AN HISTORICAL SKULL COLLECTION AND ITS USE IN FORENSIC ODONTOLOGY AND ANTHROPOLOGY

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ABSTRACT

The Institute of Forensic Medicine, Copenhagen, houses a collection of historical skulls of unclear origin, marked with a general geographic or "racial descriptor". Would these historical skulls be of any value for the forensic odontologist and anthropologist concerned with teaching and casework? We tried to clarify this question by recording non-metric dental traits and by performing craniometric analyses.

A morphological and morphometric investigation of anatomical/dental traits in 80 adult skulls was performed. For each skull four non-metric dental traits using the ASU-System and three non-metric cranial traits were recorded. Nineteen cranial measures were also taken following the FORDISC programme manual. The non-metrical data were tabulated as frequencies, and the metric data were entered in the FORDISC programme. Observed non-metric trait frequencies were compared with published data. The FORDISC programme computed a discriminatory analysis for each skull and thereby assigned the skull to the most probable ethnic category.

The results for the non-metric traits showed that the traits generally followed the expected frequencies in 80% of the cases. The FORDISC programme correctly assigned ethnicity based on skull measurements in overall 70% of the cases.

It was found that this historical collection does show expected dental non-metric and craniometric traits and the collection may be of value in forensic casework in terms of comparison and for teaching purposes.

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INTRODUCTION

Forensic odontologists and anthropologists are regularly asked by the police to describe the physical traits of unknown dead bodies. The purpose of these descriptions is to assist the police in their search for a missing person with a matching description, leading to identification of an unknown body. The forensic team has various methods to obtain information about the deceased, such as evaluation of sex, age and ethnic origin.[1, 2]

The various methods employed for determination of ethnic origin include both metric and non-metric assessments. For example, computer programmes have been developed which match certain craniofacial measurements with a database containing craniofacial measurements from osteological material of known ethnicity.[3] However, the assessment of non-metric traits may be more subjective, as they cannot be discretely quantified, but rather reflect the training and experience of the investigators in identifying and recording these traits. Furthermore, when evaluating ethnicity it may be those self-same non-metric traits, least commonly seen by the investigator, which prove the most crucial. In Denmark, for example, shovel shaped incisors are rarely seen in the general Danish population, but forensic identification cases may involve the remains of purported Greenlanders (Inuit/"Mongoloid"), who often have these traits. Thus a Danish forensic odontologist, with Danish odontological training, may simply not have much experience in discerning these traits. This may be remedied by studying skeletal collections, which include material of varied ethnicity. While such collections do exist, especially in North America,[4] most European collections tend to be of an historical and archaeological nature.

The purpose of this investigation was to apply some of the methods used for evaluation of ethnicity to a large collection of historical and archaeological skulls, in order to evaluate the usefulness of an older anthropological skull collection concerning casework, in terms of training and teaching. Non-metric dental traits were recorded and craniometric analyses performed. Results were compared with the known ethnic provenance.

MATERIAL

The material belongs to different skull collections at the University of Copenhagen. Three groups of

different ethnicity labelled as; “Black”, “Chinese” and “Eskimo” were evaluated. These skulls were collected in the 17th and 18th century. Most only had a general geographic descriptor as “Africa”, “China”, or a general racial descriptor as “Black” or “Chinese”. The Eskimo material was excavated in Greenland during 17th-18th century, and consists of both pre-colonial Inuit (i.e. prior to AD 1721) and post-colonial Inuit (postdating AD 1721) material. The post-colonial population might reflect the present Greenland population better as it is known that there has been significant commingling between Europeans and Inuit.[5] We therefore specifically chose the more recent 17th and 18th century material for this study, even though some skulls did not have a precise archaeological description. In all, 80 adult skulls were analysed; 26 Greenland Inuit/“Eskimo”; 29 Africans/ “Blacks”; and 25 Asians/“Chinese or Malay”. All skulls with intact crania were selected. In some individuals the lower jaw was missing and in several cases part of the dentition was lost postmortem.

METHODS

Four non-metric dental traits were recorded for each skull:
1) shovel-shape on upper central incisors, breakpoint 3-6 (c-f);
2) Carabelli trait on upper first molars, breakpoint 5-7;
3) cusp number on lower second molars;
4) enamel extensions on upper first molars.

The standards of the Arizona State University Dental Anthropology System (ASU) were used for registration.[6,7]

Three non-metric cranial traits were recorded in the jaws;
1) palatal shape;
2) palatine torus;
3) mandibular torus.

Palatal shape was recorded to be either horseshoe-shape, v-shape or parallel-sided as described by Byers *et al.*[9] To keep the recording as simple as possible description of palatal shape was based only on morphological evaluation and not on measurements.[8] Mandibular and palatine tori were recorded by the ASU system.[7]

Along with the recording of the non-metric traits mentioned above, the investigators assigned whether the skull was African, Inuit or Asian. The non-metric data were tabulated as frequencies and compared with published data.[6-11]

Nineteen cranial measures were taken following the FORDISC programme manual,[3] and the metric data was entered in the FORDISC* programme. The FORDISC programme computed a canonical discriminatory analysis for each skull and thereby assigned the skull to the most probable ethnic category. The programme assigns both sex and ethnicity, but for this study only ethnicity was tabulated. The programme allows scoring in various ethnic categories and it was decided to include scoring for the category “White”, as several of the individuals may represent mixed ancestry.

All observations and measurements were made in blind trials, although some of the skulls had ethnicity or provenance written on them in the parietal region (Fig.1). Cohen’s Kappa was used for evaluating agreement of the predicted ethnicity. Ten skulls were re-evaluated a month later with no significant difference between the results of the two evaluations.

RESULTS

Table 1 shows the distribution of the dental non-metric traits. Three of the traits (Carabelli cusps, Cusp number and Enamel Extensions) could be scored in most cases (50/80, 46/80 and 50/80, respectively), while Shovel-shape could be scored in only 27/80 cases. This was due to postmortem loss of the incisors. This was especially evident for the Inuit skulls, as these represent skulls retrieved from inhumation

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Fig.1: *All observations and measurements were made in blind trials, although some of the skulls had their ethnicity or provenance written on the parietal surface*

Table 1: *Distribution of dental non-metric traits*

Dental Trait		"Black"	"Chinese"	"Eskimo"	Total
Shovel shape	present	0	4	2	6
	absent	14	7	0	21
	Total	**14**	**11**	**2**	**27**
Carabelli´s cusp	present	2	2	0	4
	absent	18	13	15	46
	Total	**20**	**15**	**15**	**50**
Cusp number	4 cusps	7	8	6	21
	5 cusps	8	7	10	25
	Total	**15**	**15**	**16**	**46**
Enamel Extensions	present	19	3	4	26
	absent	1	7	16	24
	Total	**20**	**10**	**20**	**50**

Table 2: *Distribution of jaw traits*

Jaw Trait		"Black"	"Chinese"	"Eskimo"	Total
Palatal Shape	horseshoe-shape	1	7	20	28
	v-shape	10	12	4	26
	parallel-sided	13	3	1	27
	Total	**24**	**22**	**25**	**71**
Palatal tori	present	1	1	6	8
	absent	24	21	19	64
	Total	**25**	**22**	**25**	**72**
Mandibular tori	present	1	0	8	9
	absent	21	19	15	55
	Total	**22**	**19**	**23**	**64**

Table 3: *Agreement between ethnicity as by dental traits (columns), versus labels (rows)*

Ethnic category	African	Asian	Inuit	Total
"Black"	**20**	3	1	24
"Chinese"	3	**16**	3	22
"Eskimo"	0	5	**21**	26
Total	23	24	25	72

Table 4*: Non-metric agreement rates and Cohen´s Kappa values for each ethnic category*

Ethnic category	Overall agreement	Cohen´s Kappa
"Black" - African	0.90	0.78
"Chinese" - Asian	0.81	0.55
"Eskimo" - Inuit	0.88	0.73
All	0.79	0.69

Table 5a: *Dental non-metric frequencies compared with published frequencies*

Dental Trait		Published data	Recorded data
Shovel shape	"Black"-African	0.11	0.00
	"Chinese"-Asian	0.37	0.39
	"Eskimo"-Inuit	0.73	1.00
Carabelli´s cusp	"Black"-African	0.14	0.09
	"Chinese"-Asian	0.17	0.11
	"Eskimo"-Inuit	0.20	0.00
Cusp number (4 cusps)	"Black"-African	0.43	0.47
	"Chinese"-Asian	0.50	0.55
	"Eskimo"-Inuit	0.26	0.38
Enamel extensions	"Black"-African	0.0-0.8	0.00
	"Chinese"-Asian	0.55	0.55
	"Eskimo"-Inuit	0.47	0.52

burials. Indeed, only in two cases was it possible to determine shovel shape among the 26 skulls of Inuit provenance. Conversely, the three non-metric traits of the jaws could generally be scored in most cases (Palatal Shape in 71/80; Palatine Tori in 72/80, and Mandibular Tori in 64/80) (Table 2).

The dental non-metric traits provided a good basis for deciding ethnicity or provenance (Table 3). It was possible to assign ethnic provenance to 72 of the skulls. The overall agreement was 0.79 and Cohen´s Kappa was 0.69. The agreement rates and Cohen´s Kappa values for each ethnic category is given in Table 4. It is seen that Africans/ "Blacks" had the best agreement, while the Asian/"Chinese" category had the worst.

The results for the dental non-metric traits showed that the traits in general followed the expected frequencies (Table 5a). For the non-metric jaw traits "Inuit" in general had horseshoe shaped palates, "Chinese" had v-shape, and "Blacks" had parallel sided palates. Mandibular and palatine tori were rare in the "Black" and "Chinese" groups while both kinds of tori were frequently seen in the Inuit group (Table 5b). Jaw traits were compared with published data. Overall the above mentioned characteristics of this material were also described in former publications. [8-11]

The FORDISC programme correctly assigned ethnicity based on skull measurements in 71 % of the cases (Table 6). Cohen´s Kappa was 0.59. Ten skulls were assigned to the "White" category. The agreement rates and Cohen´s Kappa values for each ethnic category is given in Table 7. These values are generally comparable to the values for the non-metric traits: in both instances Asians/"Chinese" have the lowest agreement, and low Kappa values.

DISCUSSION

The purpose of this investigation was to evaluate whether an old collection of skulls was of any value with regard to morphology studies. Due to the quality

Table 5b: *Frequencies of recorded non-metric jaw traits*

Jaw Trait		Recorded data	Published data
Palatal Shape	"Black"-African Parallel sided	0.54	0.46
	"Chinese"-Asian V-shaped	0.55	-
	"Eskimo"-Inuit Horseshoe shaped	0.80	0.50
Palatine Torus	"Black"-African	0.04	0.05
	"Chinese"-Asian	0.05	-
	"Eskimo"-Inuit	0.25	0.25
Mandibular tori	"Black"-African	0.05	0.08
	"Chinese"-Asian	0.00	-
	"Eskimo"-Inuit	0.35	0.47

Table 6: *Agreement between ethnicity as by morphometry, (columns) versus labels, (rows)*

	African	Asian	Inuit	European	Total
"Black"	21	3	1	3	28
"Chinese"	2	13	1	6	22
"Eskimo"	1	4	19	1	25
Total	24	20	21	10	75

Table 7: *Morphometric agreement rates and Cohen´s Kappa values for each ethnic category*

Ethnic category	Overall agreement	Cohen´s Kappa
"Black" - African	0.87	0.71
"Chinese" - Asian	0.79	0.47
"Eskimo" - Inuit	0.89	0.75
All	0.71	0.59

of the skull material, with a number of missing teeth and fragmented jaws, it was not possible to record all traits in all individuals. There were some difficulties especially concerning shovel-shape on Inuit incisors. These teeth have extremely short roots resulting in the fact that the majority of these were lost postmortem. We chose to record the non-metric traits, which in our experience are the most used in forensic odontological casework. Results were compared with published data and overall the frequencies of the dental non-metric traits recorded in this study were in accordance with data published by Scott and Turner.[6]

Palatal shape was based only on a morphological evaluation. No measurements were taken to evaluate this trait. The results were compared with data published by Gill[8] and Byers *et al.*[9] and seemed to follow the pattern described. However, direct comparison was not possible in all cases. Concerning frequencies of tori, the Inuit group tended to have these traits more often than the two other groups. This is in concordance with data published by Hrdlicka,[10] Petersen[11] and Hauser *et al.*[12]

As seen in Tables 4 and 7, there was a slightly better overall agreement when using non-metric traits than morphometrics, although for the case of Inuit/"Eskimo" category the opposite was the case. The lower agreement is to some extent due to the fact that the FORDISC programme was allowed to score a case as "White", even though none of the cases was labelled as such. When judging the non-metric traits, assignment was made to only the three categories of provenance. Even though our study was conducted in blind trials, the investigators knew that all cases were belonging to the categories "Black", "Chinese" or "Eskimo". It should be added that the FORDISC programme has data on Inuit skulls from our collections, but these data were collated from the pre-colonial part of the collections.

Even though the FORDISC programme has scored sex of the individuals, it is not published here since the aim of this study was to evaluate ethnicity.

As a test for non-metric traits *per se*, we could have included skulls of European (Danish) extraction but chose not to. This was because the aim of the study was to evaluate not the single traits, but rather how these traits were represented in the collection. However, Cohen´s Kappa statistic for evaluating the agreement was included, in order to see if the predicted categories did reflect real ethnic differences in trait frequencies and skull morphometrics. Except for the morphometric analyses of the Asian/"Chinese" skulls, with a Kappa statistic of 0.47, the Kappa statistics were in the range 0.55 - 0.78, indicating fair agreement.

Underlying the whole project, both in terms of the labelling of the cases, as well as the tabulation of traits and measures by ethnic group, is the question of race. When the collections were established, skulls were traded and swapped between anthropological institutions. It was thought that even just a few skulls could clearly "define" the special characteristics of the different races, although it was not clear what was meant by the term, nor how many races there were. Indeed, in the collections there is a skull labelled as "Gypsy", and another as "Swede". Clearly, such labels are meaningless as the variation of

population, even inside smaller population groups, is much bigger than can be accounted for by a few skulls. The labelling of the skulls is clearly inadequate: what exactly is meant by the term "Black" or "Chinese, from Penang"? On the other hand, geographical differences in dental and cranial traits and sizes do exist, but it cannot be seen as definite, discriminate groups, but rather as "clinal" differences.[13,14] However, it was found that traits and cranial measures, as recorded for modern population groups, are reflected in the collections. This means that the skull collection can be used as training material, as it does allow the forensic odontologist or anthropologist to see these traits and perform morphometrical analyses.

The acquisition of this collection, sometimes by indiscriminate exhumation of graves, sometimes from local anatomical departments in far away countries (at the time run by European doctors and clerks), cannot be considered ethical by today's standards. On the other hand, while some material has been repatriated, this requires a specific knowledge of provenance. In the case of the Greenland samples, for example, an agreement has been made with the Greenland National Museum so that it now owns the Greenland material, and research may only be performed following permission from the authorities. The material still resides at the University of Copenhagen, as it is considered a scientific and archaeological material. It may ultimately be fitting that these skulls may assist in better and faster identification of the dead, and not only be an example of racial prejudices of the past.

CONCLUSION

This historical collection does show expected dental non-metric and craniometric traits and, as such, may be of value in forensic casework in terms of comparison and for teaching purposes. Although not all skulls have definite archaeological descriptions, we would argue that this may indeed be an advantage, as it must be foreseen that previous strict geographical or ethnic categories will not be applicable in the future.

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