superficial

layer has been interpreted as a sign of pressure conditions in the joints (*Sicher*, 1952; *Sicher & Weinmann*, 1952).

As regards the time at which the collagen fibres are organized there are various opinions. *Steinhardt* (1934) found that in the newborn the disc is highly cellular and that the fibres are not arranged in bundles; differentiation of the tissue begins after birth, and at the age of 15 months the disc has a fibrous structure, as in the adult. A similar result was reached by *Cunat et al.* (1956) in respect of the rat; 2 days after birth a few collagen fibres were evident; between 5 and 30 days the number gradually increased and later assumed a dense fibrous character, with relatively few cells. *Symons* (1952), on the other hand, in a series of human foetuses found that collagenous fibres began to appear at a CR length of only 70 mm and that at birth the disc was composed of dense fibre bundles.

With age the tissue is thus considered to become richer in collagen and poorer in cells. Some of the fibroblasts may later on develop into chondroid cells, which could become true chondrocytes (*Orban* 1957). Small islands of hyaline cartilage may also be found in older persons.

That cartilage cells occur in the articular disc has also been mentioned by others (*Kjellberg*, 1901; *Petersen*, 1930; *Schaffer*, 1930; *Baecker*, 1931). This was not found, however, by *Mankiewitz* (1886), *Lubosch* (1906) or *Rees* (1954).

With few exceptions the studies of the histologic structure of the articular disc have been concerned with adults, and the materials have usually been small. Since many of these adults have also displayed pathologic changes in their temporo-mandibular joints, it has been difficult to obtain a clear picture of the normal structure of the disc. As regards young subjects only small materials have been studied by *Bauer* (1932, 1941); it was found that as in adults the collagenous fibres were arranged parallel to the surface of the condyle in children with deciduous and mixed dentitions.

The present study was undertaken to examine histologically the collagen structure of the human temporo-mandibular disc in a normal series of a wide range of ages so as to obtain information on any structural changes in the disc with age.

MATERIAL AND METHOD

An attempt was made to obtain a material as nearly normal as possible. It consists of articular discs from 58 subjects of both sexes with the following age distribution:

(i) Thirty foetuses from the 14th intrauterine week (total length 12.5 cm and weight 40 g) to birth. All weeks from the 14th to 24th week are represented as is at least every foetal month of the subsequent period until birth.

(ii) Eight children and adolescents of the following ages: 3 months, 1 year, 2 years, 6 years, 7 years, 12 years, 14 years, 19 years.

(iii) Twenty adults:

Age (years)	21—30	31—40	41—50	>50
Number	5	6	6	3

All subjects in the adult age group had largely normal occlusion. Few subjects had had extractions, and then not of more than three or four teeth. No signs of temporo-mandibular joint disorders had been recorded.

In all cases the right articular disc was examined. In the younger foetal material the disc was removed within 2 hours of abortion and in the older foetal material not later than 12 hours *post mortem*. In the other groups the disc was removed at autopsy not more than 18 hours *post mortem*.

Demineralization of the formalin-fixed discs was performed in 5 per cent trichloroacetic acid. The specimen was cut into serial sections in sagittal, transverse or horizontal planes. The thickness of the sections ranged from 10 to 25 μ. Four successive sections were stained with haemalum-eosin *(Mayer)*, azan *(Heidenhain)*, resorcin fuchsin *(Weigert)*, and picrofuchsin *(van Gieson)*. The same stainings were repeated throughout the series, 6 sections being omitted after each series of four.

RESULTS

Foetuses

In the early foetal stages (third month) the cells dominated (Fig. 1), but there was an incipient formation of collagen, evidenced as a few thin fibres. These fibres increased in calibre and

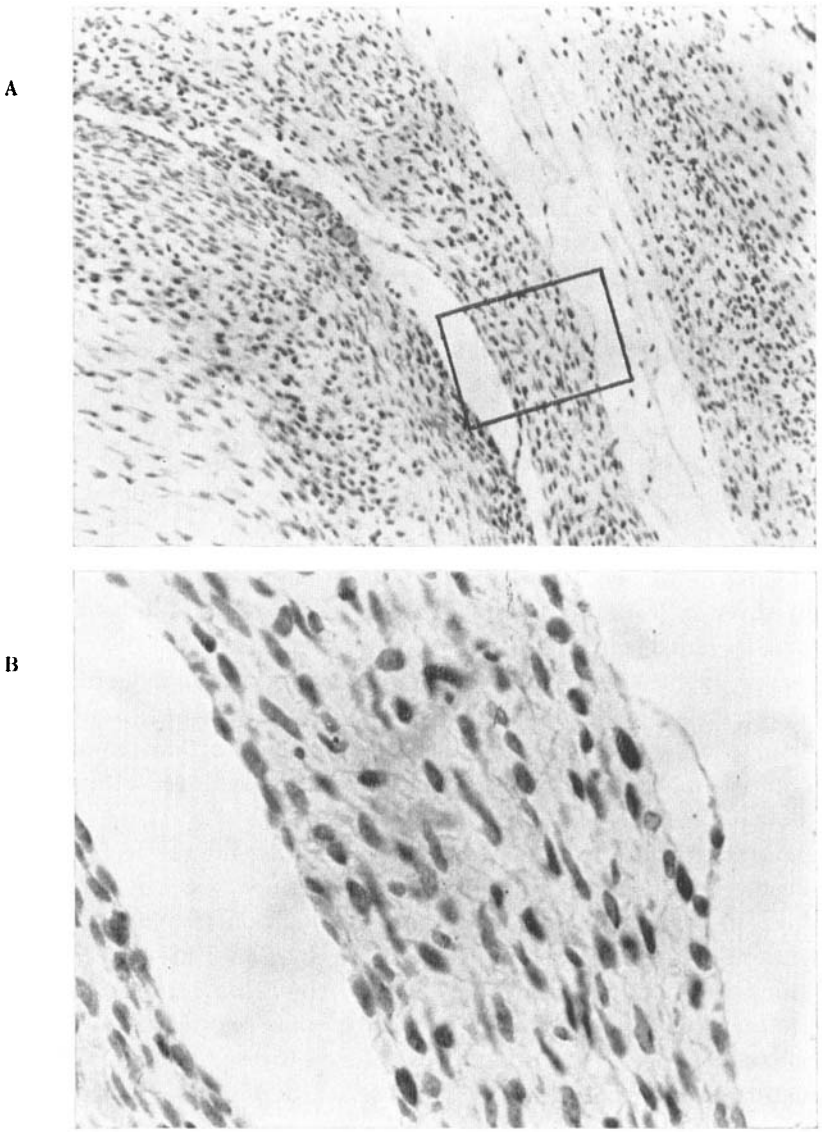
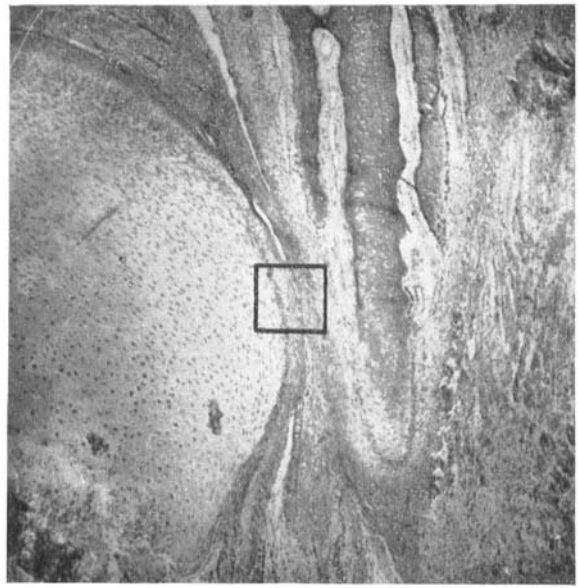


Fig. 1 (A) Survey photomicrograph (× 100) and (B) higher magnification (× 400) of the temporo-mandibular disc of a foetus at the third month. Sagittal section, van Gieson's pichrofuchsin.

A



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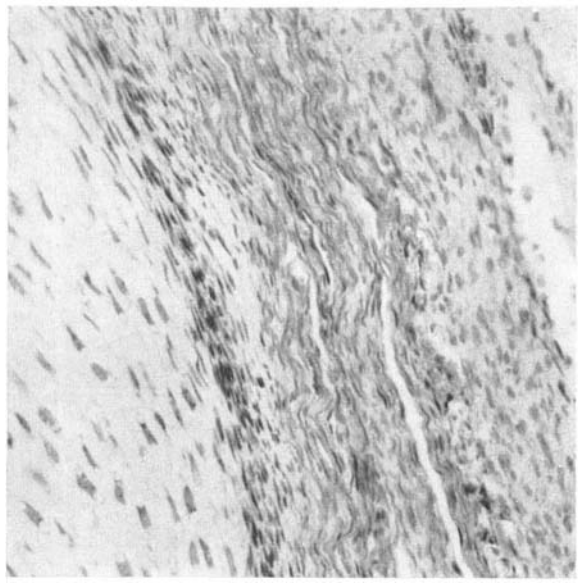
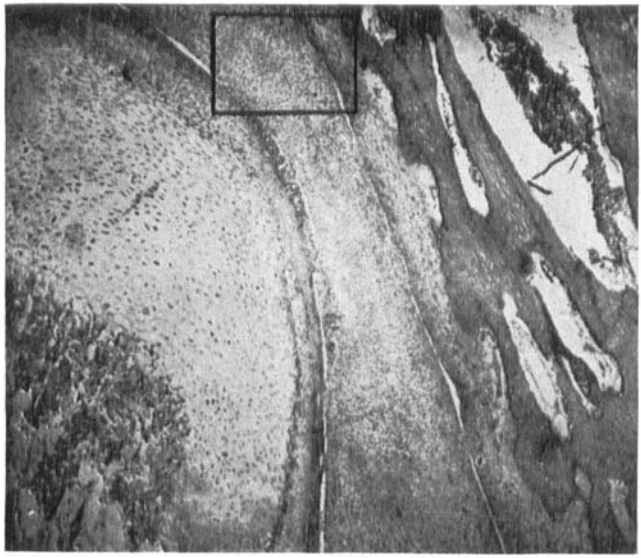


Fig. 2 (A) General photomicrograph (× 40) and (B) greater magnification (× 160) of the articular disc of a foetus at the fourth month. Sagittal section, Heidenhain's azan.

A



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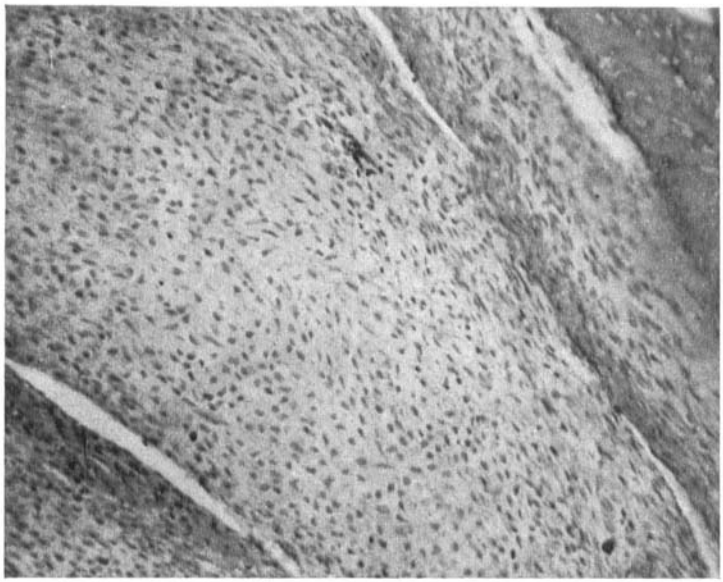


Fig. 3 (A) General photomicrography (× 40) and (B) greater magnification (× 160) of the articular disc of a foetus at the sixth month. Sagittal section, van Gieson's pichrofuchsin.

length with age, and after only the fourth intrauterine month some fibres in the central portion of the disc were arranged in an antero-posterior direction (Fig. 2). After a further month such fibres dominated in the superior layer, while in the inferior layer no such orientation was evident.

At the fifth to sixth months there was a definite organization also in the anterior and posterior parts. The collagen fibres in the posterior portion followed the same course as those in the central portion, that is, longitudinally in the superior layer, passing to the posterior part of the capsule, and unorganized in the inferior layer (Fig. 3). In the anterior portion the opposite disposition was found. Here the unorganized fibres were found in the superior layer and the longitudinal ones in the inferior layer, passing to the anterior part of the capsule.

This arrangement of the collagen fibres was observed in all the specimens of the fifth and sixth months. It tended to become more marked until birth, there being an increase in the collagen components, at the same time as the cells decreased in number. Elastic fibres with largely the same course as the collagen fibres were fairly numerous.

Children and adolescents

Only 3 months after birth the fibres in the whole of the middle portion had assumed an antero-posterior course.

In the superior layer of the posterior part, the fibres followed the same direction as before, but showed a tendency to fuse into bundles, which continued in the posterior part of the capsule. In the deeper zone, however, the fibres ran vertically, transversely and longitudinally, to form interweaving bundles (Fig. 4). The tendency for the bundles to increase in thickness and their characteristic interwoven arrangement in the posterior part became more pronounced with age. The cells also decreased in number, as did the elastic fibres, so that the whole of the tissue developed a denser structure.

In the anterior part, too, the collagen fibres became gradually coarser. At an early age they followed an antero-posterior course chiefly in the inferior layer, but later on all the fibres in this part ran in that direction. They were not densely packed as in the

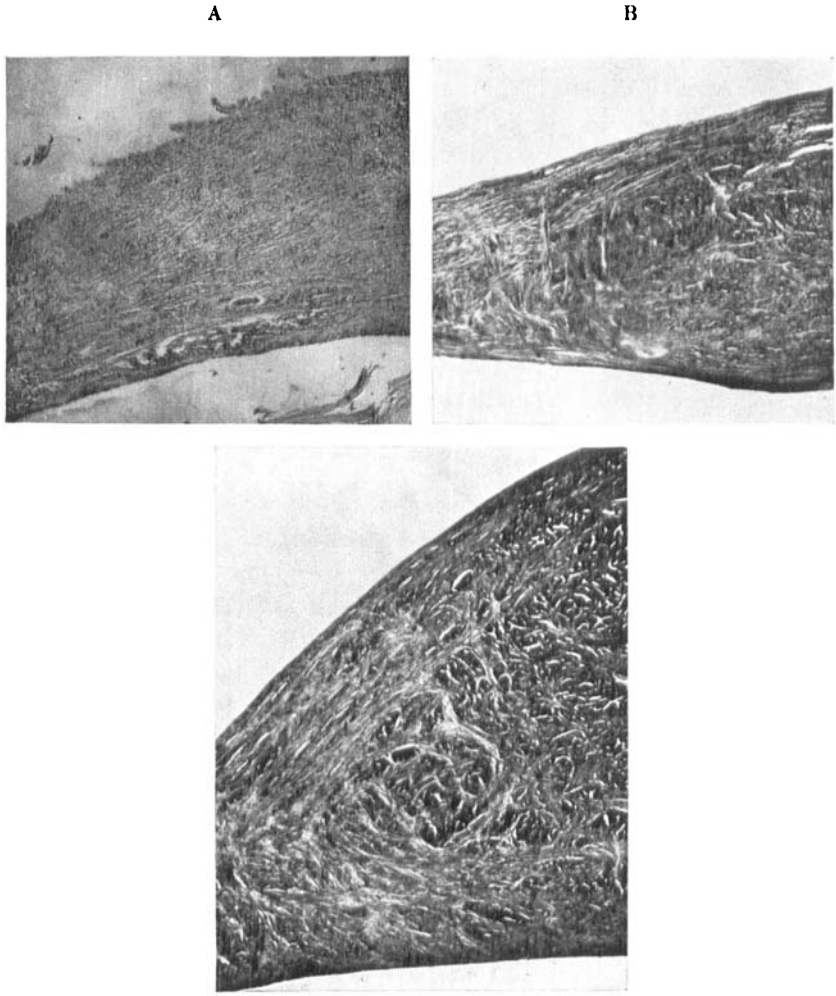
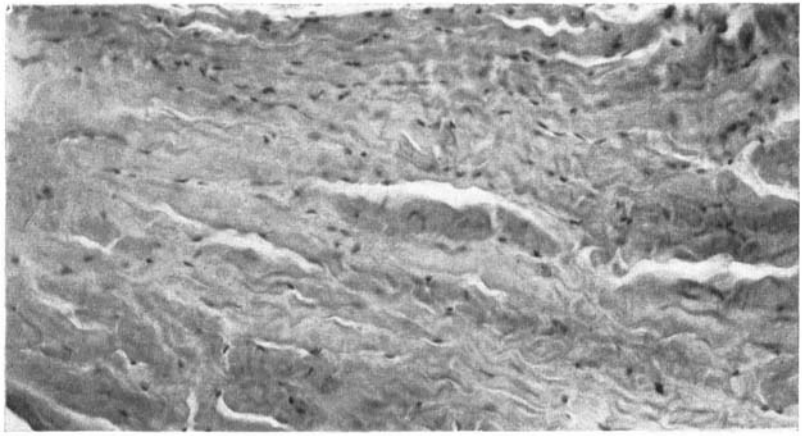


Fig. 4. The posterior part of the articular disc at (A) 3 months, (B) 2 years and (C) 6 years. Sagittal section, (A) van Gieson's pichrofuchsin, (B—C) Heidenhain's azan. (× 40).

middle portion of the disc, and in principle followed the same course as the tendon fibres of the lateral pterygoid muscle.

When growth was nearly complete the collagen structure was that observed in specimens from a 19 year old boy. As Fig. 5 shows, the tissue was rich in collagen and fairly poor in cells.

A



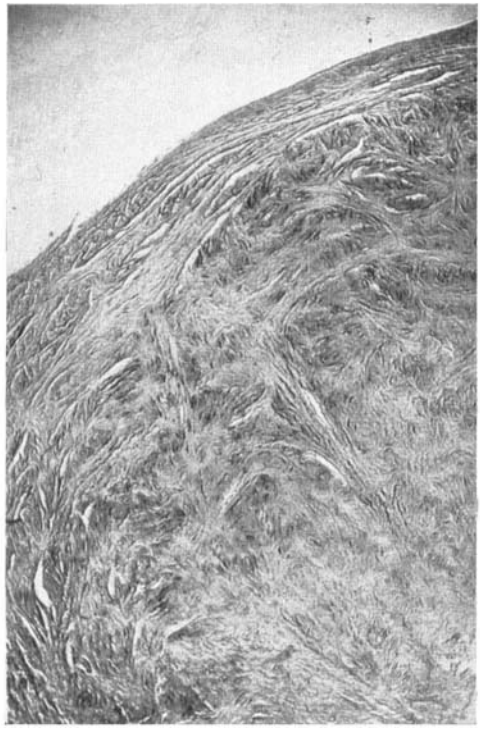


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Fig. 5. (A) Middle (× 160) and (B) posterior (× 40) portion of the articular disc at 19 years. Sagittal section, van Gieson's pichrofuchsin.

A

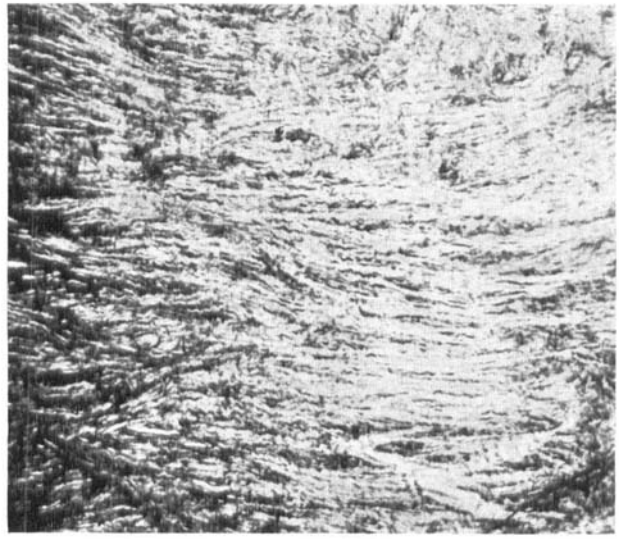

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Fig. 6 (A) Middle and (B) posterior portion of the articular disc at 40 years. Horizontal section. Heidenhain's azan. (× 160).

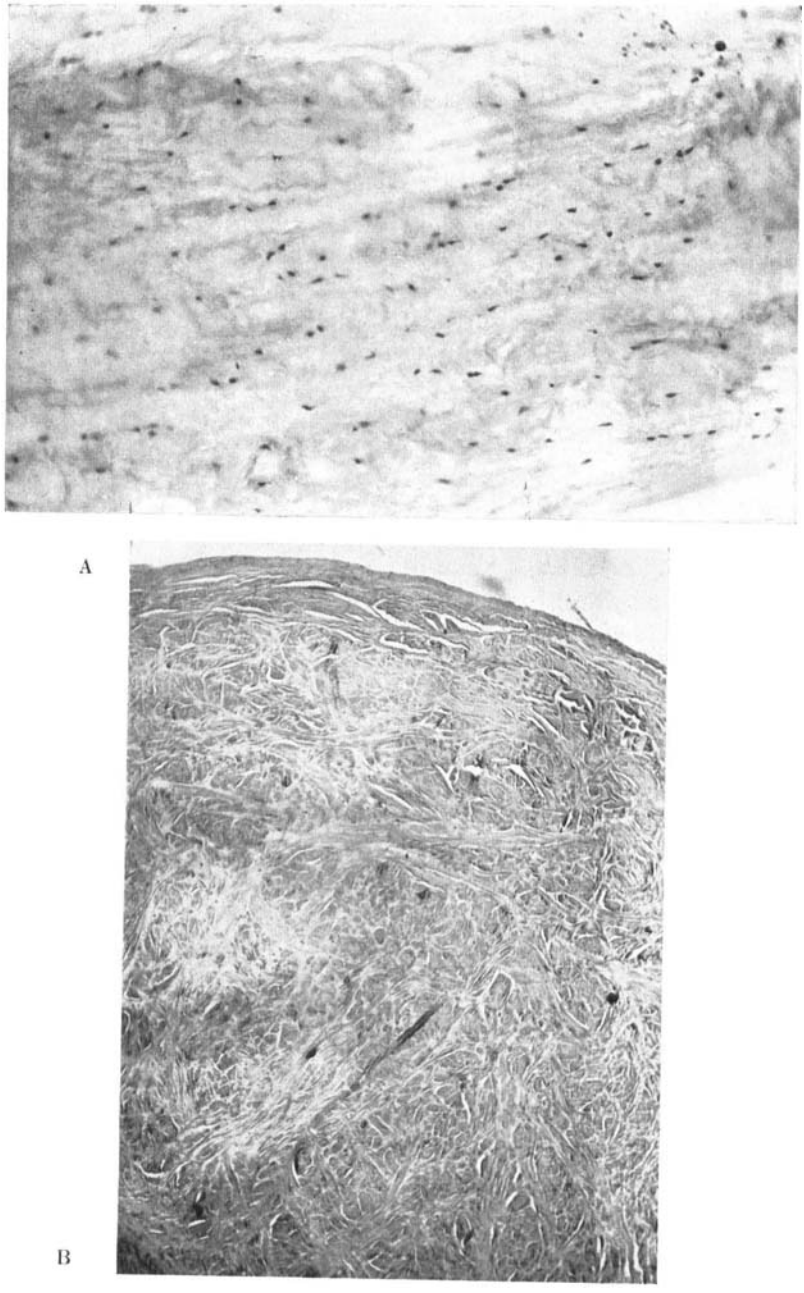

Fig. 7. (A) Middle (× 160) and (B) posterior (× 40) portion of the articular disc at 65 years. Sagittal section, van Gieson's pichrofuchsin.

The fibres ran in an antero-posterior direction, fairly densely packed, in the whole of the central disc, and continued into the anterior part largely in the same direction though not densely packed. In the posterior part the fibres in the superior layer followed an antero-posterior course. Thick bundles ran perpendicularly or obliquely to the surface down into the deeper zone, where bundles with transverse and longitudinal directions also were observed. The bundles were closely interwoven. Elastic fibres were sparse. The cells were small and round except superficially, where they were elongated and flattened. This was noted chiefly in the central region. The cells were fewer in the superior than in the inferior layer. No cartilage cells were observed.

Adult group

The orientation of the collagen fibres in the different parts of the disc was largely the same in this age group as in adolescents (Fig. 6). The tissue gradually became richer in collagen and poorer in cells with age and finally the picture resembled that in Fig. 7 (from a 65-year-old subject). In the narrow middle portion the collagen fibres ran densely packed in the antero-posterior direction. Between these there were few flattened fibroblasts. In the inferior layer there was a narrow structureless hyaline zone which also continued into the anterior part. The posterior part displayed the same characteristic structure as was noted in the younger discs, but the fibre bundles, now considerably thicker, were more densely interwoven. No elastic fibres were observed, nor were there cartilage cells.

DISCUSSION

The material permits a comparison of the collagen structure of the articular disc at all ages.

The observations were in accordance with those reported by *Symons* (1952), in that the collagen fibres were observed at an early intrauterine stage and were numerous at birth. As early as 3 months after birth the fibrillar orientation typical of the disc was found. This suggests that with the functional movements of the mandible the collagen fibres are oriented in a definite pattern. Though the initial structure of joints is moulded on the adult pattern it must not be imagined that the functional

capacities of the joints are necessarily the same in young and adult individuals (*Barnett et al.*, 1961). As is well known, marked changes in form and function with age can be seen in the temporo-mandibular joint. It is reasonable to presume that the collagen structure of the disc at various ages would be greatly dependent on these changes. The predominantly antero-posterior orientation of the fibres is probably a function of the lateral pterygoid muscle, the upper portion of which is inserted in the anterior part of the capsule. The orientation of the fibres in the posterior portion of the disc indicates, on the other hand, that this part is subjected to multidirectional traction.

It would seem impossible to draw any conclusions on pressure conditions in the joint from the collagen structure alone. That the fibres were densest in the central portion may be due to compression in this region or to age changes because of poor nutrition. It is the author's intention to return to this subject after studying the nutrition, innervation and pathologic changes in the articular disc. The absence of cartilage cells is probably accountable for by the fact that there was no history of temporo-mandibular joint disorders in the material.

SUMMARY

The structure of the collagen in the temporo-mandibular disc has been studied on 30 human foetuses (from the fourteenth intrauterine week to birth), 8 children and adolescents (aged 3 months to 19 years) and 20 adults (aged 21—65 years).

Collagen fibres were observed at an early intrauterine age. As early as 3 months after birth these fibres assumed a fibrillar orientation typical of adults.

The collagen fibres followed an antero-posterior course in the anterior part of the disc and in its central portion. In the posterior part they were similarly oriented in the superior layer, but in the deeper tissue ran vertically, transversely and longitudinally, forming interweaving bundles.

There was a gradual increase in collagen with age parallel with a reduction in elastic fibres and the number of cells. No cartilage cells were observed.

The collagen structure in the articular disc probably reflects functional adaptation.

RÉSUMÉ

LA STRUCTURE DU COLLAGÈNE DU MÉNISQUE DE L'ARTICULATION TEMPORO-MANDIBULAIRE CHEZ L'HOMME

La structure du collagène du ménisque de l'articulation temporo-mandibulaire a été étudiée sur 30 fœtus humains (de la quatorzième semaine de vie intra-utérine à la naissance), 8 enfants et adolescents (âgés de 3 mois à 19 ans) et 20 adultes (âgés de 21 à 65 ans).

Des fibres collagènes ont été observées à un stade précoce de la vie intra-utérine, et dès l'âge de 3 mois après la naissance, elles affectaient déjà l'orientation fibrillaire typique de l'âge adulte.

Les fibres collagènes suivaient un parcours antéro-postérieur dans la partie antérieure du disque et dans sa portion centrale. Dans la partie postérieure, elles étaient orientées d'une manière semblable dans les couches superficielles, et étaient dirigées verticalement, transversalement et longitudinalement dans la profondeur du tissu, formant des faisceaux entremêlés.

Il y avait une augmentation progressive du collagène avec l'âge, parallèlement à une réduction des fibres élastiques et du nombre de cellules. Aucunes cellules cartilagineuses n'étaient observées.

La structure du collagène dans le ménisque reflète probablement une adaptation fonctionnelle.

ZUSAMMENFASSUNG

DER STRUKTURELLE AUFBAU DES KOLLAGENS IM DISCUS ARTICULARE BEIM MENSCHEN

Der strukturelle Aufbau des Kollagens im Discus articulare beim Menschen wurde an 30 Embryos studiert (Präparate von der 14. Embryonalwoche bis zum Partus), 8 Kindern und Jugendlichen (von 3 Monaten bis 19 Jahren) und 20 Erwachsenen (von 21 bis 65 Jahren).

Kollagene Fasern wurden in einem frühen embryonalen Stadium beobachtet, und diese nehmen bereits 3 Monate nach der Geburt die für Erwachsene typische fibrilläre Orientierung an.

Die kollagenen Fasern verlaufen in anterior-posterior Richtung im vorderen und mittleren Teil des Discus. In dem hinteren Teil sind sie in gleicher Weise gegen die Temporalisseite orientiert; gehen aber winkelrecht oder schräg zur Oberfläche in

die tieferen Schichten, wo sie in allen Richtungen hin verlaufen.

Mit steigendem Alter wird eine sukzessive Zunahme des Kollagens beobachtet, mit einer gleichzeitigen Verminderung des Elastins und der Zellanzahl. Keine Knorpelzellen wurden beobachtet.

Die kollagene Struktur des Discus articulare ist mit grösster Wahrscheinlichkeit ein Ausdruck der funktionellen Anpassung.

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