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A BIOMETRIC STUDY OF OCCLUSION AND DENTAL ARCHES IN A SERIES OF MEDIEVAL SKULLS FROM NORTHERN SWEDEN

by

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MATERIAL

The present study was made on the so-called Västerhus material. It was discovered in the course of excavation for an aviation field on Frösön in northern Sweden. The Västerhus chapel and its graveyard were brought to light in 1951. The skeletons were subsequently sent to the Museum of National Antiquities in Stockholm for further investigation.[1]

The material consisted of the skeletons of about 250 adults, in addition to a number of children, and comprised the local inhabitants buried in the graveyard from the 11th century to some time in the 13th century.

The degree of representativeness of the material is hard to judge. The district around Storsjön early became a centre with communications both eastward to the Bothnian Sea, and westward into Norway in the direction of Trondheim. Moreover, there was some incidence of Lapps in these districts. It is therefore difficult to determine whether elements of different races are included in the material. On the other hand, in view of the lively communications, it presumably does not consist of individuals from a strictly delimited, small isolate.

The series on which the present study was made consisted of 97 skulls selected from the whole material. The selection was

[1] I take this opportunity of expressing my thanks to Dr. N.-G. Gejvall, Keeper of the Osteologic Collections of the Museum of National Antiquities, for his kindness in placing this material at my disposal.

based solely on the number of remaining teeth. The crania of children and old persons were not, however, included.

The age and sex were determined (by *N.-G. Gejvall*) according to *Martin's* method (see Table 1). The sex determination was facilitated by the placing in the graveyard, the men being buried in its southern part and the women in its northern part.

The number of missing teeth, lost either *intra vitam* or *post mortem*, is shown in Table 2. The third molars in both the upper and lower jaw were relatively often missing *intra vitam*, probably owing to aplasia. However, since no roentgenologic examination of the material was made, it cannot be ruled out that certain third molars were impacted in the jaws. Under the heading "Lost *intra vitam* or *post mortem*" are included not only the cases in which the alveolar process in the region in question was destroyed *post mortem*, but also those in which a whole jaw or parts of it were missing. Thus, a skull without its lower jaw is recorded in Table 2 as lacking all 16 teeth in the lower jaw. "Missing *intra vitam*" denotes that the tooth had never been formed, was deeply impacted or had been lost during life. "Lost *post mortem*" denotes the number of empty alveoli in which it could be determined from the sharp margins that the teeth had fallen out after death. As far as single-root teeth are concerned, this is particularly common since the very shape of the roots makes the teeth liable to loosen from their sockets. The total number of missing teeth is fairly large. This is due to the fact that cases with relatively few teeth were included, even though it was possible to make only a limited number of measurements in such cases.

In determinations of the width of the dental arch in the upper jaw, present-day values for men and women aged 21—24 years were included for the sake of comparison. These measurements were made on students and staff of The Royal School of Dentistry in Stockholm. In every case alginate impressions (Tissuetex) were taken, and dental stone (Coecal) models made.

AIM OF THE INVESTIGATION

The aim of the present study was to make metric determinations of the occlusion and dental arches and, if possible, to compare the results with those from similar investigations.

Table 1

The present material

Age group	Males	Females	Total
Juvenile	8	4	12
Adult	16	24	40
Mature	24	21	45
Total	48	49	97

Table 2

Teeth missing in the medieval crania studied

	Tooth no.		1	2	3	4	5	6	7	8
Missing *intra vitam*	Upper jaw	Right	5	8	5	9	10	14	8	20
		Left	10	14	7	10	15	13	11	13
	Lower jaw	Right	5	4	0	0	2	13	8	21
		Left	3	2	1	2	4	15	8	27
Lost *post mortem*	Upper jaw	Right	32	29	16	11	14	6	9	19
		Left	27	27	12	11	12	7	5	10
	Lower jaw	Right	23	17	16	5	9	5	3	2
		Left	28	15	12	10	7	2	7	4
Lost *intra vitam* or *post mortem*	Upper jaw	Right	6	6	6	6	6	6	6	6
		Left	6	6	6	6	6	6	6	7
	Lower jaw	Right	2	2	3	3	3	3	3	3
		Left	2	2	2	2	2	2	2	2
Total no. missing	Upper jaw		86	90	52	53	63	52	45	75
	Lower jaw		63	42	34	22	27	40	31	59
Percentage missing	Upper jaw		44.3	46.4	26.8	27.3	32.5	26.8	23.2	38.7
	Lower jaw		32.5	21.6	17.5	11.3	13.9	20.6	16.0	30.4

Although the author is well aware that such a study may not lead to conclusive findings, he considers it expedient to take every opportunity of analyzing material from different historical epochs. It is necessary to have far more comprehensive material, described with a full account of the methods used, than that now at our disposal from different geographic regions and epochs, before any definite conclusions can be drawn with respect to changes in occlusion and the size of the jaws in the course of history. The present study is intended as a contribution to this endeavour.

METHODS

The following measurements were made,

A. With respect to the individual jaw:
   1. Width of the dental arch, measured at the first premolars (B_1) and at the first molars (B_2)
   2. Length of the dental arch
   3. Height of the palatal vault
   4. Incisor inclination
   5. Dental arch space (crowding-overspacing)

B. With respect to occlusion:
   1. Overjet (horizontal overbite)
   2. Overbite (vertical overbite)
   3. Sagittal relation in the molar region.

All the determinations were made with the technique described by *Lundström* (1948), except that the palatal vault was measured with an accuracy of ± 0.5 mm, instead of *Lundström's* ± 0.1 mm. The procedure in the various measurements was as follows,

A. 1. *The width of the dental arch* was measured (with an accuracy of ± 0.1 mm) with sliding calipers at the first premolars (B_1) and at the first molars (B_2). In the upper jaw, the measuring points were the midpoints of the fissures on the first premolars, and the deepest points in the central fossae of the first molars, respectively. In the lower jaw, B_1 represents the distance between the most lingual points on the crowns of the first premolars, and B_2 the distance between the lingual surfaces of the first molars, measured between the mesio-lingual and disto-lingual cusps (Fig. 1 a).

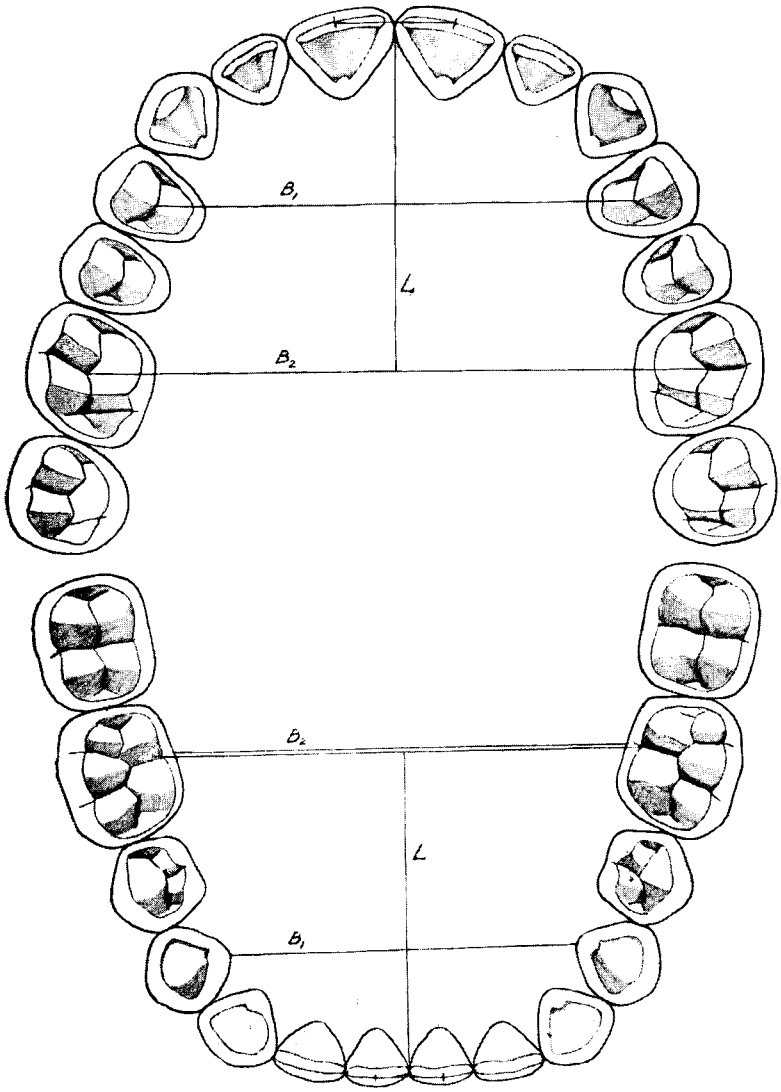

Fig. 1 a. Measurement of the width of the dental arch at first premolars (B_1) and first molars (B_2) and the length of the dental arch (L) (after *Lundström*).

2. *The length of the dental arch* was measured with calipers according to *Korkhaus,* modified by *Lundström* to measure in three dimensions (Fig. 1 b). The measurements are carried out as follows: The points of the calipers are adjusted to the distance between the measuring points on the first molars by means of a scale on a bar between the caliper points. It is attached to one of these points and runs in a slide at the other. The reading is made at one edge of the slide. Another metal bar runs from the

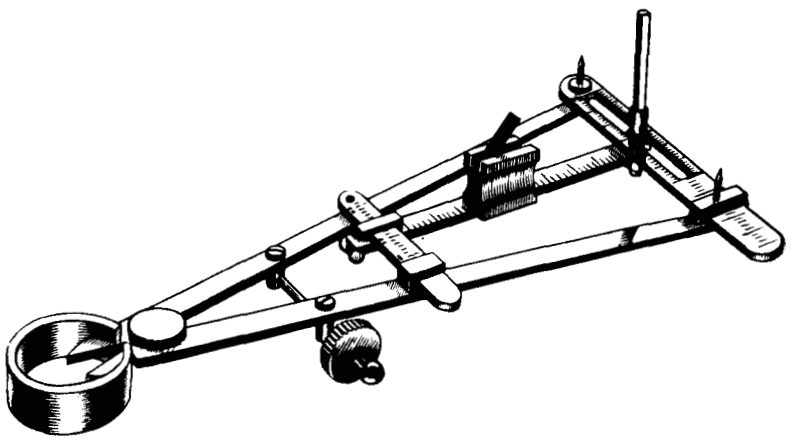

Fig. 1 b. Three-dimensional calipers (indicated by *Korkhaus,* modified by *Lundström)* for measuring the length of the dental arch, the height of the palatal vault and the inclination of the upper medial incisors (after *Lundström).*

bar between the points of the calipers. It is adjustable laterally, so that one end can always be placed in the centre of the distance between the points of the calipers. For measuring the length of the dental arch, the points are placed in the central fossae of the first molars, the runner being adjusted so that its posterior upper edge is on a level with the midpoint of the edge of the medial incisors (Fig. 1 b).

3. *The height of the palatal vault* was measured with an accuracy of ± 0.5 mm, at right angles to the plane of occlusion in the line connecting the measuring points on the first molars, and to the highest point of the vault (usually in the midline). The aforementioned calipers were used and placed in the same way as in measurement of the length of the dental arch. A semicircular

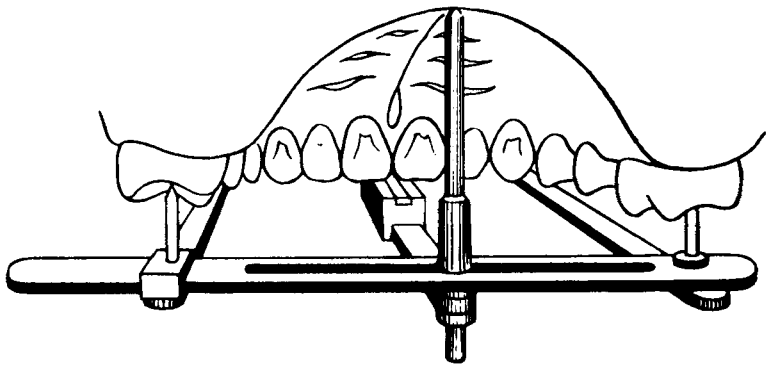

Fig. 2. Measurement of the height of the palatal vault (after *Lundström*).

rod with a 0.5 mm scale, movable vertically through a hole in the metal bar, was used to measure the height of the palate to within 0.5 mm (Fig. 2).

4. *The incisor inclination* was also measured with the three-dimensional calipers, applied in the same way as in measurement of the length of the dental arch. The slide is provided with a hinged rod, which can be adapted to the labial surface of the tooth (Fig. 3). The value for the incisor inclination was obtained by measurement of the distance between the posterior endpoint of the aforementioned rod and the posterior end of the slide,

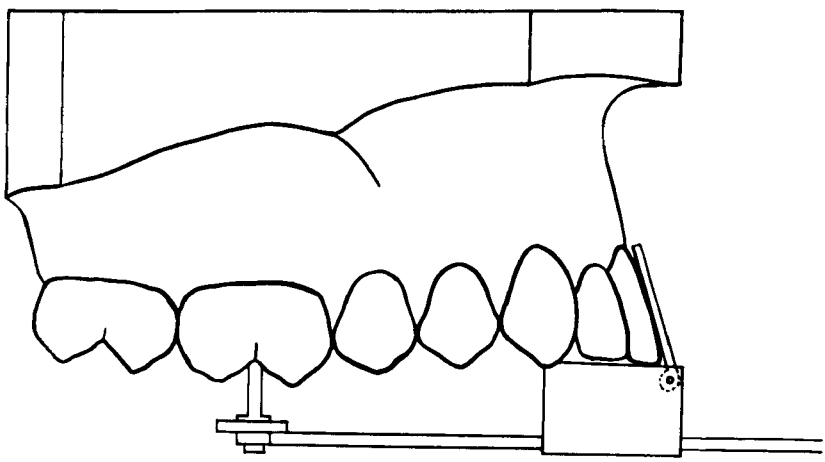

Fig. 3. Measurement of the inclination of the upper incisors (after *Lundström*).

1 mm corresponding to approximately 6.3°. Only the inclination of the medial incisors was calculated. Each was measured separately; when their inclination differed, the mean value was used.

5. *The dental arch space* was measured, with an accuracy of ± 0.1 mm, with the help of the sliding calipers. The teeth were measured by pairs, starting with the first molar and second premolar on the left side (K_1). The measuring points were the distal contact points of the first molar and first premolar. The measurements were then continued with the first premolar and canine (K_2), up to and including the first molar on the right side. To the sum of the figures for these groups (K_1 to K_6) was added any medial diastema (Fig. 4). The sum of the corresponding tooth widths ($M_1 \ldots M_1$) was subtracted from this figure. A positive value thus denotes overspacing, and a negative value crowding. It should be mentioned that the completely regular dental arch is not characterized by a numerical value of zero but, at any rate in the upper jaw, by a value of about + 1 mm (*cf. Lundström*, 1944, 1951).

B. 1. *The overjet* was measured, with an accuracy of ± 0.5 mm, at the two medial incisors, using a spatula graded in millimeters, with its tip ground down. The overjet is given as the mean of the distance from the labial surface of the left lower medial incisor to the midpoint of the edge of the left upper medial incisor, and of the same distance between the right lower medial incisor and the right upper medial incisor. The distances were measured parallel to the plane of occlusion and at right angles to the dental arch (Fig. 5). When the medial incisors of the upper jaw were worn, the measurement was made from the labial margin of the worn surface.

2. *The overbite* was also measured at the medial incisors, and is given as the mean value of the distance from the edge of the left lower medial incisor to the point on its labial surface at which the spatula was placed in measuring the overjet, and of the same distance on the right lower medial incisor. This point was marked with a sharp pencil, and the distance measured with an accuracy of ± 0.1 mm, using the sliding calipers. A frontally open bite is denoted by a negative distance, and the other cases by positive ones.

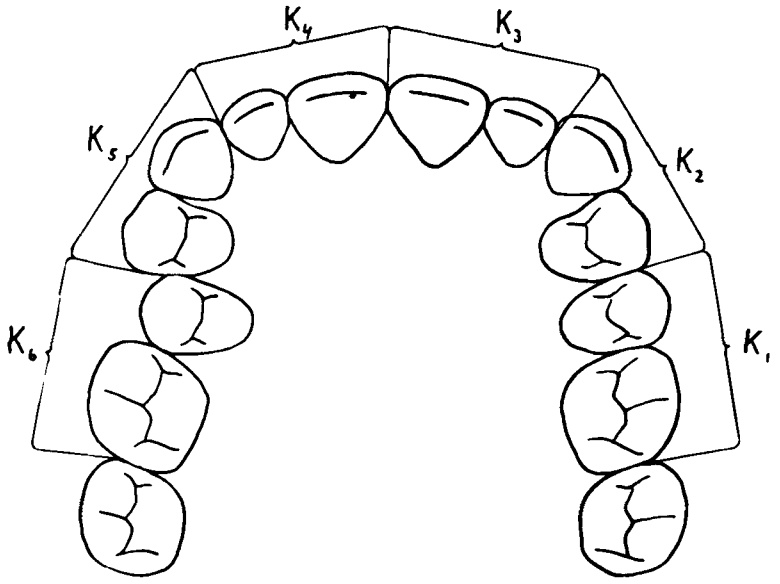

Fig. 4. Measurement of dental arch space. The whole space is obtained by adding the values for the six sections (K_1—K_6) and any medial diastema (after *Lundström*).

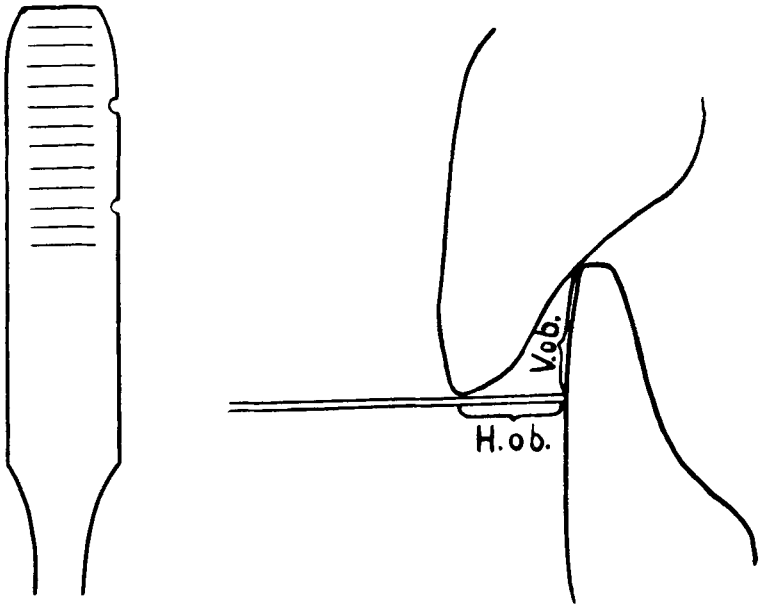

Fig. 5. Measurement of overjet (horizontal overbite) and overbite (vertical overbite) — (after *Lundström*).

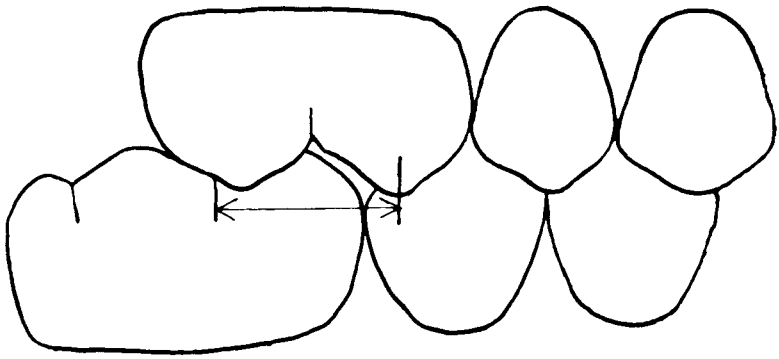

Fig. 6. Measurement of sagittal molar relation (after *Lundström).*

3. *The sagittal relation* was determined at the first molars. Cases in which the mesio-buccal cusp tip of the upper tooth impinged on the deepest point between the mesio-buccal and centro-buccal cusps of the lower tooth have been denoted as normal occlusion. This value is given as 0. Every forward displacement of the lower jaw is denoted by a positive value, and a backward displacement by a negative value. Vertical lines were made with a sharp pencil on the mesio-buccal cusp tip of the upper tooth, and on the aforementioned fissure of the lower tooth, and the distance between them (in the sagittal direction) measured with the sliding calipers with an accuracy of ± 0.1 mm (Fig. 6).

ERROR OF THE METHOD

In order to determine the error of the method, 25 cases in which the majority of measurements could be made were taken from the total material. Double determinations were made in these cases, and the error of the method calculated by use of the formula $\sigma_i = \sqrt{\frac{\Sigma d^2}{2n}}$, in which d is the difference between two determinations, and n the number of double determinations. The results, recorded in Table 3, in most cases show higher values than those obtained by *Lundström* (1948) and *Lysell* (1955) for corresponding measurements on plaster models.

The following are among the possible causes of the more uncertain values obtained in measurements on the present series of crania than in measurements on plaster models,

Table 3

Measuring error in mm for the mesio-distal tooth width, dental arch spac (total space K 1—K 6 and medial diastema), width of dental arch (B_1 and B_2), length of dental arch (Ll and Lr), incisor inclination (inc. inclin.), palatal vault molar relation (S.M.l and S.M.r.), overbite and overjet

Tooth no.	Upper jaw				Lower jaw			
	Left		Right		Left		Right	
	n	σ_i	n	σ_i	n	σ_i	n	σ_i
1	22	0.09	21	0.08	23	0.12	22	0.06
2	19	0.09	19	0.12	23	0.12	23	0.08
3	23	0.11	22	0.15	23	0.18	22	0.16
4	23	0.09	23	0.09	22	0.10	25	0.10
5	22	0.12	23	0.09	25	0.11	23	0.14
6	24	0.25	22	0.23	23	0.17	24	0.18
7	22	0.29	22	0.24	25	0.13	25	0.21
8	18	0.26	14	0.33	13	0.19	16	0.13

	Upper jaw		Lower jaw			Upper jaw — Lower jaw	
	n	σ_i	n	σ_i		n	σ_i
Medial diastema	5	0.08	3	0.06	S.M.l	14	0.26
Total space	20	0.48	22	0.49	S.M.r	13	0.16
B_1	21	0.37	22	0.26	Overbite.....	24	0.10
B_2	19	0.30	23	0.26	Overjet	24	0.14
Ll	17	0.27	18	0.21			
Lr	14	0.31	17	0.28			
Inc. inclin.	15	0.29					
Palatal vault ...	18	0.30					

1. Measurement from a point on a tooth movable in its alveolus to points beyond this tooth must, owing to the motility of the tooth (motility of the point), be more uncertain than at corresponding measurement on a plaster model.

2. On the severely worn teeth of the crania, it is often difficult to determine the greatest mesio-distal width of a tooth.

3. It is easier on a plaster model than on glossy dental and bone surfaces to obtain a foothold for the edges and points of the sliding calipers, so that they do not slip.

4. Certain measuring points are less distinct in the cranial material.

Table 4

Width in mm of dental arch at first premolars (B_1) and first molars (B_2), length of dental arch (L) and height of palatal vault (Pv) by age groups

		Juvenile			Adult			Mature			Total		
		n	$\bar{x} \pm \varepsilon(\bar{x})$	σ	n	$\bar{x} \pm \varepsilon(\bar{x})$	σ	n	$\bar{x} \pm \varepsilon(\bar{x})$	σ	n	$\bar{x} \pm \varepsilon(\bar{x})$	σ
Upper jaw	B_1	10	38.20 ± 0.39	1.22	23	36.65 ± 0.49	2.37	3	36.90 ± 0.81	1.40	36	37.10 ± 0.35	2.12
	B_2	10	49.50 ± 0.80	2.52	23	48.85 ± 0.43	2.08	2	50.70 ± 0.00	0.00	35	49.14 ± 0.37	2.17
	L	10	28.77 ± 0.56	1.76	16	27.73 ± 0.50	1.99	1	25.80 ± —	—	27	28.04 ± 0.38	1.99
	Pv	9	17.86 ± 0.95	2.86	20	18.53 ± 0.61	2.73	2	20.15 ± 0.65	0.92	31	18.44 ± 0.48	2.70
Lower jaw	B_1	10	27.16 ± 0.62	1.95	33	25.89 ± 0.38	2.17	32	25.42 ± 0.40	2.29	75	25.86 ± 0.26	2.24
	B_2	12	36.24 ± 0.32	1.10	35	37.49 ± 0.37	2.19	18	36.71 ± 0.67	2.83	65	37.04 ± 0.28	2.26
	L	10	25.16 ± 0.52	1.64	20	24.00 ± 0.36	1.62	3	24.90 ± 0.96	1.66	33	24.43 ± 0.29	1.67

Table 5

Width in mm of dental arch at first premolars (B_1) and first molars (B_2), length of dental arch (L) and height of palatal vault (Pv). By sex and age groups

	Sex	Juvenile			Adult			Mature			Total		
		n	$\bar{x} \pm \varepsilon(\bar{x})$	σ	n	$\bar{x} \pm \varepsilon(\bar{x})$	σ	n	$\bar{x} \pm \varepsilon(\bar{x})$	σ	n	$\bar{x} \pm \varepsilon(\bar{x})$	σ
Upper jaw													
B_1	♂	8	38.11 ± 0.46	1.30	11	38.05 ± 0.69	2.30	3	36.90 ± 0.81	1.40	22	37.92 ± 0.40	1.86
	♀	2	38.55 ± 0.27	1.20	12	35.36 ± 0.47	1.62	—	—	—	14	35.81 ± 0.51	1.92
B_2	♂	7	50.59 ± 0.82	2.18	10	49.83 ± 0.64	2.01	2	50.70 ± 0.00	0.00	19	50.20 ± 0.44	1.94
	♀	3	46.97 ± 0.43	0.74	13	48.09 ± 0.51	1.85	—	—	—	16	47.88 ± 0.44	1.74
L	♂	7	29.47 ± 0.43	1.13	10	27.16 ± 0.54	1.71	1	25.80	—	18	27.98 ± 0.45	1.89
	♀	3	27.13 ± 1.21	2.10	6	28.67 ± 0.98	2.39	—	—	—	9	28.16 ± 0.76	2.29
Pv	♂	7	18.76 ± 0.97	2.57	10	19.64 ± 0.38	1.19	2	20.15 ± 0.65	0.92	19	19.37 ± 0.41	1.79
	♀	2	14.50 ± 0.00	0.00	10	17.41 ± 1.08	3.42	—	—	—	12	16.96 ± 0.94	3.27
Lower jaw													
B_1	♂	8	27.45 ± 0.71	2.00	15	26.83 ± 0.59	2.30	21	25.62 ± 0.53	2.41	44	26.37 ± 0.36	2.37
	♀	2	26.00 ± 1.20	1.70	18	25.11 ± 0.41	1.74	11	25.05 ± 0.64	2.11	31	25.14 ± 0.33	1.83
B_2	♂	8	36.64 ± 0.24	0.67	13	38.55 ± 0.61	2.19	11	36.85 ± 0.93	3.09	32	37.49 ± 0.43	2.43
	♀	4	35.45 ± 0.64	1.27	22	36.87 ± 0.42	1.96	7	36.47 ± 0.98	2.59	33	36.61 ± 0.35	2.03
L	♂	7	25.70 ± 0.47	1.24	10	24.20 ± 0.45	1.43	2	25.25 ± 1.55	2.19	19	24.86 ± 0.35	1.53
	♀	3	23.90 ± 1.16	2.01	10	23.80 ± 0.59	1.85	1	24.20	—	14	23.85 ± 0.46	1.73

RESULTS

Width and Length of the Dental Arch

Height of the Palatal Vault

The results are given in Table 4, in which are recorded the means, the standard errors of the means and the standard deviations for the width of the dental arch at the first premolars (B_1) and the first molars (B_2). Table 4 also shows the length of the dental arch (L) in both the upper and lower-jaw, and the height of the palatal vault (Pv).

No significant differences are present between the various age groups (juvenile, adult and mature). Since the groups are small, the values are, however, relatively uncertain.

If the material is classified by sex, higher values are generally noted for men than for women (Table 5).

With respect to the various characteristics, the collected values for all the groups are in close agreement with those found by *Lundström & Lysell* (1953) in a Danish material from the same period.

A comparison with *Lundström's* investigations of a Swedish stone age and medieval series shows good agreement with respect to *e.g.* the width of the upper jaw (Table 6).

The question whether the width of the dental arches has decreased in the course of historical times is a matter of particular interest.

Although *Lundström* found significant differences between his medieval and present-day material, he did not ascribe decisive importance to this observation, owing to the uncertainty regarding the representativeness of the former material. As far as men are concerned, the present writer noted a similar difference (diff. B_1 upper jaw: 1.50 ± 0.50 mm, $t = 3.00$**; diff. B_2 upper jaw: 2.50 ± 0.64 mm, $t = 3.91$***). In women, a tendency in the same direction is present (diff. B_1 upper jaw: 1.10 ± 0.58 mm, $t = 1.90$; diff. B_2 upper jaw: 1.30 ± 0.57 mm, $t = 2.28$*).

A study of the results of various investigations on present-day Swedish material *(Lundström; Seipel; Lysell)* also discloses significant differences, *i.e.*, B_1 upper jaw, men *(Lundström; Lysell):* diff. 1.5 mm, $t = 3.00$**, and B_2 upper jaw, women *(Seipel; Lysell):* diff. 1.7 mm, $t = 3.78$***. Naturally, these differences

are not necessarily real ones, but may be partly due to differences in the measuring technique. Differences in the values in present-day series may, in fact, be dependent on systematic differences between the investigations. In such series, there is a considerable incidence of occlusal fillings in the teeth in question (first premolars and first molars), so that it is often difficult to fix the measuring points accurately. It is therefore conceivable that one worker may consistently place the measuring points further lingually than another.

A further possible explanation of the differences in the width of the dental arch is that, owing to early extraction of deciduous teeth, the first molars have migrated mesially and have then lodged in a more anterior and narrower part of the jaw. If the number of such cases of extraction differs in the respective

Table 6

Width in mm of dental arch of upper jaw at first premolars (B_1) and first molars (B_2) in some series from various periods. Unless otherwise stated, the material is Swedish

Author	Period	B_1				B_2			
		n	Sex	$\bar{x} \pm \varepsilon(\bar{x})$	σ	n	Sex	$\bar{x} \pm \varepsilon(\bar{x})$	σ
Lundström	Stone Age	14	♂	36.8 ± 0.5	2.0	16	♂	48.9 ± 0.9	3.5
»	»	5	♀	35.6		7	♀	48.1	
»	Medieval	43	♂	37.2 ± 0.4	2.3	7	♂	49.5 ± 0.4	2.9
»	»	14	♀	36.6 ± 0.7	2.6	32	♀	49.2 ± 0.5	3.0
Lundström & Lysell	» (Danish)	54	♂	37.7 ± 0.3	2.3	44	♂	50.5 ± 0.5	3.2
Lundström & Lysell	Medieval (Danish)	35	♀	36.5 ± 0.4	2.3	34	♀	49.6 ± 0.6	2.7
Lysell	Medieval	22	♂	37.9 ± 0.4	1.9	19	♂	50.2 ± 0.4	1.9
»	»	14	♀	35.8 ± 0.5	1.9	16	♀	47.9 ± 0.4	1.7
Lundström	Present-day	48	♂	34.9 ± 0.4	3.0	41	♂	47.3 ± 0.6	3.8
Seipel	Present-day (21 yrs)	57	♂	36.1 ± 0.3	2.3	55	♂	46.6 ± 0.5	3.4
»	Present-day (21 yrs)	142	♀	34.3 ± 0.2	2.2	135	♀	44.9 ± 0.2	2.8
Lysell	Present-day (21—24 yrs)	48	♂	36.4 ± 0.3	2.2	48	♂	47.7 ± 0.5	3.4
»	Present-day (21—24 yrs)	49	♀	34.7 ± 0.3	1.9	47	♀	46.6 ± 0.4	3.5

series, this may contribute to the discrepancies between them. In the series of the present author, which shows the highest values in both the aforementioned comparisons, there were only few extractions. In this series, all the teeth (excluding the second and third molars) were present in 80 per cent of the cases.

In the remaining 20 per cent (20 cases), the missing teeth were distributed as follows: canines, 2 cases; one premolar (on one or both sides), 14 cases; first molar (on one or both sides), 4 cases. The molars were presumably extracted on the grounds of caries, whereas the remaining missing teeth were extracted chiefly on account of crowding, often in combination with a narrow jaw. In such cases, the teeth migrate mesially and, here as well, lodge in a more anterior and narrower part of the jaw. In these cases any measurements possible were made without taking into account the mesial migration.

Only 6 of the 20 cases (about 12 per cent) belonged to the male group; consequently, the extractions had only a limited effect on the value for this group.

To sum up, it can be stated with respect to these comparisons of the width that they give the same indications as *Lundström's* results regarding the difference between the conditions in the Middle Ages and those of the present day. Whether these differences can be taken as evidence that a decrease in the width of the dental arch has, in fact, taken place since the former period is highly dependent on the representativeness of the medieval material. There is an inevitable risk that such series may represent small isolates, with closely related individuals. The fact that the values from such divergent regions as Själland (Denmark), Jämtland (northern Sweden) and Gotland (an island in the Baltic) are in good agreement nevertheless speaks against this supposition.

Even if the question of the representativeness of the medieval material is disregarded, however, it cannot be definitely determined, until a sufficiently large present-day material without loss of teeth is available, whether any actual decrease in width of the dental arch has occurred from the Middle Ages to the present day. This is because such losses, accompanied by mesial migration, can produce a decrease in width at the first molars that cannot be calculated exactly. On the other hand, extraction

in present-day material of, for example, deciduous molars or permanent first molars can cause distal migration of first premolars. They will then be lodged more posteriorly in the arch, *i.e.*, in a wider part of it than would be possible in a jaw with the full complement of teeth. However, exclusion of the cases with extracted teeth, in which there are often narrow jaws with crowding of teeth, would obviously prejudice the representativeness of the present-day material.

There were, however, few extractions of permanent teeth in the present-day material used in this investigation. In a comparison with the medieval material, the width of the dental arch, at both the first premolars and first molars, showed significantly lower values in men, and a similar tendency in women. Consequently, it may be warranted to assume that a decrease in width of the dental arch has occurred from the Middle Ages to the present day. In view of the limitation of the material, however, such a conclusion must be made with the utmost caution.

Dental Arch Space

Owing to the large number of teeth missing, calculation of the dental arch space could be made in a few cases only. The values recorded in Table 7 are therefore uncertain, and do not permit any comparisons with results of other investigations.

Sagittal Relation in the Molar Region

The sagittal relation of the jaws showed only an inappreciable deviation from the normal position ($= 0.00$). In the mature group, extensive attrition had resulted in marked wearing down of the cusps of the first molars. Consequently, measurements could be made on either side in two cases only (Table 8).

Overbite and Overjet

The tendency with increasing age to decreased overbite and overjet, particularly the former, that was observed by *Lundström & Lysell* (1953) was also apparent in the present series. The material is, however, too small to permit definite conclusions. A comparison between the overbite in the juvenile and the mature group nevertheless indicates a decrease (2.31 ± 0.57 and 0.24 ± 0.54 mm, respectively; $0.02 > p > 0.01$); see Table 8.

Table 7

Dental arch space in mm. Positive values denote overspacing. Negative values denote crowding

Jaw	Juvenile			Adult			Mature			Total		
	n	$\bar{x} \pm \varepsilon(\bar{x})$	σ	n	$\bar{x} \pm \varepsilon(\bar{x})$	σ	n	$\bar{x} \pm \varepsilon(\bar{x})$	σ	n	$\bar{x} \pm \varepsilon(\bar{x})$	σ
Upper jaw	7	+ 1.51 ± 1.49	3,95	9	− 0.32 ± 1.41	4.24	2	+ 0.85 ± 1.65	2.32	18	+ 0.52 ± 0.92	3.89
Lower jaw	6	+ 0.73 ± 1.33	3.26	16	− 0.29 ± 0.60	2.41	12	− 0.75 ± 0.77	2.68	34	− 0.27 ± 0.45	2.63

Table 8

Sagittal relation in the molar region, overbite and overjet, and incisor inclination. All values in mm. For the incisor inclination, 1 mm corresponds to approximately 6.3°

	Juvenile			Adult			Mature			Total		
	n	$\bar{x} \pm \varepsilon(\bar{x})$	σ	n	$\bar{x} \pm \varepsilon(\bar{x})$	σ	n	$\bar{x} \pm \varepsilon(\bar{x})$	σ	n	$\bar{x} \pm \varepsilon(\bar{x})$	σ
Molar rel. right ...	9	− 0.30 ± 0.35	1.04	24	− 0.04 ± 0.42	2.07	2	+ 1.05 ± 0.07	0.10	35	− 0.05 ± 0.31	1.83
Molar rel. left.....	9	− 0.36 ± 0.39	1.16	23	− 0.19 ± 0.35	1.67	2	+ 1.70 ± 1.70	2.40	34	− 0.12 ± 0.28	1.61
Overbite	9	2.31 ± 0.57	1.71	20	1.67 ± 0.41	1.83	9	0.24 ± 0.54	1.62	38	1.48 ± 0.30	1.87
Overjet	9	3.50 ± 0.37	1.10	20	3.25 ± 0.38	1.70	10	2.16 ± 0.69	2.17	39	3.03 ± 0.28	1.76
Incisor inclin.....	8	13.30 ± 0.28	0.80	15	13.64 ± 0.19	0.74	1	14.2		24	13.55 ± 0.16	0.77

Table 9

Overbite and overjet in mm in various series

Author	Period	Overbite n	Overbite $\bar{x} \pm \varepsilon(\bar{x})$	Overbite σ	Overjet n	Overjet $\bar{x} \pm \varepsilon(\bar{x})$	Overjet σ
Lundström & Lysell	Medieval	94	2.09 ± 0.20	1.84	95	2.24 ± 0.20	1.95
Lysell	»	38	1.48 ± 0.30	1.87	39	3.03 ± 0.28	1.76
Lundström (♂)	Present-day	52	3.3 ± 0.3	2.2	52	2.8 ± 0.2	1.6
Seipel (♂)	» »	243	3.20 ± 0.14	—	244	2.52 ± 0.12	—
» (♀)	» »	249	3.46 ± 0.13	—	250	3.41 ± 0.13	—

Compared to *Lundström & Lysell's* values, the overjet is greater in the present material, the respective figures being 3.03 ± 0.28 and 2.24 ± 0.20 mm; $p = 0.02$. The probable reason is that the mature group, in which the overjet is less than in the younger groups, is underrepresented in the present material (Tables 8 and 9).

The relation between overbite and overjet is shown graphically in Fig. 7. In the two younger groups, overbite and overjet largely coincide. In the oldest group, on the other hand, the overbite is 0 except in two cases, whereas the overjet varies. The two exceptions consist of one case of marked postnormal occlusion, and one with a frontally open bite, which was probably due to attrition alone.

As far as the incisor inclination is concerned, no difference could be demonstrated between the groups. The mean value for the whole series is in good agreement with that found by *Lundström & Lysell.*

GENERAL OBSERVATIONS

Already in a cursory study of the material a striking feature was the marked attrition present even in young individuals. Since this matter will be dealt with in a later paper, no further discussion will be entered into here.

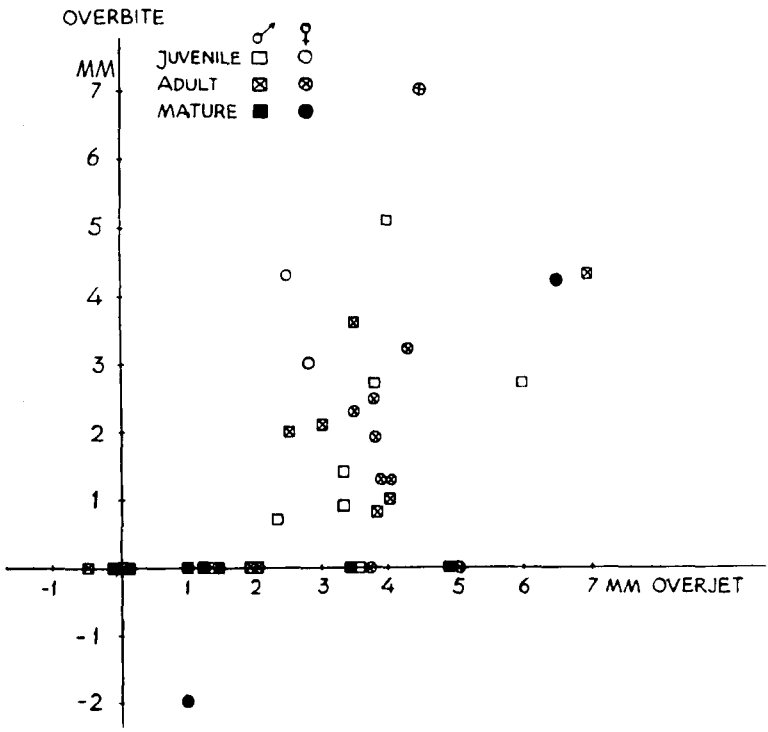

Fig. 7. Relation between overbite (vertical overbite) and overjet (horizontal overbite) measured in mm.

Anomalies were observed in the form of retained deciduous teeth (lower second deciduous molars: Fig. 8), impacted teeth (canines, third molars), aplasia (upper lateral incisors, third molars), rotated teeth, marked crowding, postnormal and prenormal occlusion. In fact, all types of anomaly that are seen nowadays were found. Since no roentgen examinations were made, no prevalence figures can be given for the numerical anomalies and impaction of teeth.

In many cases a several millimeter thick deposit of supragingival tartar was present on the lingual surfaces of the lower incisors and on the buccal surfaces of the upper first (and second) molars.

The difference in the incidence of caries is perhaps the most conspicuous feature in a comparison between this medieval material and present-day series.

Fig. 8. Retained left lower second deciduous molar in adult woman. Roentgenologic examination confirmed aplasia of corresponding permanent tooth. Conditions similar in right half of the jaw.

As pointed out e.g. by *Euler & Werner* (1936) considerable sources of error exist in registration of caries in cranial material. In the present series, the author has counted as caries only such lesions in which distinct loss of substance was found. In a cranial material such as the present one, it cannot be determined macroscopically whether or not dark streaks in the fissure system, in which a probe might fasten, are actually carious. Only sectioning and microscopic examination could give an answer to this question but, for obvious reasons, such a procedure is impracticable.

In 4 of the 48 men, caries was present in one tooth. Of the 49 women, 10 had altogether 28 teeth affected. Thus, in the whole material, altogether 32 teeth were found to be carious; 22 of them were in the lower jaw and largely in the molar region (Table 10).

It can be mentioned that *Rygge* (1913), *Mellquist & Sandberg* (1937) and *Cristophersen* (1938, 1939, 1941 a and 1941 b) observed a low prevalence of caries in early Scandinavian material from various periods. No comparisons can, however, be made

Table 10

Total number of carious teeth in the present Swedish medieval skull material

Upper jaw		Lower jaw	
Tooth	No. involved	Tooth	No. involved
M_3	2	M_3	5
M_2	2	M_2	5
M_1	2	M_1	5
P_2	2	P_2	2
P_1	2	P_1	1
C	0	C	3
I_2	0	I_2	1
I_1	0	I_1	0

with the present series, since the aforementioned authors recorded the carious lesions in a different way.

It does not seem feasible to give any percentage figures for caries in a cranial material such as the present one. This is because the teeth missing *intra vitam* may have been lost owing to caries, or through complete wearing down, or in some other way, such as due to trauma. Consequently, any prevalence figures would be unreliable.

A common feature seems to have been periapical destruction, in many cases probably due to severe, rapid attrition. Since no roentgenologic examination was made, no prevalence figures can be given. In numerous cases, however, the buccal bone surface had been perforated, and cavities of bone destruction the size of beans or hazel-nuts were seen.

SUMMARY

Recordings are made in 97 skulls from a medieval northern Swedish material of the width and length of the dental arch, the height of the palatal vault, dental arch space, incisor inclination, sagittal relation in the molar region, and the overbite and overjet.

The magnitude of the measuring error is determined for all the aforementioned characteristics. It is found to be larger than

in corresponding measurements on plaster models. This is suggested to be due to the following factors, among others,

Measurement from a point on a tooth movable in its alveolus to points beyond this tooth must, owing to the motility of the tooth (motility of the point), be more uncertain than a corresponding measurement on a plaster model.

In the heavily worn teeth of the crania, it is often difficult to determine the greatest mesio-distal width of a tooth.

It is easier on a plaster model than on glossy dental and bone surfaces to obtain a foothold for the edges and points of the sliding calipers, so that they do not slip.

Certain measuring points are less distinct in the cranial material.

Chiefly owing to the large number of teeth lost *post mortem*, the measurable material is reduced to such a degree that comparisons with other material are hampered. The results are nevertheless largely in agreement with those obtained by *Lundström & Lysell* in a medieval Danish material.

The dental arches are found to be narrower in the author's present-day material than in the medieval material. For example, the width at the upper first molars in men shows a decrease of 2.50 ± 0.64 mm ($t = 3.91$***) and in women of 1.30 ± 0.57 mm ($t = 2.28$*). Whether this decrease in width is to be taken as evidence that the dental arch has actually decreased in width from the Middle Ages to the present day is highly dependent on the representativeness of the medieval material. There is an inevitable risk that such material may originate from a small isolate with closely related individuals. The fact that values from such divergent regions as Själland (Denmark), Jämtland (northern Sweden) and Gotland (an island in the Baltic) are in good agreement nevertheless speaks against this hypothesis.

Even if the representativeness of the material is disregarded, it cannot be determined with certainty whether an actual decrease in width has occurred until sufficient present-day material without loss of teeth is available. This is because loss of teeth, accompanied by mesial migration, may produce a decrease in width at the first molars that cannot be determined exactly. On the other hand, extraction in present-day material of, *e.g.*, deciduous molars or permanent first molars can cause distal migra-

tion of first premolars. They will then be lodged more posteriorly *i.e.*, in a wider part of the arch. Exclusion of the cases with extracted teeth, in which there is often a narrow jaw with crowding of teeth, would obviously prejudice the representativeness of the present-day material.

Few extractions of permanent teeth had taken place, however, in the present-day material used here. In a comparison with the medieval material, the width of the dental arch, at both the first premolars and first molars, shows significantly lower values in men, and a similar tendency in women. Consequently, it may be warranted to assume that a decrease in width of the dental arch has occurred from the Middle Ages to the present day. It is stressed that, in view of the limitation of the present material, such a conclusion can be made only with the utmost caution.

Among other observations in the material are the marked attrition, frequent occurrence of supragingival tartar, and the low prevalence of dental caries.

RÉSUMÉ

UNE ÉTUDE BIOMÉTRIQUE DE L'OCCLUSION ET DES ARCADES DENTAIRES SUR UN ENSEMBLE DE CRÂNES DU MOYEN-ÂGE PROVENANT DU NORD DE LA SUÈDE (JÄMTLAND)

Sur 97 cas provenant d'un ensemble de crânes du moyen-âge du Jämtland, il a été procédé à l'enregistrement de la largeur et de la longueur des arcades dentaires, de la hauteur du palais, de l'étendue des arcades dentaires, de l'inclinaison incisive, des relations sagittales dans la région molaire, des rapports d'engrénement incisif dans le sens vestibulo-lingual et dans le sens vertical.

En raison du grand nombre de pertes dentaires survenues post mortem, l'ensemble utilisable a d'abord été réduit jusqu'à ce que la comparaison avec d'autres observations soit justifiable. Le résultat concorde cependant dans l'ensemble avec les résultats obtenus par *Lundström & Lysell* à partir d'observations provenant du Danemark du moyen-âge.

L'ensemble de sujets contemporains observés par l'auteur présente des arcades dentaires plus étroites que celui du moyen-âge. Ainsi, la largeur au niveau par exemple des premières molaires

supérieures présente chez l'homme une diminution de 2,50 ± 0,64 mm. ($t = 3{,}91^{***}$) et chez la femme de 1,30 ± 0,57 mm. ($t = 2{,}28^{*}$). La diminution de largeur ainsi trouvée peut-elle être considérée comme faisant preuve que la largeur des arcades ait diminué du moyen-âge à nos jours? Cette question est intimement liée au problème de la valeur représentative des observations du moyen-âge. Il existe toujours un certain risque pour qu'elles soient constituées d'îlots d'individus de proche parenté. Contre cette hypothèse parle cependant le fait que les valeurs trouvées à des endroits aussi différents que l'île de Seeland (Danemark), le Jämtland (Suède du Nord) et l'île de Gotland (dans la mer Baltique) concordent fort bien. Mais même sans tenir compte de cette question de la valeur représentative, il est impossible de déterminer avec certitude si une véritable diminution de largeur a eu lieu, avant d'avoir accès à un ensemble moderne suffisamment étendu d'observations sans pertes dentaires: à la suite des mouvements de mésialisation ces pertes peuvent en effet déterminer des diminutions de largeur dont la valeur ne saurait être calculée avec exactitude.

Parmi les autres remarques effectuées sur ces observations on peut citer l'intense abrasion, l'abondance des calculs supra-gingivaux et la faible fréquence de la carie dentaire.

ZUSAMMENFASSUNG

EINE BIOMETRISCHE UNTERSUCHUNG DER OKKLUSION UND DER ZAHNBOGEN BEI MITTELALTERLICHEM, NORDSCHWEDISCHEM SCHÄDELMATERIAL

Bei 97 mittelalterlichen jämtländischen Schädeln ist die Zahnbogenbreite und Länge, sowie die Gaumenhöhe, Zahnbogenweite, Inzisivneigung, Sagittalrelation im Molarengebiet, vertikaler und horizontaler Überbiss, registriert worden. Das verwertbare Material ist, vor allem auf Grund des häufigen Ausfallens von Zähnen post mortem in solchem Grade reduziert worden, dass Vergleiche mit anderem Material erschwert sind. Im Grossen und Ganzen stimmen jedoch die Resultate mit denen überein, die *Lundström & Lysell* bei mittelalterlichen, dänischen Schädeln fanden. Das neuzeitliche Material des Verfassers hat schmälere Zahnbögen als das mittelalterliche. So ist z. B. der Breitenabstand zwischen

den ersten Oberkiefermolaren bei Männern um 2.50 ± 0.64 mm ($t = 3.91$***) und bei Frauen um 1.30 ± 0.57 ($t = 2.28$*) vermindert. Die Frage, ob die in den Resultaten auftretende Breitenverminderung als Beweis für eine Verminderung der Bogenbreite vom Mittelalter zur Jetztzeit angesehen werden kann, hängt mit der Frage der Repräsentativität des mittelalterlichen Materiales intim zusammen. Es besteht natürlich immer die Gefahr, dass das Schädelmaterial mehr oder weniger von nahe verwandten, an isolierten Orten lebenden Individuen stammt. Dagegen spricht jedoch die Tatsache, dass Werte von so verschiedenen Fundplätzen wie Seeland (Dänemark), Jämtland in Nordschweden und Gotland (Insel in der Ostsee) recht gut übereinstimmen. Auch wenn man von der Frage der Repräsentativität absieht, kann man nicht mit Sicherheit entscheiden, ob eine Breitenminderung stattgefunden hat, bevor man Zugang zu ausreichend umfassendem, neuzeitlichem Material ohne Zahnverluste hat. Wenn solche Zahnverluste Mesialwanderungen zur Folge haben, kann es zu Verminderung der Breitenwerte kommen, die nicht exakt berechnet werden können.

Gleichzeitig mit anderen Beobachtungen bei dem untersuchten Material, kann man kräftige Abrasionen, reichliches Vorkommen von supragingivalem Zahnstein sowie niedrige Kariesfrequenz vermerken.

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