Degenerative disease in the temporomandibular, metatarsophalangeal and sternoclavicular joints

An autopsy study

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The right temporomandibular, sternoclavicular and first metatarsophalangeal joints were removed post mortem from 39 subjects. The surfaces of the various parts of the joints were examined and evaluated according to a grading system. Repeated evaluation of the joints showed a good reproducibility of the grading system. Of the 33 temporomandibular joints, 12 showed deviations in shape. Degenerative disease was uncommon and seen in only 3 joints. The total »score for degeneration» showed only a weak correlation with age ($r = 0.28$, $r_s = 0.08$). Degenerative disease was common in the 35 sternoclavicular joints. All joints except 7 showed degenerative changes. A moderate correlation was found between age and the score for degeneration ($r = 0.58$). Of the 39 metatarsophalangeal joints only 5 were allotted no points of degeneration. A moderate correlation was found between age and score for degeneration ($r = 0.61$). No significant differences of degeneration were found between sexes. The coefficient of correlation between the score for degenerative disease of the temporomandibular joint and the degeneration score for the sternoclavicular joint and the toe-joint were $r = 0.22$ ($r_s = 0.16$) and $r = 0.46$ ($r_s = 0.44$), respectively. The significant association of degenerative disease found between the toe-joint and the sternoclavicular joint ($r = 0.54$, $r_s = 0.54$) was reduced (to $r = 0.29$) when age-dependence was excluded. The degenerative changes described in this material are probably mostly due to local factors.

Key-words: temporomandibular joint, sternoclavicular joint, metatarsophalangeal joint, osteoarthritis

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Degenerative joint changes (syn. osteoarthrosis, degenerative joint disease, osteoarthritis) are usually ascribed to mechanical loading of the joint surfaces, but other factors of systemic nature, such as genetic, metabolic and vascular disturbances may also be involved. This indicates that the pathogenesis of degenerative changes in joints in general (*Sokoloff*, 1969; *Meachim & Freeman*, 1973) and in the temporomandibular joint (*Carlsson & Öberg*, 1974 a) is obscure. Though degenerative joint changes in general tend to increase in frequency with age (*Heine*, 1926) it has

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not been proved that the occurrence of such changes is exclusively age-dependent and there are different opinions about its variability with sex. These obscurities can probably be explained by differences as to *e.g.* the anatomy and loading of different joints. An investigation of the correlation between osteoarthrosis in various joints in a given individual might be able to show whether its development can be ascribed to systemic factors.

Such an analysis of the hip-joint, knee-joint and joints of the big toe from 29 cadavers showed that »there was no relationship between the degeneration of one joint and another in terms of the age of the subject» (*Hall & Kinoshita*, 1969), and it was concluded »that alterations in the joints occur independently».

The temporomandibular joint is of central importance for the function of the masticatory system, but our knowledge of the role played by osteoarthrosis and by other diseases of the temporomandibular joint is still vague (*Carlsson & Öberg*, 1974 b). This paper concerns a comparison between the frequency of degenerative disease of the temporomandibular, sternoclavicular and metatarsophalangeal joints in the same individual.

Degenerative joint disease is here to be understood as a non-inflammatory disorder of synovial joints, characterised by deterioration of the articulating surface layer, as well as by changes in the subarticular tissues.

MATERIAL AND METHODS

The right temporomandibular joint, the right sternoclavicular joint and the right first metatarsophalangeal joint were removed post mortem from 39 subjects (21 males and 18 females), aged 2 to 82 years (Table I). The material consisted as far as possible of persons who had died sudden deaths or in accidents. But individuals known to have had diseases or injuries that might possibly influence the joints were not accepted. For technical reasons it was not possible to obtain all three joints from every individual, with the result that the material consisted of 33 temporomandibular joints, 35 sternoclavicular joints and 39 toe joints. Each specimen consisted of a block of the actual joint and surrounding soft tissues. After fixation in 5 per cent formaldehyde buffered to pH 7.4 with sodium barbiturate, the joints were carefully opened and the surfaces of the various parts of the joints were examined macroscopically. The findings were recorded by description, drawings and colour photographs. Each series of joints was examined separately (independently of the other two). Each joint was examined jointly by two examiners for degenerative changes. Six weeks later 10 joints of each type were selected at random to check the reproducibility of the grading system.

Table I. *Age and sex distribution of the individuals from whom the specimens were obtained*

Sex	—19	20—39	40—59	60—	Total
Males	1	7	7	6	21
Females	5	5	3	5	18

Grading system. A grading system for judging the degeneration of joint surfaces published by *Bennett, Waine & Bauer* (1942) was modified for the three joints. Different parts of the joints were judged separately and a total score of degeneration for the whole joint was afterwards calculated. The scale was as follows:

One unit: Slight uneveness, granularity of the surface, shallow furrows or streaking.

Two units: Larger amount of these changes, and, in addition, some fraying, splitting, and pitting of the articular surface, with or without small erosions.

Three units: Marked degrees of the above abnormalities with extensive ulcerations.

Four units: Large areas of complete degeneration, accompanied by exposure and condensation (eburnation) of the subchondral bone.

The scale was slightly modified according to the differences in the anatomy of the three joints.

The temporomandibular joint was divided into the condyle, temporal component (tubercle + fossa) and disk and besides any surface changes, deviations in shape were judged according to principles given by *Öberg, Carlsson & Fajers* (1971). The following 3-grade scale was used:

0 no demonstrable changes

1 local changes in shape (comprising less than one third of the joint surface)

2 extensive changes in form (affecting at least one third of the joint surface)

The sternoclavicular joint was divided into a sternal part, clavicular part and intermediate disk. In the temporomandibular joint and the sternoclavicular joint, disks with small perforations (3 mm at most) were allotted 3 points, disks with larger perforations (> 3 mm) 4 points. The metatarsophalangeal joints were divided into the phalangeal and capital regions. The capital region was further divided into the areas of head, sesamoid ridge, medial and lateral sesamoid grooves. The sesamoid bones could not be judged because they were often not included in the specimens.

Statistical methods. The agreement between double determinations was calculated according to Scott's pi (π):$\pi =$

$$\frac{\%\text{ observed agreement} - \%\text{ expected agreement}}{100 - \%\text{ expected agreement}}$$

(*Scott*, 1955). The comparison of score for degeneration for men and women were analysed with Mann-Whitney's U-test. The correlation was analysed both with the product-moment-correlation (r) and with Spearman's rank-correlation corrected for ties (r_s; *Siegel*, 1956). The following symbols for the levels of statistical significance were used: * $0.01 \leqslant p < 0.05$, ** $0.001 \leqslant p < 0.01$, *** $p < 0.001$.

RESULTS

Reproducibility of evaluation. Repeated evaluation of the 10 toe-joints comprised 50 double determinations (10 joints with 5 regions). Of these, 38 were allotted the same score as before, while 12 were given a score differing by 1 point. The corresponding figures for 10 sternoclavicular joints (40 double determinations: 10 joints, 4 regions) were 27 and 13, respectively. For 10 temporomandibular joints (30 double determinations) the figures were 28 and 2, respectively. The reproducibility according to Scott's pi was 0.62 for the toe-joints, 0.39 for the sternoclavicular joints and 0.81 for the temporomandibular joints.

Temporomandibular joint (33 joints)

Of the 33 joints, 12 showed deviations in shape of the components (Table II). Degenerative disease changes were uncommon and seen in only 3 joints, all of which also showed deviations in shape of the condyle and 2 in the shape of the fossa. The disk was perforated in all 3 joints, the joint surface of the temporal

Table II. *Distribution of degeneration points between age, sex and joints (n = 39). T = temporomandibular joint, M = metatarsophalangeal joint, S = sternoclavicular joint*

Sex	Age	Degen. points T*	Degen. points T**	Degen. points M	Degen. points S	Total
	2	—	—	0	0	0
	8	0	0	0	0	0
	10	0	0	3	0	3
	14	0	0	1	1	2
	15	0	0	2	3	5
	21	0	1	1	1	3
	23	0	0	3	1.5	4.5
	34	—	—	4	1.5	5.5
	35	0	0	0	2.5	2.5
	36	0	0	2	1.5	3.5
women	42	0	0	4	2.5	6.5
	47	0	0	6	1	7
	48	3	5	10	4	22
	61	0	0	19	—	19
	63	—	—	20	6	26
	65	0	0	6	1	7
	74	5	8	16	6	35
	82	0	0	7	2	9

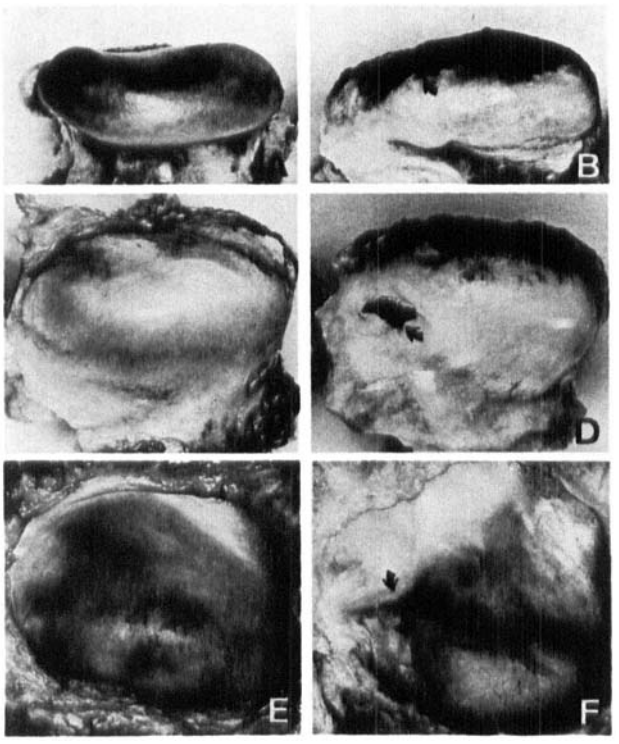

Fig. 1. Temporomandibular joints. Condyle, disk and temporal component, from a macroscopically normal joint (ACE) and a joint with degenerative changes (BDF). Note deviations in shape in the lateral parts of the condyle (B arrow) and the temporal component (F arrows). In the same parts of the temporal component degenerative changes are seen and a perforation of the disk is located between the regions of the condyle and temporal component which have deviations in shape. The total score for degeneration was 8. (Posterior parts at top and lateral parts to left.)

Table II. cont.

Sex	Age	Degen. points T*	Degen. points T**	Degen. points M	Degen. points S	Total
	19	0	0	0	0	0
	26	0	0	3	1	4
	29	0	0	3	0	3
	31	0	1	8	2	11
	32	—	—	6	5	11
	35	0	1	5	3	9
	35	0	1	3	0	4
	38	0	3	9	2.5	14.5
	43	—	—	7	3	10
	43	0	0	4	6	10
men	45	0	2	10	0.5	12.5
	46	0	0	1	7	8
	47	4	6	11	2	19
	53	0	2	12	7	21
	56	—	—	0	0	0
	61	0	0	2	—	2
	62	0	0	18	—	18
	68	0	0	13	5	18
	68	0	0	7	4.5	11.5
	72	0	0	8	—	8
	73	0	0	6	7	13

* surface changes; ** surfaces changes + deviations of shape

component showed lesions in 2 cases while the condyle showed no superficial degeneration in any of the cases. An example of a normal joint as well as of a joint with degenerative changes is given in Fig. 1.

The total »score for degeneration» which thus comprised evaluation both of degenerative lesions and deviations in shape, showed a weak correlation with age ($r = 0.28$, $r_s = 0.08$); Fig. 2).

Sternoclavicular joint (35 joints)

Degenerative disease was common in this joint (Table II). All joints except 7 showed degenerative changes. The clavicular part showed many more changes than the sternal part (42 and 16 points, respectively). Disk perforations were seen in 5 joints. Examples of joints with and

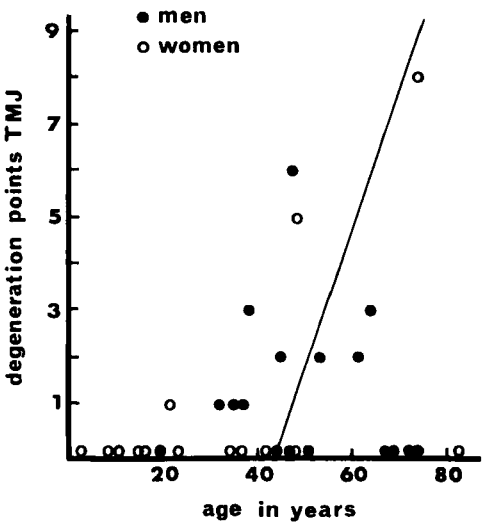

Fig. 2. Relationship between the extent of degeneration of the temporomandibular joint (surface changes + remodelling) and the age of 33 subjects ($r = 0.28$, $r_s = 0.08$, $y = -13.2 + 0.3\,X$).

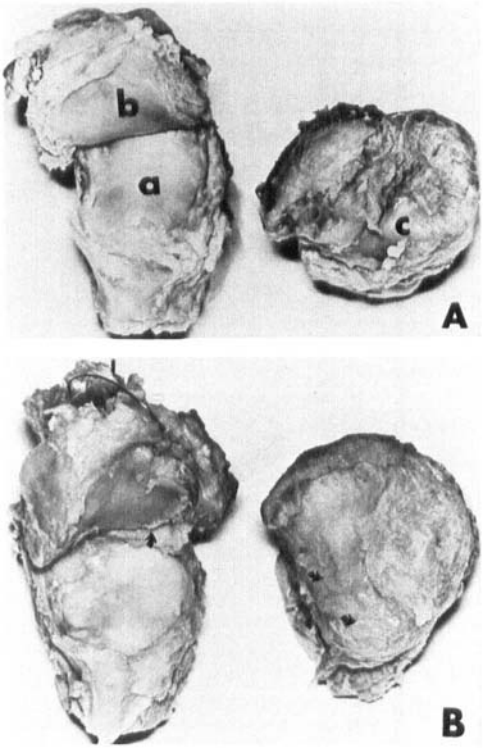

Fig. 3. Sternoclavicular joints. A. Macroscopically normal joint. Sternal part (a) and disk (b) to the left, clavicular part (c) to the right. B. Joint with degenerative changes including a small perforation of the disk (arrow) and marked irregularity and fraying of the clavicular part (arrows). The total score for degeneration of the joint was 7.

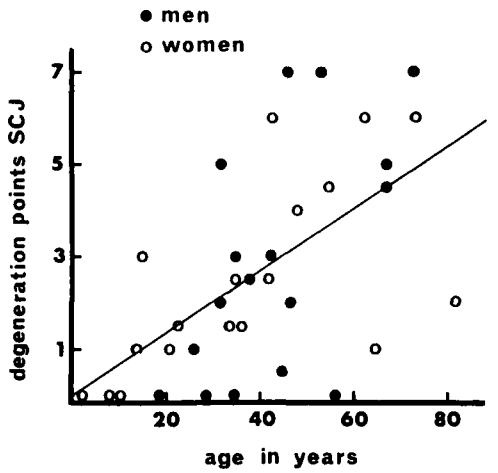

Fig. 4. Relationship between the extent of degeneration of the sternoclavicular joint and the age of 35 subjects ($r = 0.58$, $y = -0.02 + 0.07\,X$).

without degenerative changes are given in Fig. 3.

A moderate correlation was found between age and the score of degeneration ($r = 0.58$***; Fig. 4).

First metatarsophalangeal joint (39 joints)

Degeneration was often seen in this joint (Table II). Only joints from 5 individuals (2, 8, 19, 35 and 56 years) were allotted no points of degeneration, while all the remaining 34, including 3 individuals, aged 10—15 years, had various forms of changes (Fig. 5). The distribution of the degenerative changes was even among the 5 sites judged. The correlation between the changes in the various sites was significant and moderate with a coefficient of 0.5—0.6.

The degree of degeneration increased with age (Fig. 6). The correlation coefficient for association between age in years and score for degeneration was $r = 0.61$***.

Correlation between changes in different joints

The three individuals with degenerative lesion of the temporomandibular joint had degenerative changes also in the two other joints examined. In the sternoclavicular joint the changes were mild to moderate in two of them, severe in the third; in the toe-joint all changes were severe. The coefficient of correlation between the score for degenerative disease (including score for deviation of form) of the temporomandibular joint and the degeneration score for the sternoclavicular joint and the toe-joint were $r = 0.22$ ($r_s = 0.16$) and $r = 0.46$** ($r_s = 0.44$), respectively (Figs. 7 & 8). The coefficient of correlation between the score of degeneration for the toe-joint and sternoclavicular joint was

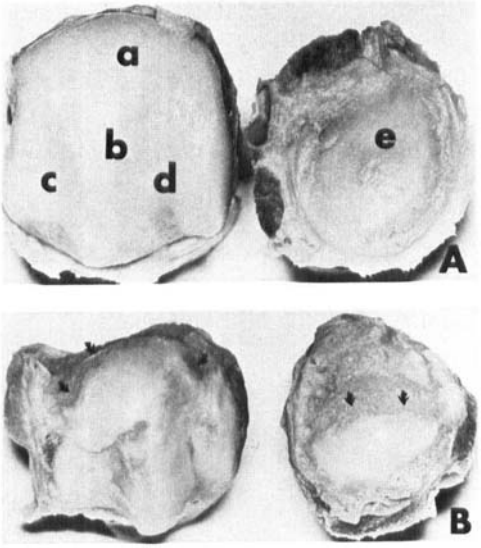

Fig. 5. First metatarsophalangeal joints. A. Macroscopically normal joint. Capital region (a—d) to the left, phalangeal region (e) to the right. a. head. b. sesamoid ridge. c. lateral and d. medial sesamoid grooves. The total score for degeneration of the joint was 1 (granularity of phalangeal surface, e). B. Joint with degenerative changes including bone exposure (arrows) in all regions but the medial groove. The total score for degeneration of the joint was 19.

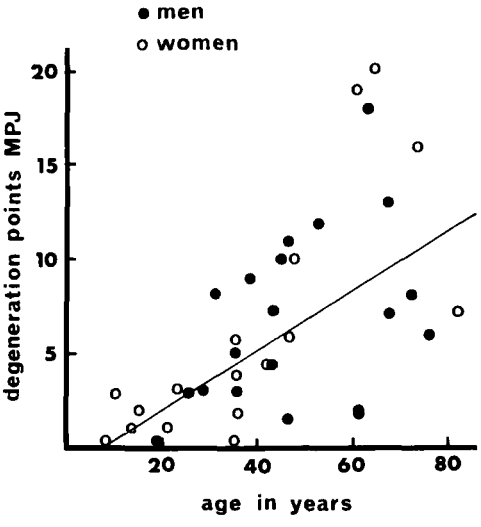

Fig. 6. Relationship between the extent of degeneration of the first metatarsophalangeal joint and the age of 37 subjects (r = 0.61, y = —1.1 + 0.17 X).

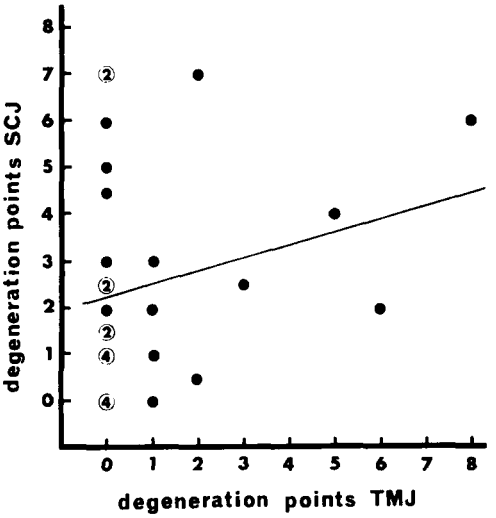

Fig. 7. Relationship between the extent of degeneration of the temporomandibular joint (TMJ) and sternoclavicular joint (SCJ) of 29 subjects (r = 0.22, r_s = 0.16, y = 2.3 + 0.27 X). The figures inside the rings denote the number of individuals with the same values for the two variables.

r = 0.54*** (r_s = 0.54). Partial correlation analysis to exclude age-dependence gave the following partial correlation coefficients: $r_{TM.A}$ = 0.38*, $r_{TS.A}$ = 0.07 and $r_{MS.A}$ = 0.29[1]). This means that when the age-dependence was excluded by partial correlation the association between temporomandibular and sternoclavicular joint degeneration was greatly reduced and also between metatarsophalangeal and sternoclavicular joint degeneration. On the other hand the association between temporomandibular and metatarsophalangeal joint degeneration was almost as strong as before but on a reduced level of significance.

Sex difference

No significant differences of degeneration were found between sexes for either joint according to the Mann-Whitney test.

[1]) M = metatarsophalangeal, S = sternoclavicular, T = temporomandibular, A = age.

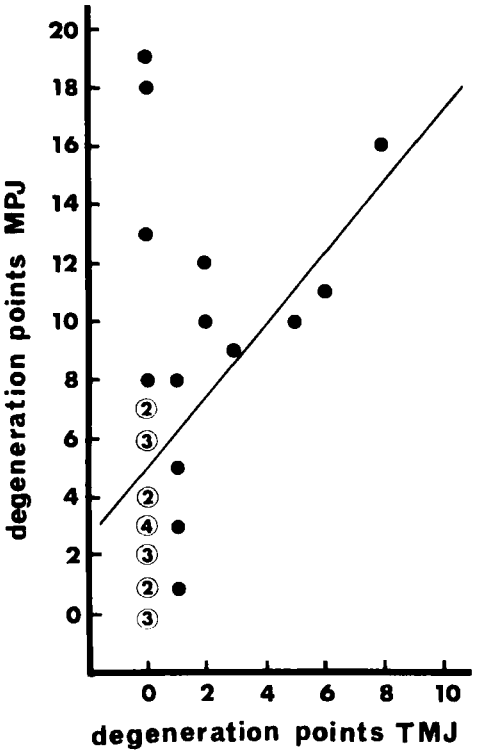

Fig. 8. Relationship between the extent of degeneration of the temporomandibular joint (TMJ) and first metatarsophalangeal joint (MPJ) of 33 subjects ($r = 0.46$, $r_s = 0.44$, $y = 5.0 + 1.2\,X$). The figures inside the rings denote the number of individuals with the same values for the two variables.

DISCUSSION

The frequency of degenerative disease varied widely between the three joints examined. It was most common in the metatarsophalangeal joints, only 13 % of which showed no signs of degeneration, while as many as 91 % of the temporomandibular joints were without demonstrable surface injury. Twenty per cent of the sternoclavicular joints were without surface injury. The higher frequency of degenerative disease in the toe joints is in good agreement with the figures reported by *Hall & Kinoshita* (1969). No macroscopic examination of sternoclavicular joints of the type in the present investigation could be traced in the literature, but *Sokoloff & Gleason* (1954) reported a high frequency of degenerative changes in a histological study: »By the end of the third decade, degenerative changes are seen in a fair number of specimens. These become progressively more severe and frequent, and as a result, a normal-appearing joint is not seen frequently after the fifth decade.» Similar results have been reported by *Silberberg et al.* (1959) in a histological study of 200 sternoclavicular joints.

Degenerative changes in the temporomandibular joints have been reported in higher frequency in other series (*Öberg et al.*, 1971). This difference can probably be explained by the relatively low average age of the present material — 70 % of the individuals were below 50 years. In other temporomandibular joint series where the frequency of degenerative disease was high (*Blackwood*, 1963; *Carlsson et al.*, in preparation; *Öberg & Omnell*, in preparation) most of the individuals were above 60 years.

The risk of degenerative joint changes increases with age, but this correlation was not very strong in the present material (Figs. 2, 4, 6). It was strongest — and significant — for the toe joint ($r = 0.61^{***}$) and for the sterno-clavicular joint ($r = 0.58^{***}$), but weak and not significant for the temporomandibular joint ($r = 0.28$, $r_s = 0.08$). The very few cases with degenerative disease and deviation of shape in temporomandibular joint in this material (Fig. 2) makes it necessary to be careful with conclusions about age-dependence, even if the correlation tests showed very low association. *Hall & Kinoshita* (1969) found no age-dependence of degeneration of the toe in their material, but they did find a correlation for the distal femur (r =

0.60***) and the proximal tibia (r = 0.44**).

A comparison between the extent of the degenerative changes in the various joints showed a fairly weak but significant correlation between the metatarsophalangeal joint and the temporomandibular joint (r = 0.46**) but very weak between the sternoclavicular joint and the temporomandibular joint (r = 0.22, r_s = 0.16; Figs. 7, 8). Neither was age-dependence equal for all three joints, and when age-dependence was excluded by partial correlation the only significant association between degeneration in the three joints was between the temporomandibular and metatarsophalangeal joint (r = 0.38*). The weakness of the correlations and the variation in frequency of the degenerative changes can eventually be explained by differences in the function (movements and loading) and anatomy of the various joints.

The toe-joint differs both functionally and anatomically from the other two joints. Weightbearing implies a direct load during movements of a magnitude which probably does not occur in the other joints, although it is claimed that muscle force generates the greatest load in joints (*Radin*, 1972—1973). In the present investigation it was not possible to assess the frequency of hallux valgus, which is an important aetiological factor of degenerative disease of the first metatarsophalangeal joint (*Haines & McDougall*, 1954; *Sutro*, 1965). Anatomically this joint differs from the other two joints in that its surface is made up of hyaline cartilage and by the fact that it has no disk.

The temporomandibular joint and the sternoclavicular joint resemble one another in structure but differ in function. Their joint surfaces have a varying amount of coarse, collagen fiber bundles and fibrocytes which in some areas give the tissue the appearance of fibrous connective tissue. Within those parts of the joint surfaces that are used during function a cartilage-like layer developes with chondroid cells and an increased amount of intercellular substance. The surface is, however, always covered by a thin layer of fibrous connective tissue. The temporomandibular joint is used for the complex movements of the mandible and the load to which it is exposed varies with, among other things, the appearance of the dentition. The sternoclavicular joint takes part in the function of the shoulder girdle. If age, function and structure were the only factors in the development of degenerative disease the significant association in this material between the toe-joint and the temporomandibular joint becomes puzzling as all these factors are different. A systemic factor could explain this association. However, the age-dependence of temporomandibular joint osteoarthrosis was uncertain and the association between the temporomandibular and sternoclavicular joints was weak and non-significant in spite of their structural similarity.

Unlike the toe joint, the temporomandibular joint and the sternoclavicular joint are divided into two parts by a disk, which probably influences both the function and the development of degenerative disease. The difference in score for degenerative changes which in the present investigation was found between the condyle and the temporal component of the temporomandibular joint and between the sternal and clavicular parts of the sternoclavicular joint may be due to this morphological factor.

The big toe showed a more even distribution of the score between the different joint components. Neither did *Hall & Kinoshita* (1959) find any significant differ-

ence in score between the different components of the big toe with the exception of the sesamoids.

The investigation showed that the degenerative changes described are probably mostly due to local functional factors within the individual joints but the influence of an age-independent systemic joint disease factor cannot be excluded.

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