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Assessment of morphological changes degree on the articular surfaces of the temporomandibular joints on the historical skeleton material

A. Stangret, I. Teul

Chair and Department of Normal Anatomy, Pomeranian Medical University, Szczecin, Poland

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Background: *The aging process in the temporomandibular joints (TMJs) is related, more or less, with degenerative processes. Despite the rich literature on morphology and anatomy and the functioning of the components of the TMJs, there is much less research studies on the anatomy and diseases of these joints on historical populations. The aim of the study was to analyse the frequency and intensity of morphological and dysfunctional changes within the TMJ.*

Materials and methods: *The research material included skeleton material from three chronologically and geographically diverse archaeological series located in Poland in the cities: Strzelce Krajenskie (n = 86), Santok (n = 86) and Wroclaw ('Kuronia' collection) (n = 70). The examination of the skeletal material was based on the macroscopic analysis of the articular surfaces of the TMJ.*

Results and Conclusions: *The difference in the frequency of degenerative changes observed on the articular surfaces of the TMJs between the examined skeletal series from selected cities was insignificant (Santok: 81.4%, Strzelce Krajenskie: 72.1%, 'Kuronia': 68.6%). However, the obtained results showed a difference in the intensity of changes in the TMJ between individuals representing the early medieval population from Santok and individuals from the beginning of the 20th century collection 'Kuronia'.* (Folia Morphol 2022; 81, 2: 487–492)

Key words: temporomandibular joints, degenerative changes in joints, temporomandibular disorders, determinant of physiological stress

INTRODUCTION

Temporomandibular joints (TMJs), *Articulatio temporomandibularis*, due to their morphological structures, are the bicondylar joints, coupled in every movement. Their anatomical and functional structure is more complex than in other joins of the human body [1, 30].

The articular surface on the temporal bone is the acetabulum. It consists of glenoid fossa (the front part of the mandibular fossa) and the articular eminence of the temporal bone. The articular head is the surface of the mandible (ovoid condylar process seated atop a narrow mandibular neck) [1, 38].

Temporomandibular joints in apes are characterised by a much shallower acetabular fossa and slightly marked articular eminence, while in humans TMJs have a deep fossa and well-marked eminence [2, 3, 14].

Distinguishing feature of the TMJ is its articular surface, covered with avascular fibrocartilage. There-

Address for correspondence: Dr. A. Stangret, Chair and Department of Normal Anatomy, Pomeranian Medical University, al. Powstańców Wielkopolskich 72, 70–111 Szczecin, Poland, tel: +48 91 466 1543, e-mail: anatomia@pum.edu.pl

Figure 1. Examples of changes observed on the articular surfaces of the temporomandibular joints.

fore, cartilage is abrading relatively quickly, which makes TMJ prone to various factors (e.g. masticatory system load level), exposing it to dysfunctional changes. What is more it works all the time, also at night [1].

Temporomandibular disorder is a condition characterised by dysfunctional or/and painful changes that affect masticatory muscles, TMJ and associated structures [5, 7]. The disorders within the TMJs constitute a large percentage among viscerocranium diseases [1, 10].

The ageing process in the TMJ is related inter alia to degenerative processes [18]. Despite the rich literature on morphology of the components of the TMJ [13, 15–17, 19, 23, 25, 26, 33], there is much less research studies (especially from lost two decades) in this subject on historical populations [20, 27, 34].

The morphology of the viscerocranium adapts to the environment; therefore, extinct prehistoric and historical populations may be valuable for testing hypotheses [6]. In addition, the analysis of TMJs degenerations can enrich the research on factors that are responsible for the functional structure of the viscerocranium [24, 27].

Bone changes, as marks of a past infection process or a reaction to biomechanical overload on bone surfaces, do not manifest equally. They differ in intensity, take different forms and shapes. From very delicate individual spikes and stripes, through characteristic patterns, to strong protuberances and massive ridges of irregular bone.

Changes in the morphology of the articular surfaces of the TMJs are the basis for the classification of the periosteum and bone tissue reactions as a result of the reaction of osteoclasts and osteoblasts to the pathogen. Among bone reactions, there are repair processes that cause bone thickening, and osteolytic (degenerative, erosive) processes, resulting in a lack of bone tissue (Fig. 1) [27–29].

MATERIALS AND METHODS

The selection of osteological material in this study depended on the state of bone preservation. The decisive factor qualifying the suitability for the study was the state of preservation of the articular surfaces of the TMJs of the temporal bone and the head of the mandible. The material differed in terms of sex and age-at-death. Individuals from Infants I and II groups were excluded from the study due to the lack of complete development of articular surfaces of the TMJs.

As the abnormal articular surface of the TMJs we considered the one in which at least one of its surfaces has been diagnosed with single or collective combinations of pathological changes as signs of erosive and proliferative reactions, as a result of the activity of a pathogenic factor.

The research material includes skeleton material from the three chronologically and geographically diverse archaeological series located in Poland in the cities: Strzelce Krajenskie (XIII–XV c.), Santok (XIII c.), Wroclaw ('Kuronia' collection) (XIX/XX c.).

Eighty six individuals (43 males and 36 females, and 7 individuals of undefined sex) were analysed from the Santok skeleton series, representing the population of the early middle ages; also 86 individuals (42 males, 29 females and 15 adults of undefined sex) were analysed from the Strzelce Krajenskie skeleton series and 70 individuals (34 men and 36 women) from the 'Kuronia' collection.

The examination and classification of the bone changes resulting from disease processes in TMJs of individuals from historical populations was performed

based on the methods used in previous anthropological, paleopathological and bioarchaeological studies [27, 28].

During the research, each of the preserved surfaces of the TMJs was carefully examined and analysed macroscopically. Additionally, an electronic microscope DigiMicro 2.0 was used for the observation.

Changes in the TMJs were classified based on the Richards and Brown scale modified for the purposes of this work (taking into account the comments of Rando and Waldron [2012]) [27]. According to the criteria proposed by Richards and Brown (1981) [28], the degree of degeneration of the condylar process of the mandible and the fossa and articular eminence of the temporal bone was assessed. Each TMJ articular surface was examined and divided into areas for evaluation purposes. In the case of the condyle, the divisions proposed by Mongini (1972) [22] were used. Three 60° areas were designated, and each of them was further divided into posterior, top, and anterior areas. In the case of the articular surface on the temporal bone, the articular eminence and the fossa were distinguished, and then the medial, central and lateral areas were separated.

First, the entire material was divided according to the frequency of degenerative changes according to the following scale (scale 1):

— 0: no degenerative changes;
— 1: any degenerative changes present.

The intensity of changes on the articular surfaces of the condylar process of the mandible and the fossa as well as the articular eminence of the temporal bone was assessed according to the criteria for assessing changes and degenerations (scale 2):

— 0: norm;
— 1: remodelling;
— 2: local erosion;
— 3: local proliferation/osteophytes and/or erosion (in less than 5 areas);
— 4: general proliferation and/or erosion (in 5 and more areas);
— 5: eburnation and/or complete destruction of articular surfaces.

Erosion was defined as the area of pitting or porosity on the joint surface (macroporosity or microporosity, localised or spread). Proliferation is new bone growth on the surface of a joint. It can appear as bumps or flat growths. The presence of new bone on the surface of the joint indicates an attempt to "stabilise" the joint. Additionally, marginal osteophytes were noted as bone growths forming along the edges of the joint.

In addition, the presence of reconstruction of the articular surface was noted, being an adaptation to occlusive stress preceding erosion and degeneration of the cortex. Moffett (1974) [21] suggested that the TMJs are in a state of constant equilibrium between structure and function [4]. Under normal conditions, equilibrium is maintained by the processes of adaptive remodelling. This can be disrupted by functional requirements that are too high, leading to the next degeneration of the joints.

For each series basic statistics in the form of frequency tables were performed. Differences in frequency and intensity of changes on the articular surfaces of the TMJs were tested using Kruskal-Wallis test and post-hoc tests to check between which groups the differences were statistically significant.

RESULTS

In the examined skeleton series form Santok, the percentage of bone changes (according to scale 1) on the articular surfaces of the TMJ was 81%. The analysis of the results showed that the local proliferative and erosive changes were the most common in the Santok individuals ('2' and '3' — scale 2). The strongest degenerative change observed on all examined articular surfaces of the TMJs was the general proliferation of the articular surface or erosion in more than five areas. No changes of the '5' level were observed in any individual from this skeleton series

In series from Strzelce Krajenskie, the percentage of bone changes (according to scale 1) on the articular surfaces of the TMJ was 72%. The analysis of the results showed that in individuals from this series, local proliferative and erosive changes were the most common on the TMJ articular surfaces ('2' and '3' — scale 2). The strongest degenerative change observed on all examined articular surfaces of the TMJs was the general proliferation of the articular surface or erosion in more than five areas. In this skeleton series, no changes at the '5' level were observed in any individual.

In the examined skeletal series from Wroclaw, the percentage of bone changes (according to scale 1) on the articular surfaces of the TMJ was 68.5%. The analysis of the results showed that in individuals from the 'Kuronia' collection, local erosive lesions ('2' — scale 2) were the most common — 41%. The most severe degenerative change observed on all

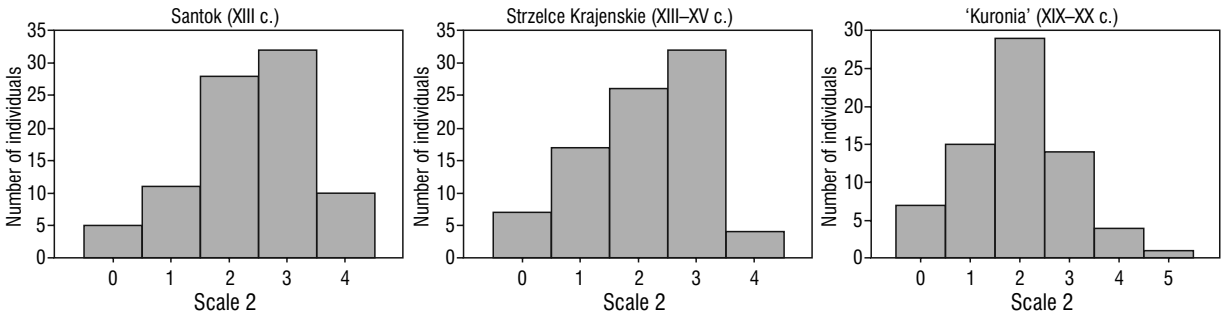

Figure 2. Distribution of degenerative changes in the temporomandibular joints of the studied individuals, based on the scale 2.

Table 1. Differences between the studied skeleton series

Series	Time period	N	TMJ	TMJ (%)
Santok	XIII c.	86	70	81%
Strzelce Krajenskie	XIII–XV c.	86	62	72%
'Kuronia'	XIX/XX c.	70	48	68.5%

N — number of examined individuals; TMJ — the total number of all individuals with bone changes in the temporomandibular joint (one or both); TMJ (%) — the percentage of all individuals with bone changes in the temporomandibular joint

Table 2. P-value for multiple comparisons (bilateral) (Scale 1)

	Santok R: 129,99	Strzelce Krajenskie R: 118,73	'Kuronia' R: 114,47
Santok (XIII c.)		0.87	0.51
Strzelce Krajenskie (XIII–XV c.)	0.87		1.00
'Kuronia' (XIX/XX c.)	0.51	1.00	

Independent variable (grouping): Series. Kruskal-Wallis test: H (2, N = 242) = 3.68, p = 0.16.

Table 3. P-value for multiple comparisons (bilateral) (Scale 2)

	Santok R: 135,37	Strzelce Krajenskie R: 119,83	'Kuronia' R: 106,51
Santok (XIII c.)		0.8744	0.03
Strzelce Krajenskie (XIII–XV c.)	0.44		0.71
'Kuronia' (XIX/XX c.)	0.03	0.71	

Independent variable (grouping): Series. Kruskal-Wallis test: H (2, n = 242) = 7.21, p = 0.03.

examined articular surfaces of the TMJs was complete destruction of the articular surfaces present in only one individual (Fig. 2).

Table 1 presents the most important differences between the studied historical series.

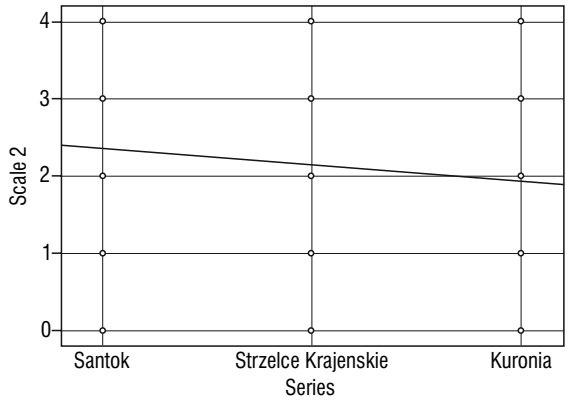

Figure 3. Comparison of skeletal series in relation to the intensity of bone changes in the temporomandibular joints (scale 2).

A statistical analysis was performed to check whether there were differences between the skeletal series in frequency and intensity of bone changes in the TMJs (Tables 2, 3). The analysis with the Kruskal-Wallis test showed statistically significant differences between the series from Santok and the 'Kuronia' collection. In individuals from Santok there were more intense bone changes (scale 2) in the area of TMJs (Fig. 3).

DISCUSSION

In the studied skeleton material, statistical analysis did not show any significance in the differences in the frequency of bone changes in TMJ between individuals from the examined series. However, the obtained results showed a difference in the intensity of changes observed on the articular surfaces of the TMJs between individuals from the Santok series and from the 'Kuronia' collection. Adaptive reconstruction also occurred more frequently among individuals from the 'Kuronia' collection, suggesting a large

predisposition of these joints to adapt to occlusive conditions or the harmful influence of factors. More intense degenerative changes of the TMJ, manifested by bone changes on the articular surfaces, occurred more frequently in individuals from the skeleton series from an early medieval site, i.e. exposed to more severe living conditions, especially related to diet, which directly and indirectly affects the occlusion, and the latter affects the TMJs.

The formation of the elements of the TMJs depends on many factors; therefore, the analysis of their changes can provide a number of important information about the life of historic populations. The analysis of bone changes in TMJ, which is one of the most important elements of our masticatory system, may not be such a good indicator of living conditions and their sensitive measure, such as body height. However, included in the methods used as determinants of pressure level from environmental factors, it will enrich the research and analysis of changes in the biocultural system and biological condition of historical populations, as a source of information about lifestyle and nutrition.

The results of analyses of the differentiation of bone changes in the TMJ over time in the skeleton material representing the populations from the early and late middle ages, the 19th and 20th centuries, presented in this work, prove that changes in the biological condition of these communities may have occurred in the aspect of the presence of TMJ dysfunction.

Research on the skeleton material concerning the issue discussed in this article has been ignored in the last two decades. Despite the enormous amount of information that the TMJ may carry, on the environment, diet, and the general condition of the studied population, most of them date back to the 1990s [8, 9, 11, 12, 28, 31, 32, 35–37]. It is suggested to continue and expand research in this area in order to clarify the relationship between the environment, and the occurrence of changes in the TMJ. This joint, like all joints in the human body, reacts to the external environment and the information obtained from them is scientifically significant.

CONCLUSIONS

More intense degenerative changes of the TMJs, manifested as bone changes on the articular surfaces, occurred more often in individuals from the early medieval skeleton series, i.e. exposed to more severe living conditions.

The study of the frequency and intensity of changes in the TMJ can be used as a determinant of physiological stress affecting biological condition in the examined skeletal series.

Conflict of interest: None declared

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