Postnatal development of the human temporomandibular joint

II. A microradiographic study

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Ingervall, B., Carlsson, G. E. & Thilander, B. Postnatal development of the human temporomandibular joint. II. A microradiographic study. *Acta Odont. Scand.* 34, 133—139, 1976.

Temporomandibular joint specimens from 22 subjects aged 1 month to 23 years were examined microradiographically. There occurred considerable interindividual variations in mineralization of the joints but nevertheless, systematic changes in mineralization were demonstrated during the periods of development and growth. A continuous compact bony layer formed early in the fossa and tubercle while the outer mineralized layer of the condyle consisted of calcified cartilage. A continuous bony layer around the periphery of the condyle was not fully developed before about 20 years of age. Growth of the articular tubercle was characterized by a spongy appearance of the bony layer over the tuberculum up to the end of puberty. No corresponding growth changes could be seen in the fossa. No mineralized parts could be seen in the disk or the fibrous layers of the articular surfaces.

Key-words: Temporomandibular joint, growth, microradiography

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The histological picture of the human temporomandibular joint between the ages of 2 days and 27 years was described in an earlier paper (*Thilander, Carlsson & Ingervall*, 1976). It was found that the development of the joint micro-morphologically resembled in many respects that of the guinea-pig (*Öberg*, 1964) and of the rat (*Durkin, Heeley & Irving*, 1973). Remodelling of different components of the joint was seen both with and without relation to cartilage. The relative importance of periosteal and condylar changes in the total growth pattern of the mandible was discussed in the light of these observations. All questions could not, of course, be answered by the histologic method used and the need for other micro-morphologic methods was recognised. In the present investigation, the postnatal development of the temporomandibular joint was studied microradiographically in order to determine the extent of mineralization in different parts of the joint and its variations from birth to adult age.

MATERIAL AND METHODS

The material consisted of specimens from 22 subjects, 19 males and 3 females, having an age-distribution of 1 month to 23 years (Table I).

All the temporomandibular joint speci-

Received for publication, December 22, 1975.

Table I. *Age- and sex distribution of material*

Age (years, months)	Male	Female
0.1— 4.11	4	3
5.0— 9.11	4	
10.0—14.11	3	
15.0—19.11	3	
20.0—23.5	5	
Total	19	3

mens were obtained from individuals who had died sudden deaths; most often accidents, suicides or from acute diseases. None of them had had chronic diseases known to be capable of influencing growth.

The specimens consisted of the right temporomandibular joint, which was removed *en bloc* and comprised the entire joint including the fossa, tuberculum, condyle and collum, disk and capsule as well as contiguous parts of bone and soft tissues. The specimens were fixed in absolute alcohol and embedded in methylmetacrylate. Hard tissue sections, on the average 150 μ thick, were cut. Half of the material was cut sagittally and the other half transversely. Microradiograms were obtained using exposures of 20 minutes at 20 kV and 32 mA, with a focus-film distance of 30 cm; a Ni-filter and Kodak Maximum Resolution Plates were used.

RESULTS

The extent of mineralization in different parts of the joint varied markedly with age. Striking differences were also seen in this respect between the condyle and the temporal component and in different parts of each. Notable differences were also found among individuals of the same age groups.

In the youngest specimens (1 month), the condyle and the most superficial parts of the temporal component were incompletely mineralized. No continuous mineralized bone layer was seen in the condyle, in contrast to the deeper parts of the tuberculum (Fig. 1 A, B). Mineralization seemed to occur in small discrete centers. These centers soon coalesced to form a continuous bony layer in the temporal component while the condyle showed a thin trabecular system and an upper border consisting of mineralized cartilage (Fig. 1 C, D).

With increasing age, the thickness of the trabeculae in the condyle began to increase but at the same time they became fewer in number (Figs. 2 C, 5 C, D). A thick compact layer along the mandibular neck developed early (Figs. 2 A, 4 A).

Growth of the articular tubercle was reflected in the spongy character of the compact bone layer, which constituted the osseous part of the temporal joint component (Figs. 2 A, B, 3 C, 4 C, D, 5 A). The fossa appeared homogeneous, reflecting a more static state, during the whole of the observation period (Figs. 2 A, 3 B, 4 A, B).

By 12 years of age, the entire peripheral mineralized layer of the upper surface of the condyle still consisted of calcified cartilage (Fig. 5 C). During the teen-age period, an outer superficial bony layer began to form through the confluence of the most superficial trabeculae. Starting in the neck region, the bony layer was seen to run in a superior direction and by about 20 years formed an almost continuous upper bony layer (Fig. 5 D). At the same time, the bony layer of the tuberculum became homogenous (Fig. 5 B). In the young adult joint, the continuous bone layers, which constituted the outer osseous margins of the joint components, were

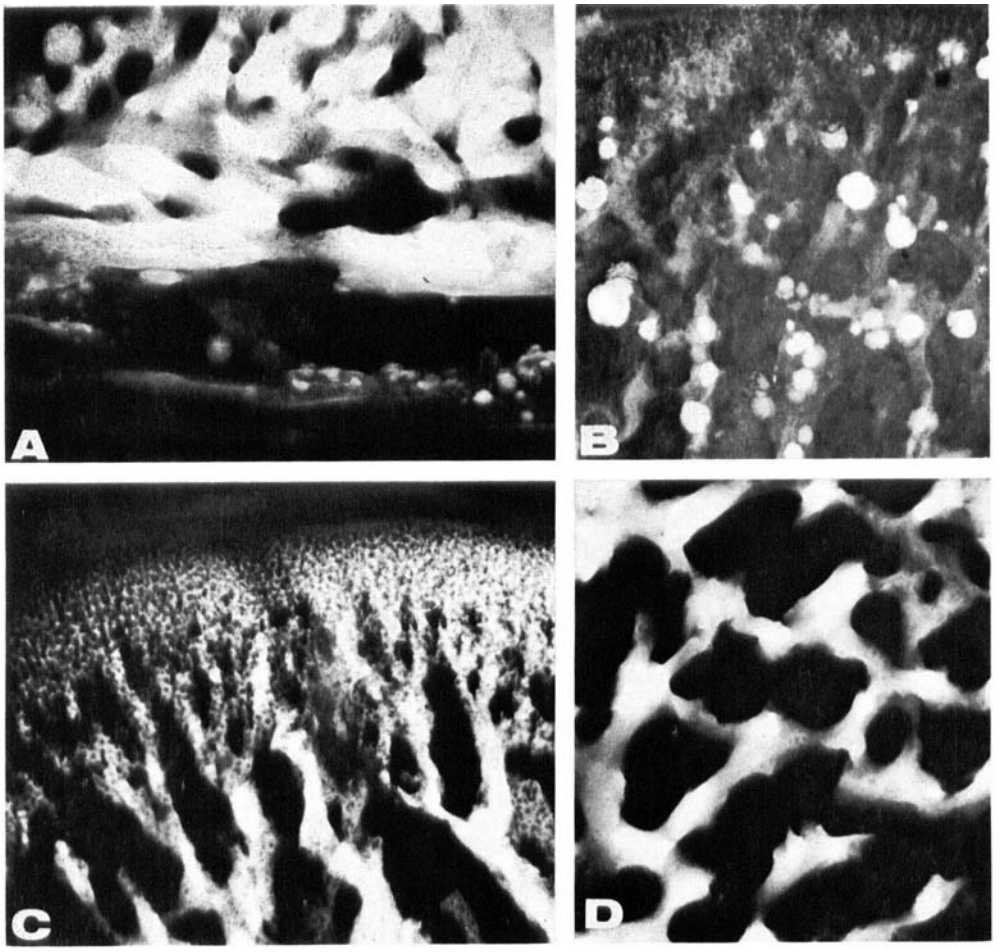

Fig. 1. Details of microradiograms of sagittal sections of temporomandibular joints. A tuberculum and B superior part of the condyle from a 1-month old boy. The tuberculum is more mineralized than the condyle. which shows mineralization centres only in deeper parts. C superior part of the condyle from an 1½-month old boy. In this specimen the mineralization has become more homogenous than in B, including the calcifying cartilage and spongiosa. D spongy bone in the deeper part of the condyle from a 7-month old girl. Cores of higher mineralized areas in the thin trabeculae. Magnification A-D 64 ×.

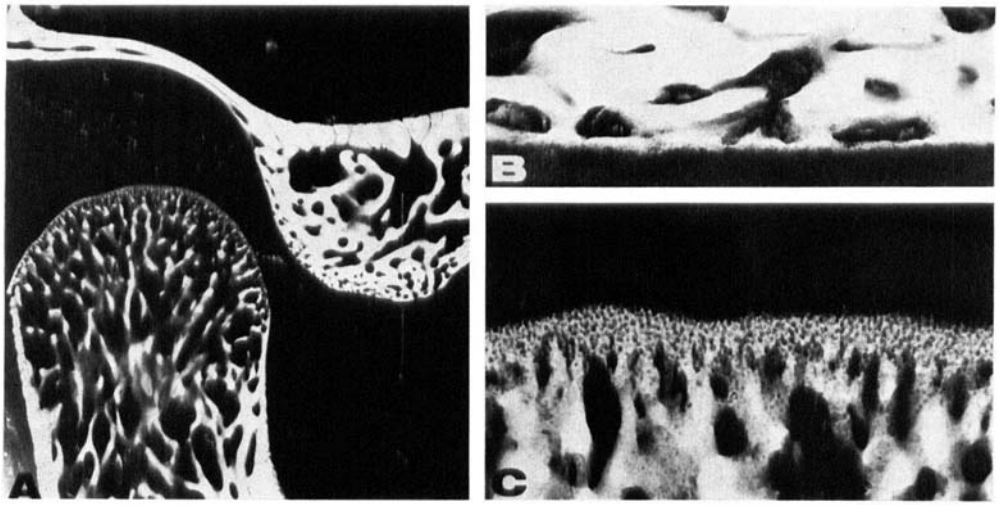

Fig. 2. Microradiogram of a sagittal section of the temporomandibular joint from an 18-month old boy. A Survey. Note that there is no mineralization in the disk and other soft tissues of the joint. B Detail of the most inferior part of the tuberculum. C Detail of the most superior part of the condyle. Remnants of calcified cartilage are seen in the trabeculae. Magnification A 4.3 ×, B, C 55 ×.

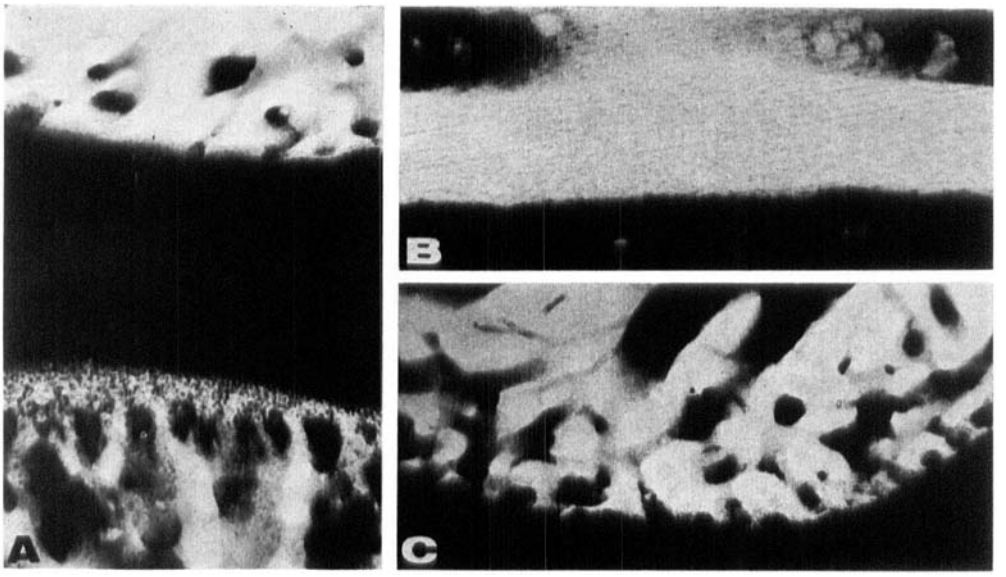

Fig. 3. Details of a microradiogram of a sagittal section of the temporomandibular joint from a 2-year old boy. A antero-superior part of condyle (below) and posterior slope of tuberculum. Note difference in mineralization between temporal and mandibular component and absence of mineral in disk and articular surfaces. B bottom of fossa. C top of tuberculum. Magnification A—C 55 ×.

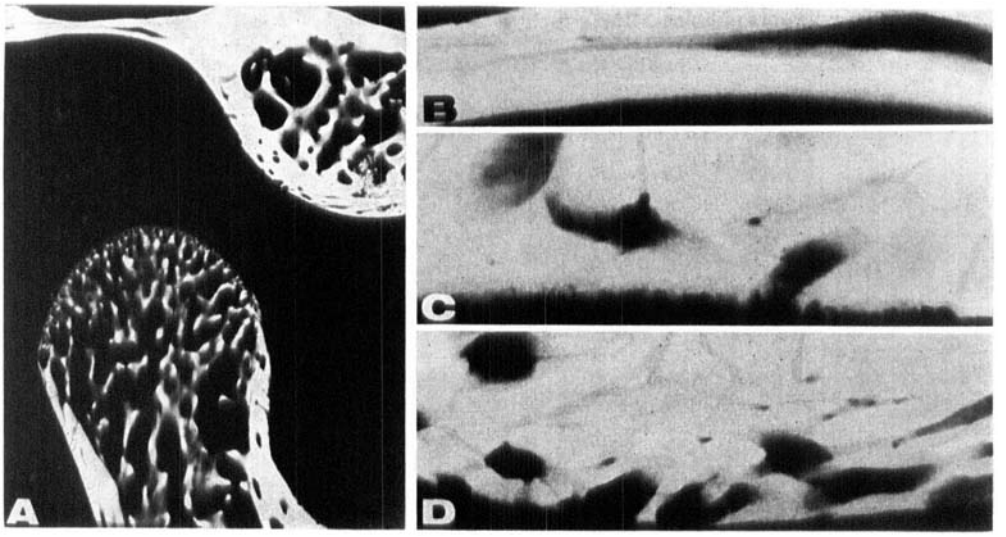

Fig. 4. Microradiogram of a sagittal section of the temporomandibular joint from a 6-year old boy. A. Survey. B, C, D. Details of bottom of fossa (B), posterior slope of tuberculum (transition between tuberculum and fossa) (C), and top of tuberculum (D). Observe the spongy character of the bone surface of the tuberculum compared with the even surface of the fossa. Magnification A 4 ×, B—D 55 ×.

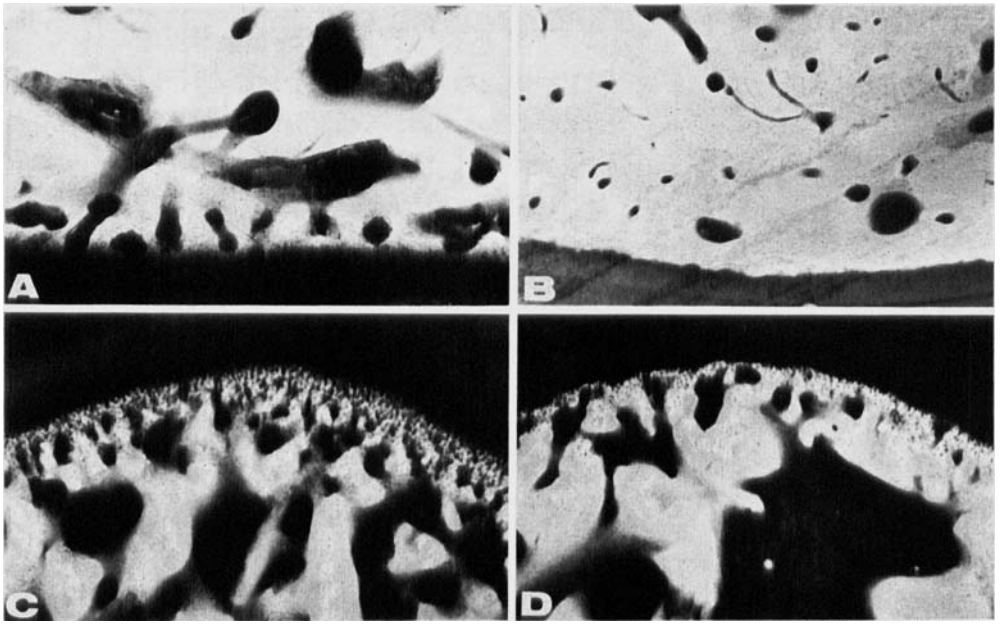

Fig. 5. Details of microradiograms of sagittal sections of temporomandibular joints. A, B, tops of tuberculum from boys aged 14½ and 19½ years, respectively. The most superficial part of the calcified cartilage is less radiopaque than the bone in the younger specimen (A). In the older specimen there is only a thin, highly mineralized layer of cartilage on the surface of the bone (B). C, D. Most superior parts of condyles from boys aged 11½ and 19½ years, respectively. In the older specimen the calcified cartilage is more mineralized than the adjacent bone (D). In both sections the trabeculae contain cores of more densely mineralized remnants of cartilage. Numerous Haversian systems with varying degree of mineralization have developed in the temporal component but not in the condyle (B, D). Magnification A—D 52 ×.

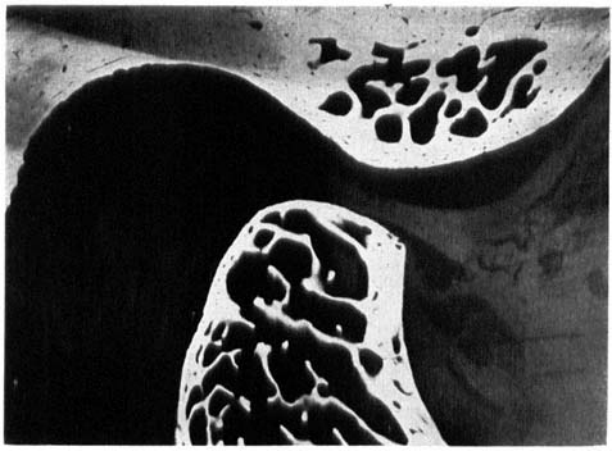

Fig. 6. Microradiogram of a sagittal section of the temporomandibular joint of a young man, aged 23½ years. There is no mineralization in the disk and other soft tissues of the joint. Magnification 2.4 ×.

fairly thick (Fig. 6). An irregular, but often thin layer of mineralized cartilage, more densely mineralized than the underlying bone, was seen in several areas of the surface of the joint components in adults (Figs. 5 B, D).

No calcification could be seen in the disk and capsule or in the fibrous lining of the articular surfaces of the condyle and the temporal component (Figs. 2 A, 3 A, 4 A, 6).

DISCUSSION

According to the principles of selection, the material may be regarded as representative of a »normal population» ranging in age from birth to around 20 years. The distribution of the specimens as to age was fairly even, but owing to the wide interindividual variation, especially up to the age of 6 months and in puberty, a larger series would have been desirable. It is, however, difficult to obtain specimens filling the adopted criteria and the collection of the material was discontinued after three years. With the histotechnical and microradiographic procedures used, a reliable visualisation of the mineral distribution can be expected, possibly with the exception of tissues with very low mineral content (*Öberg*, 1964; *Hall, Röckert & Saunders*, 1972).

The series of microradiograms revealed significant differences in mineral content of the various calcified tissues. The calcified cartilage which occupied large parts of the condyle in the youngest specimens, had a low degree and uneven distribution of mineralization. Very soon its mineral content was comparable to that of the spongy bone and in joints of young adults, the calcified cartilage had a higher degree of mineralization than the adjacent bone.

Even at 6 months of age both the condyle and the temporal component were considerably mineralized. The gross microradiographic appearance of the temporomandibular joint does not undergo any dramatic changes between 2 and 12 years, which is of importance for interpretation of TMJ-radiograms in children. From the beginning to the end of teen-age it gradually assumes adult appearance, which it reaches after 20 years of age. It should be remembered that the spongy character of the bone of the tubercle — seen even earlier than at age 2 years and continuing till about 20 years — is a sign of normal growth of the joint. In some radiographic projections it might otherwise be mistakenly diagnosed as a degenerative symptom.

The shape of the temporomandibular joint is not definitive at the end of the growth period. It can still undergo changes and remodelling, due to functional demands but also, of course, in connection with degenerative joint disease (*Blackwood*, 1966; *Carlsson & Öberg*, 1974).

None of the specimens in this study showed mineralization in the disk, capsule or fibrous articular lining of the joints. This makes it logical to classify mineralized areas found in the disks of young adults having functional disturbances of the TMJ, as pathological (*Carlsson et al.*, 1967). It is, however, debatable whether such soft tissue calcification in the aged as has been observed in humans (*Macalister*, 1954; *Carlsson, Hassler & Öberg*, 1974) and in guinea pigs (*Öberg*, 1964), may be regarded as a sign of ageing or as a result of a pathological process, e.g. in degenerative joint disease.

Acknowledgement. — This work was supported by grants from the Swedish Medical Research Council (Project No. K72—24X—3800—01).

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