Thickness of the soft tissue layers and the articular disk in the temporomandibular joint

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Out of 115 right temporomandibular joints from Swedish subjects aged 1 day to 93 years, 48 joints without any gross sign of arthrosis or deviation in form were examined histologically.
The joint components were cut sagittaly, each into four parts. Histological sections were made of the condyle, the temporal component and of the articular disk. The total thickness of the soft tissue layers was measured in decalcified sections, cut from the medio-central and lateral parts of the condyle and the temporal component and from the medial, medio-central, latero-central and lateral regions of the disk. In the medio-central sections from the condyle and temporal component the thickness of the fibrous connective tissue layer i.e. the surface layer was also registered. The soft tissue layers were thickest in the condyle superiorly, about 0.4–0.5 mm, in the temporal component on the postero-inferior slope of the articular tubercle, about 0.5 mm, and in the disk posteriorly about 2.9 mm. In the roof of the fossa it was only 0.1 mm. The soft tissue layers on the condyle as well as the disk were thinner laterally while the corresponding tissue in the temporal component was thicker laterally. The thickness of the soft tissue layers seem to reflect the growth and functional load to which the joint is exposed.

Keywords: Anatomy; histology; human TMJ

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Judging from the description of the normal histology of the human temporomandibular joint (TMJ) and its structural changes with age (*Öberg*, 1973, *Carlsson & Öberg*, 1974), the arrangement and thickness of the tissue layers probably reflect the rate of growth and loading of the condyle and temporal component of the joint. The variation in thickness of the articular disk also indicates the topographic relation between the temporal component and the condyle.

Thus, it would be of interest to measure the thickness of the tissue layers in the different parts of the joint. Such measurements are also of importance for the radiological and the pathological diagnosis of diseases of the temporomandibular joint. The aim of this study therefore was to determine the normal range of variation of the thickness of the soft tissues and disk of healthy TMJ components.

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MATERIAL AND METHOD

The original material consisted of 115 right temporomandibular joints obtained at autopsy from 1 day to 93 years old persons of both sexes (*Öberg, Carlsson & Fajers*, 1971). Forty-eight of these joints, which on macroscopic examination were classified as normal, i.e. without any sign of arthrosis or deviation in form, were used for the present investigation. The term arthrosis is used as a synonym for osteoarthritis, and degenerative joint disease.

The sex and age distribution of the 48 joints is given in table I. After the right temporomandibular joint had been removed in block it was fixed in 5 per cent formaldehyde buffered to pH 7.4 with sodium barbiturate. The condyle, temporal component and disk were dissected free and examined. The findings were described not only verbally but also diagrammatically and photographically. The joint components were divided medio-laterally into four equal parts. Fig. 1. The lateral (L) and medio-central (MC) parts of the temporal component and of the condyle were decalcified in 0.5 M ethylene diaminetetracetate (Na_2H_2-EDTA) at pH 8.0 and embedded in paraffin. From these and from all four parts of the disk sagittal sections (5 µm) were cut in the same direction, and stained with haematoxylin-eosin, van Gieson and toluidine blue. (The latero-central (LC) and medial (M) parts of the condyle and temporal component were reserved for microradiography. The results will be reported separately.) The sections were examined separately buy two examiners in a Leitz Wetzlar light microscope and furnished with a measuring ocular (10 mm = 100 scale lines).

The soft tissue consists of the 1) connective tissue lining (articular layer) and the subarticular layers which are 2) undifferentiated mesenchyme (proliferating layer) 3) transitional layer and 4) non-mineralized zone of cartilage, in growing individuals; zone of hypertrophying cartilage (*Öberg*, 1973; Fig. 2).

The total thickness of these tissue layers including the thin deepest zone of calcifying cartilage was measured in the following areas:

Table I. *Age and sex distribution of the material (n = 48)*

Age (years)	0 – 19	20 – 39	40 – 59	60 –
Men	5	6	9	12
Women	6	1	5	4
Total	11	7	14	16

1) Condyle: anteriorly, superiorly and posteriorly. Fig. 3.
2) Temporal component: anterior slope, postero-inferior and postero-superior slopes of the articular tubercle and roof of the fossa. Fig. 4.
3) Articular disk: anterior, middle and posterior dense part. Fig. 5.

In the medio-central part of the temporal component and condyle the thickness of the articular layer (the connective tissue lining) also was measured separately.

The occurrence of the undifferentiated mesenchyme layer was registered for the different measuring areas in the medio-central parts of the temporal component and condyle.

The average values found by each examiner in the various areas measured in the three sections with different stainings were calculated. Since in a pilot study on 20 sections a t-test showed a close agreement between the examiners, the values noted buy both examiners were pooled and the means were used for the statistical analysis. (Student's t-test) Significanse levels considered were (*) $p < 0,05$; (**) $p < 0,01$; (***) $p < 0,001$.

RESULTS

The total thickness of the soft tissue layers varied greatly in different areas. Fig. 6, 7, 8 and 9. The mean values in the medio-central parts in the antero-posterior direction of the material as a whole were:

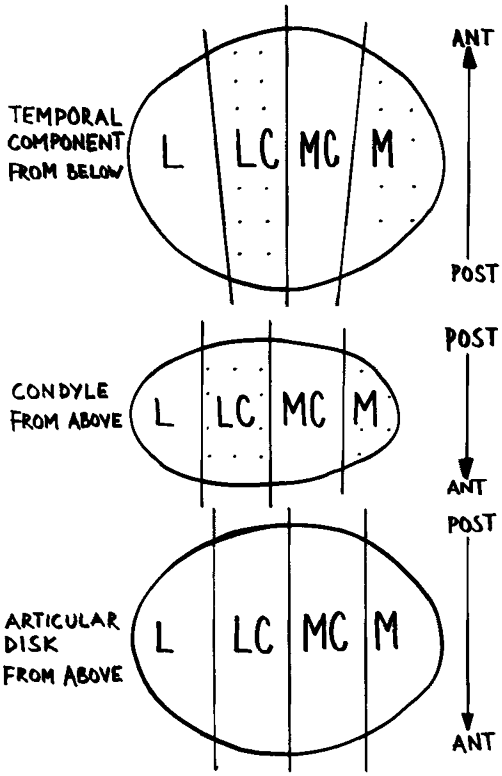


Fig. 1. Quartering of the joint components. The non-dotted parts were taken for decalcification and ordinary light-microscopic examination.

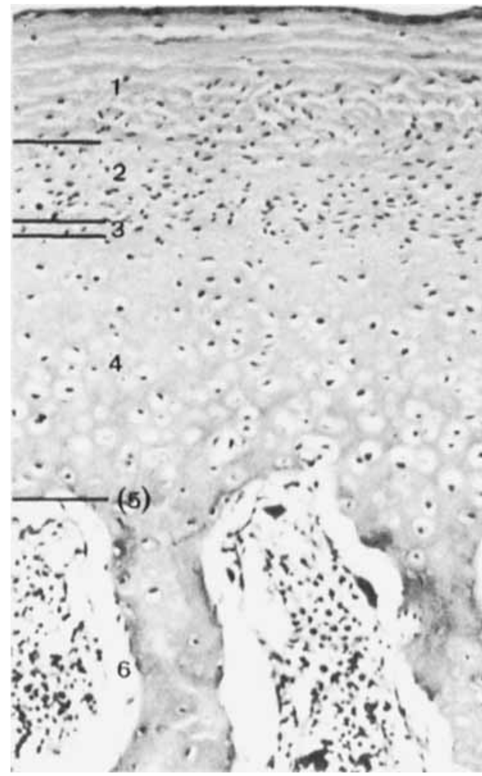


Fig. 2. The tissue layers in the superior part of the condyle from a 14 years old person. Htx-eosin. 1 = Connective tissue lining; 2 = Undifferentiated mesenchyme; 3 = Transitional layer; 4 = Cartilage; (5) = Area, where a compact bone layer develops when growth is finishing; 6 = spongy bone.

For the condyle the highest mean value was 0.48 mm superiorly, and the lowest mean value 0.25 mm posteriorly. In the temporal component the soft tissue was thickest on the postero-inferior slope of the articular tubercle, 0.45 mm, and thinnest in the roof of fossa, 0.07 mm. The articular disk was thickest posteriorly, 2.90 mm and thinnest in the middle part, 1.08 mm.

The total thickness in different parts medio-laterally varied somewhat, in as much as the soft tissues of the condyle was significantly (***) thicker centrally than laterally in the superior and posterior parts both of children and adults. In the temporal component the soft tissue layers tended to increase in thickness laterally, but significant differences were found only among the adult portion of the material on the postero-superior slope (*) of the articular tubercle and in the roof of the fossa (***). The middle (*) and posterior (***) parts of the articular disk were significantly thicker medio-centrally than laterally in the adults. The anterior, middle and posterior dense parts of the disk in the children and the anterior part of the disk in the adults showed no such a difference in medio-lateral direction.

The connective tissue lining was thin. The thickest part of the condyle was superiorly 0.18 ± 0.06 mm and the thinnest part posteriorly 0.13 ± 0.04 mm. In the temporal component the maximum value was 0.20 ± 0.08 mm and found on the posteroinferior slopes of the articular tubercle and the thinnest, 0.04 ± 0.02 mm, in the roof of fossa.

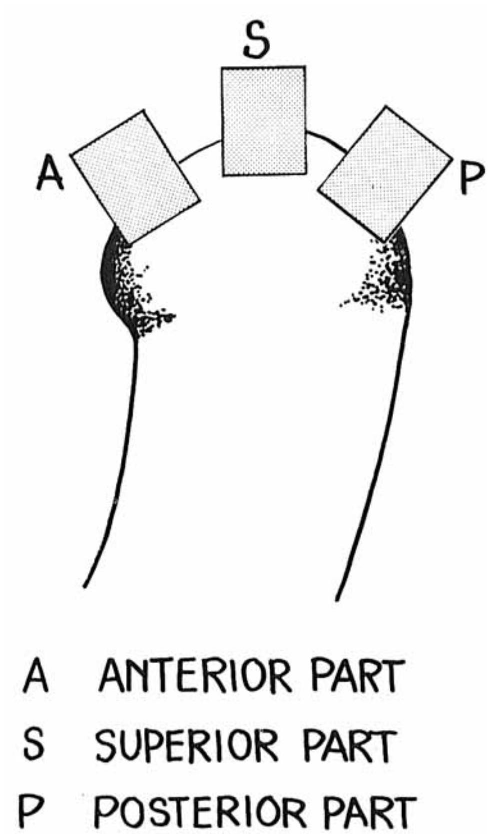


Fig. 3. Sagittal section of condyle with measuring ranges medial aspect.

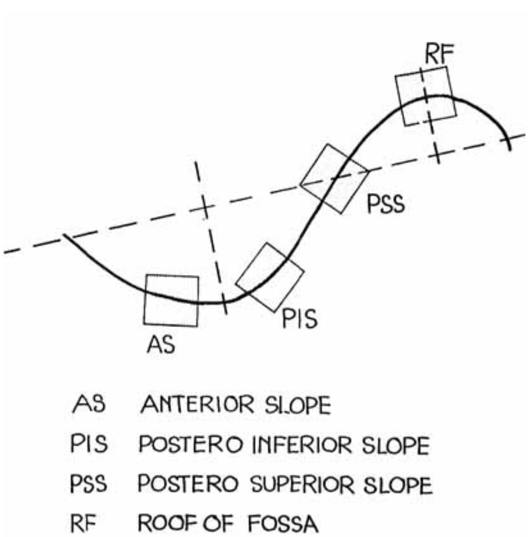


Fig. 4. Sagittal section of temporal component with measuring ranges medial aspect.

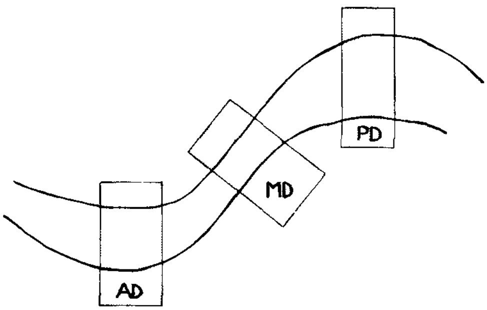
The subarticular soft tissue layers in the children were significantly (**) thicker in all parts of the condyle with the highest values being found superiorly. No difference was found between the children and the adults in the temporal component. The postero-inferior slope of the articular tubercle in adults and the anterior slope in the children showed the highest values.

Undifferentiated mesenchyme was found in all children as a continuous or almost continuous layer in all parts of the condyle, while in the two oldest in this agegroup it had been reduced on the postero-inferior slope of the articular tubercle to solitary islands of cells.

In the adults there was in the areas with the thickest tissue layers significantly (*) less undifferentiated mesenchyme than in the thinner parts. Undifferentiated mesenchyme was missing in the anterior and superior parts of the condyle in respectively 25% and 40% of the examined joints and in the postero-inferior slope of the temporal component in 25%. The posterior part of the condyle and the roof of fossa contained undifferentiated mesenchyme in all but two cases.

DISCUSSION

The material of the present study was relatively small and most of the joints were obtained from men. Since, however, the primary selection of the original material was rigorous and since none of the joints had gross signs of arthrosis or deviation in form, the results can probably be regarded as representative of the thickness of the soft tissue layers in the healthy temporomandibular joint. Due to the fact that the joint components had been dissected free and thereafter sectioned perpendicularly to the respective joint surface, the values measured corresponded to the real thickness of the fixed soft tissue layers, disregarding the possible shrinkage, that resulted from the histotechnical treatment. The shrinkage of these actual tissues seems to be less than 10% (*Hansson & Nordström*, 1977).



AD ANTERIOR DENSE PART
MD MIDDLE DENSE PART
PD POSTERIOR DENSE PART

Fig. 5. Sagittal section of the dense part of the articular disk with measuring ranges medial aspect.

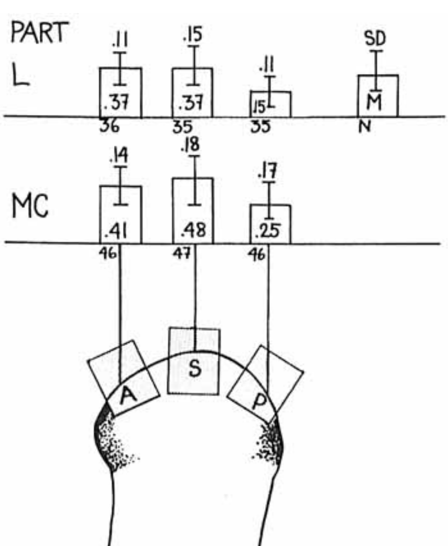


Fig. 6. Total thickness in mm of the soft tissue layers of the condyle. M = mean in mm. N = number of joints examined. The end points of vertical bar correspond to M ± SD (SD = standard deviation).

Of the measured tissue layers in the temporal component and the condyle, the connective tissue lining has, as judged from experimental studies on animals, a slow turnover of matrix components (*Öberg*, 1964; *Öberg et al.*, 1969). The layer is, like the disk, condrified in pressureloaded areas.

The same studies show that in young individuals, the undifferentiated mesenchyme, the transitional layer and the cartilage are sites of growth and of considerably quick new formation of tissues. The cell proliferation of the growth layers occurs almost exclusively in the undifferentiated mesenchyme (*Folke & Stallard*, 1966; *Öberg et al.*, 1967). Via the transitional layer the undifferentiated cells develop into chondrocytes and a cartilaginous layer is formed in areas of rapid growth, while the cells in the transitional layer develop into osteoblasts which form bone in areas of slower growth (*Öberg*, 1964; *Öberg et al.*, 1969). The last-mentioned studies also show that variations in the thickness of the growth layers indicate differences in the rate of growth.

In adults the cartilage persists or a cartilaginous layer is developed in areas exposed to heavy functional load. This layer, however, differs from that occurring during the growth period, by being, among other things, poorer in cells and richer in collagenous components. The occurrence of cartilage and variation in thickness of the entire soft tissue layer can therefore also reflect the loads to which different parts of the joint are exposed.

Except for the cartilage, the measured tissue-layers contain only soft tissue. In the cartilage only the deepest 2–4 cells layers are mineralized, except in newborns where the major part of the cartilage is mineralized (*Öberg*, 1964). With the exception of areas where there is cartilage, the distance from the joint surface to the bony layer is thus a measure of the thickness of the soft tissue. The significantly thicker subarticular soft tissue layers in the condyle in children indicate a rapid growth. The teenagers showed the highest values, which corresponds to the results of studies of growth by *Björk* (1966). The thinness of subarticular tissues in the temporal compo-

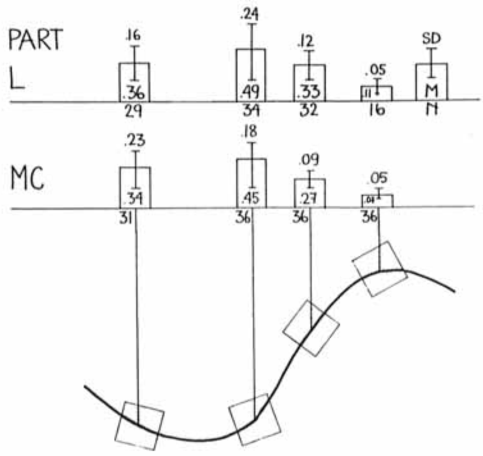


Fig. 7. Total thickness in mm of the soft tissue layers of the temporal component. M = mean in mm. N = number of joints examined. The end points of vertical bar correspond to M ± SD (SD = standard deviation).

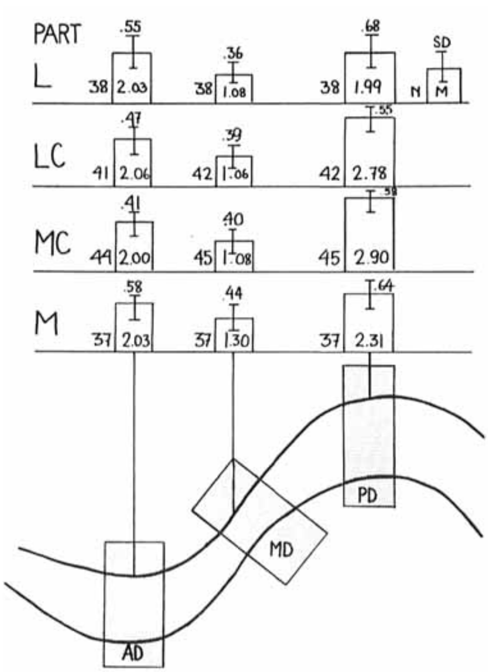


Fig. 8. Total thickness in mm of the dense portion of the disk. M = mean in mm. N = number of joints examined. The end points of vertical bar correspond to M ± SD (SD = standard deviation).

nent indicates a slower growth, while the relatively greater thickness in the articular tubercle indicates the site of growth in length of the temporal component and the growth in height of the articular tubercle, observed macroscopically by *Öberg et al.* (1971).

In the adults, the anterior and superior parts of the condyle and the postero-inferior slope of the tubercle had the thickest subarticular tissue layer. These parts of the joint are heavily loaded during function. The thickness of these tissue layers is dependent on an increase in the amount of cartilage tissue at the same time as the undifferentiated mesenchyme disappears in these parts. The growth capacity of the undifferentiated mesenchyme has probably been exhausted. In these areas, the articulating tissue layer also reaches its highest degree of chondrification. The thinner layers posteriorly on the condyle and in the roof of the fossa in the temporal component with an intact undifferentiated mesenchyme at a greater age shows that the functional load in these areas is rather small.

The lateral thinning out of the adult disk in the middle and posterior dense parts appear to be a result of the functional load, as the disk in children does not show this lateral decrease.

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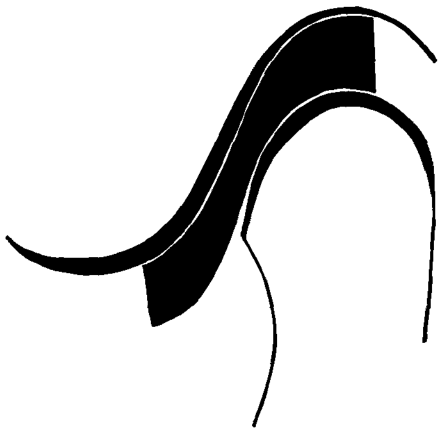

Fig. 9. Total thickness of the soft tissue layers in the TMJ components. Sagittal section.

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