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ORIGINAL ARTICLE

Degenerative changes of the temporomandibular joint. Relationship to ethnicity, sex and occlusal supporting zones based on a skull material

CECILIA MAGNUSSON[1], MATS NILSSON[2] & TOMAS MAGNUSSON[3]

[1]*Public Dental Health, Jönköping County Council, Jönköping, Sweden,* [2]*Futurum, The Academy for Health and Care, Jönköping County, Jönköping, Sweden, and* [3]*School of Health Sciences, Jönköping University, Jönköping, Sweden*

Abstract

Objective. The first aim of this study was to examine a contemporary human skull material for possible ethnic differences in respect of degenerative changes in the temporomandibular joints (TMJs). A second aim was to see if there was any correlation between such changes and occlusal support in any of the two groups and, if so, if this correlation was sex-related. ***Materials and methods:*** The material consisted of 129 Caucasian skulls and 76 skulls from Afro-Americans. Ninety-four of the Caucasian skulls came from males (73%) and the corresponding figure for the Afro-Americans was 40 (53%). Their mean age at death was 46 years (range: 19–89 years) and 37 years (range: 18–70 years), respectively. ***Results.*** Dental status was in general poor and 13% of the Afro-Americans and 26% of the Caucasians were edentulous. Form and surface changes of the TMJs were more common in the present material compared to most previous studies. No differences could be found between the two ethnic groups in respect of degenerative joint changes in the TMJs. In men, no correlation of clinical relevance could be found between severity of joint changes and occlusal support. However, in both Caucasian and Afro-American women, such a correlation was obvious, especially in higher age. ***Conclusions.*** The present findings give no evidence for any differences in the prevalence of degenerative changes in the TMJs in Caucasians and Afro-Americans. The strong correlation found between such changes and occlusal support in women but not in men might be explained by hormonal differences.

Key Words: *ethnicity, human skulls, osteoarthrosis, TMJ*

Introduction

Remodeling and degenerative changes of the human temporomandibular joints (TMJs) are common findings. The remodeling process represents an attempt of the joint to adapt to altered functional demands. When the physiological limits of remodeling are exceeded, pathological degenerative changes will develop primarily in the articular cartilage [1]. Several terms have been used to describe degenerative joint disease such as osteoarthrosis and osteoarthritis [2,3], but we have chosen to use the more neutral term *degenerative changes*.

Today there is consensus that the TMJs are load-bearing joints [1,4,5]. It can thus be assumed that the TMJs, as other load-bearing joints, will undergo changes in response to increased functionally induced stresses since 'once functional stresses exceed physical limits, the remodeling processes are no longer adequate and degenerative joint disease sets in' [4]. As a consequence of this, factors like impaired occlusal support, heavy bruxism and tough food consistency have been discussed as factors of importance for degenerative changes of the TMJs. The literature is, however, not conclusive. Some studies have claimed a correlation to these extrinsic factors while other studies have not found any such correlation (for references; see Magnusson et al. [6]). There are many possible explanations to the diverging results, such as e.g. differences in materials studied, registration methods used and misinterpretations of post-mortem artefacts.

The results presented in the literature on sex differences in respect of degenerative changes in the TMJs are also contradictory. Some studies have not found any such differences [7–10] while some have found more degenerative changes in women [11,12] and at least one previous study found more such changes in men [13]. In the present material, men

Correspondence: Tomas Magnusson, School of Health Sciences, Jönköping University, Box 1026, SE–551 11 Jönköping, Sweden. Tel: +46 36101301. E-mail: tomas.magnusson@hhj.hj.se

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had on average more degenerative changes in the TMJs compared to women [6].

In contrast, concerning the relationship between aging and degenerative TMJ changes, there is overwhelming support in the literature for a strong correlation [7–9,11,13–17]. This was also the case in the present material [6]. It has been suggested that the strong association between degenerative joint changes and age could reflect an intrinsic accumulation of tissue damage due to a gradual decline in cellular capacities for adaptation [17].

There is increasing evidence that genetic factors play an important role for the development of degenerative joint changes in general [18–24] and thus most likely also for the development of such changes in the TMJs [1]. It has been suggested that genetic differences can explain the differences found in different cultures in respect of anatomical form of the TMJs [15]. In the present sample, however, no differences were found between Caucasians and Afro-Americans in respect of anatomic size and form of the TMJs [25]. It has also been found that the prevalence of degenerative TMJ changes varies in different ethnic groups [26], but such reports are sparse, which is why more studies on this topic are warranted.

The first aim of the present study was to analyze for possible differences between Caucasians and Afro-Americans in respect of prevalence and severity of degenerative changes in the TMJs. A second aim was to see if the previously found sex difference in respect of association between such joint changes and occlusal support [27] was valid also when dividing the material according to ethnicity.

Materials and methods

The original sample was 259 well preserved skulls from adults aged from 18–100 years. The skulls came from bodies that had been donated to the Federal University of Sao Paulo, Brazil, during the time period 1933–1973. The soft tissue had been removed from the skulls by using an extremely gentle maceration technique that did not expose the bone tissue to any extrinsic trauma.

A total of 129 (49.8%) of the skulls were classified as 'branca', i.e. White/Caucasian, 53 (20.5%) of them as 'parda', i.e. Mulatto/Mixed and 76 (29.3%) as 'preta', i.e. Negroes/Afro-Americans. One skull had no classification. In the present study, the Caucasians have been compared with the Afro-Americans for possible differences in respect of degenerative changes in the TMJs. Out of the 129 Caucasian skulls, 94 (73%) came from males and 35 (27%) from females. Their mean age at death was 46 years (range: 19–89 years). Among the 76 Afro-American skulls, 40 (53%) came from males and 36 (47%) came from females. Their mean age at death was 37 years (range: 18–70 years). The age distribution of the two groups is presented in Table I. In this skull material, the Caucasians were statistically significantly older than the Afro-Americans ($p < 0.01$).

All skulls were analyzed by two of the authors (CM and TM). If one examiner was uncertain how to register an individual variable, the other examiner was consulted and a consensus was reached for the registration. The material and the methods used have been described in detail previously [6].

Registrations of form and surface changes of the condyles and the temporal components were made according to scales described by Wedel et al. [28], but when surface changes were estimated, a fifth step was added to the scale: compact layer broken up in areas >6 mm^2.

- Change in form:

  (0) Without any of the changes described under 1, 2 or 3;
  (1) Slight remodeling/flattening;
  (2) Marked remodeling; and
  (3) Deforming changes.

- Change in surface:

  (0) Without any of the changes described under 1, 2, 3 or 4;
  (1) Uneven surface, unbroken compact layer;
  (2) Marked irregular surface and/or local perforation <3 mm^2 of the compact bone layer;
  (3) Compact layer broken up in areas 3–6 mm^2 or largely distributed small perforations; and
  (4) Compact layer broken up in areas >6 mm^2.

The total sum for form and surface changes of the left and right condyle and temporal component were

Table I. Number of Caucasian and Afro-American men and women in the different age groups. percentage distribution within brackets.

	Caucasians			Afro-Americans		
Age group	Men	Women	Total	Men	Women	Total
18–30	13 (14%)	11 (31%)	24 (19%)	12 (30%)	15 (42%)	27 (36%)
31–40	24 (26%)	6 (17%)	30 (23%)	12 (30%)	13 (36%)	25 (33%)
41–50	20 (21%)	9 (26%)	29 (22%)	10 (25%)	5 (14%)	15 (20%)
>51	37 (39%)	9 (26%)	46 (36%)	6 (15%)	3 (8%)	9 (12%)

calculated and can range from 0–28. From this total score, a degenerative change index; DC-index, was created, where score 0–8 were classified as no or moderate TMJ changes, 9–16 as marked changes and 17–28 as severe changes.

As previously presented [6], there was a high statistically significant correlation between form and surface changes for the condyles and temporal components within a joint as well as between the right and left side. Because of this correlation between the sides, the statistical analyses were made without separating left and right TMJ.

The number of present teeth was registered as well as the estimated number of remaining teeth at death, where ante-mortem tooth loss was recorded when resorption of the socket or bony growth within the socket could be observed.

The estimated occlusal support was classified according to the Eichner [29] index:

- A1: Antagonist contact in all four supporting zones. No tooth-limited gap exists.
- A2: Antagonist contact in all four supporting zones. Tooth-limited gap exists only in one of the jaws.
- A3: Antagonist contact in all four supporting zones. Tooth-limited gaps exist in both jaws.
- B1: Antagonist contact is present in three supporting zones.
- B2: Antagonist contact is present in two supporting zones.
- B3: Antagonist contact is present in one supporting zone.
- B4: Antagonist contact is present in none of the supporting zones, tooth contact only in the frontal region.
- C1: Teeth in both upper and lower jaw, but no antagonist contact either in any of the supportive zones or in the front.
- C2: Teeth only in one jaw.
- C3: No teeth in upper or lower jaw.

However, when performing the statistical analyses, groups A1, A2 and A3 (antagonistic tooth contact in all four supporting zones irrespective of tooth limited gaps) as well as groups C1, C2 and C3 (no antagonist contact either in any of the supporting zones or in the front region irrespective of single remaining teeth without antagonists) were pooled together.

Statistical method

To test for statistical differences between variables and sex, Fisher's Exact Test was used. To test for correlations between variables, Spearman's rank correlation (r_s) was used, since many of the variables are ordered categorical and have a skewed distribution (non-normal). The following *p*-levels have been used: $p \geq 0.05$ = NS, $0.01 \leq p < 0.05$*, $0.001 \leq p < 0.01$**, $p < 0.001$***.

Results

Form and surface changes of the condyles and the temporal components are presented in Tables II and III. On both sides, the form as well as the surface changes were statistically significantly more pronounced in the condyles compared to the temporal components ($p < 0.001$ for all measurements).

Twenty-eight percent of the Afro-Americans had a DC-index of 1 (no or moderate TMJ changes), 43% had an index of 2 (marked TMJ changes) and 29% had an index of 3 (severe TMJ changes). The corresponding figures for Caucasians were 17%, 46% and 37%, respectively (NS). Also, when compensating for the age difference between the two groups, there was

Table II. Distribution (%) of the material concerning change in form of the right and left condyles and temporal components.

	Right			Left		
Changes in shape of	C	A-A	Total	C	A-A	Total
Condyle						
No changes	5	22	11	4	11	6
Slight remodeling/flattening	32	28	30	27	29	28
Marked remodeling	43	34	40	37	45	40
Deforming changes	20	16	19	32	16	26
Temporal component						
No changes	16	24	19	19	20	19
Slight remodeling/flattening	47	55	50	50	49	49
Marked remodeling	36	18	29	30	28	29
Deforming changes	2	3	2	2	4	2

C, Caucasians (n = 129); A-A, Afro-Americans (n = 76).

Table III. Distribution (%) of the material in respect of surface changes in the right and left condyles and temporal components.

Change in surface of	Right			Left		
	C	A-A	Total	C	A-A	Total
Condyle						
No changes	12	26	17	11	21	15
Uneven surface	22	20	21	19	17	19
Local perforations	26	25	25	18	20	19
Perforations 3–6 mm^2	15	11	13	17	8	14
Perforations >6 mm^2	26	18	23	35	34	35
Temporal component						
No changes	25	37	29	27	29	28
Uneven surface	23	24	23	21	24	22
Local perforations	33	21	28	29	22	26
Perforations 3–6 mm^2	9	7	8	9	7	8
Perforations >6 mm^2	12	12	12	15	18	16

C, Caucasians (n = 129); A-A, Afro-Americans (n = 76).

still no statistically significant difference in respect of degenerative joint changes.

Thirteen percent of the Afro-Americans and 26% of the Caucasians were edentulous. In the skulls with remaining teeth, the estimated mean number of teeth ante-mortem was 10 for the Afro-Americans and eight for the Caucasians. The corresponding figures for the lower jaw were 10 and nine, respectively.

The distribution of the skulls according to the estimated and modified Eichner index is presented in Table IV. According to the index used, the occlusal support was statistically significantly better among Afro-Americans ($p < 0.05$). This difference was explained by a better occlusal support among Afro-Americans of 35 years of age and younger, while there were no differences between the ethnic groups in higher ages.

The correlation between occlusal support according to the estimated Eichner index and the variables form and surface changes as well as the DC-index for Caucasian and Afro-American men and women in the different age groups are presented in Table V. Due to

Table IV. Distribution (%) of the material according to the estimated and modified Eichner index.

Eichner index	Caucasians (n = 129)	Afro-Americans (n = 76)	Total (n = 205)
A	9	16	11
B1	9	15	11
B2	9	16	11
B3	10	5	8
B4	17	20	18
C	47	29	40

the small number of subjects in most of the higher age groups, only three age groups were used for the statistical calculations.

In both Caucasian and Afro-American males only weak and non-significant correlations were found between degenerative changes and occlusal support (r_s-values ranging from −0.34 to 0.41, NS). In both ethnic groups, statistically significant and very strong correlations were found between the DC-index and the Eichner index in women more than 40 years old (Caucasians: $r_s = 0.63$, $p < 0.01$, Afro-Americans: $r_s = 0.82$, $p < 0.01$, respectively).

Discussion

As stated previously [6], it should be kept in mind that this skull material is not representative for the average Brazilian population in the 20th century when the results of the present study are interpreted. The vast majority probably came from a poor background. Due to this, their dental status is likely much worse than for the general population. In the present sample, only 11% had occlusal support in all four supporting zones and as many as 40% had no occlusal support.

An unknown factor that might have influenced the result is that we have no knowledge about how many subjects have had removable partial or complete dentures, but it can be speculated that only a few subjects have had such reconstructions.

Yet another weakness is that many teeth have been lost post-mortem. In most cases, it was no problems to decide if teeth had been lost ante- or post-mortem, but it is not possible to know if the teeth lost post-mortem have had antagonist contact or not, and this can have had some influence on the estimation of the Eichner index.

Table V. Correlation coefficient (r_s) between occlusal support and degenerative joint changes.

Age-group	*n*	Formchanges (r_s)	*p*	Surfacechanges (r_s)	*p*	DC-index (r_s)	*p*
94 Caucasian males							
18–30 years	13	−0.34	NS	−0.48	NS	−0.31	NS
31–40 years	24	0.41	*	0.25	NS	0.17	NS
>40 years	57	0.13	NS	0.21	NS	0.08	NS
Total sample	94	0.31	**	0.26	*	0.27	**
40 Afro-Americans							
18–30 years	12	0.49	NS	0.00	NS	0.01	NS
31–40 years	12	0.10	NS	0.28	NS	0.33	NS
>40 years	16	0.24	NS	0.40	NS	0.33	NS
Total sample	40	0.41	**	0.39	*	0.37	*
35 Caucasian females							
18–30 years	11	0.67	*	0.80	**	0.86	***
31–40 years	6	0.85	*	0.68	NS	0.73	NS
>40 years	18	0.57	**	0.50	*	0.63	**
Total sample	35	0.66	***	0.67	***	0.74	***
36 Afro-American females							
18–30 years	15	0.63	*	−0.05	NS	0.14	NS
31–40 years	13	0.24	NS	0.27	NS	0.25	NS
>40 years	8	0.60	NS	0.77	*	0.82	**
Total sample	36	0.53	***	0.31	*	0.43	*

p-levels: $p \geq 0.05$ = NS, *$0.01 \leq p < 0.05$, **$0.001 \leq p < 0.01$, ***$p < 0.001$. *n*, number of subjects; DC-index, Degenerative Change Index.

A drawback with the Eichner index is that it is based purely on the number of supporting zones and does not fully consider the distribution of the zones. Group B2, for instance, includes subjects with two supporting zones, but it does not discriminate between a situation where the two zones are on the same side or if there is one supporting zone on each side. This probably has consequences for the loading on the TMJs and might have influenced the degree of degenerative changes.

In previously published data from the total skull sample of 259 skulls we have shown that severe degenerative changes in the TMJs were common finding. We also found a strong correlation between such changes and increasing age, but no correlation between tooth attrition and joint changes was found [6]. Furthermore, a strong correlation was found between joint changes and occlusal support in older females, but not in males, and we hypothesized that hormonal differences could account for this difference [27].

In the present study, degenerative changes were equally common in Afro-Americans and Caucasians also after compensating for the differences in age and occlusal support between the two groups.

As we have stressed previously [27], when analyzing correlations between variables, one must consider not only the size but also the individual plot data. Each single scatter plot must be analyzed for linearity, otherwise there is a great risk to misinterpret the results. It is not satisfactory just to look at the statistical significance. A correlation coefficient might be statistically significantly different from zero, but it should be valued to its magnitude (at least 0.50 for two variables to be regarded as concordant). Also a correlation above 0.75 is to be considered of clinical interest, even if it is not statistically significant due to few observations.

As stated in the introduction, the literature on degenerative changes in the TMJs is contradictory and inconclusive in respect of possible sex differences as well as possible relationships to occlusal support. In the present material, men had on average more degenerative changes in the TMJs compared to women [6]. Furthermore, no correlation of clinical relevance could be found between occlusal support and degenerative joint changes in either Afro-American or Caucasian male subjects. However, such correlations were found in women, especially in older ages, in both ethnic groups. This finding strengthens our previous statement that there is a sex difference in this respect and strengthens also our hypothesis that hormonal differences can explain this difference.

One explanation to the diverging results in previous literature in these respects might be that most studies are based on archeological materials where post-mortem hard tissue artefacts are easily misinterpreted as degenerative changes [30] and sex classification is very uncertain. The present material has never been exposed to soil and the sex classification is accurate. Because of this, it is likely that the sex difference found in respect of the relationship between degenerative joint changes and occlusal support is correct.

Today it is widely accepted that both increasing age and genetics are important factors for the development of degenerative joint changes. Our results in this study, as well as in a previous one [27], suggest also that females with impaired occlusal support have a higher risk than males to develop such changes, at least at higher age.

Conclusions

- Degenerative changes of the TMJs were equally common in Afro-Americans and Caucasians.
- It seems that the importance of impaired occlusal support for the development of degenerative joint changes is strongly related to female gender.

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