A method for studying human teeth excavated in archaeological sites: A focus on recent research sites

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Abstract

For anthropologists studying archaeological, fossil, and forensic remains in order to understand the biology of ancient human communities and follow the course of evolution, it is essential to identify an individual from their fragmentary remains, particularly teeth. Teeth are unique among the resistant anatomical parts of fossil skeletons having been exposed to various forces throughout the person's life. Dental anthropology is also applied to living people, using many of the same techniques employed for analysing ancient remains. One primary theme of this discipline is to study variation in size and shape of the teeth, as recorded in casts of dentition from living people or evaluated in the skulls of archaeological and fossil specimens using metric measurements and observations of non-metric traits. Metric and non-metric data were compiled from published reports on archaeological sites in Korea and elsewhere. These data indicate that in contrast to all other ethnic groups, Koreans exhibit several non-metric traits in relatively high frequency. Interestingly, they have lower frequencies of Carabelli's traits in comparison to Western Eurasians. Based on the distribution pattern of dental traits, Koreans possess lineages from a high proportion of northeast Asian populations as well as southern groups of north-eastern Asian populations.

KEYWORDS: dental anthropology, Korean teeth, shovel-shaped incisor, distal trigonid crest, Carabelli's traits

Introduction

As cultural heritage research institutes have been established throughout Korea over the last two decades, a significant amount of research has been conducted on buried cultural properties and numerous artefacts. By analysing this material and referencing the reports, the lives of past people become better understood. Although interest in human bones excavated from various archaeological sites in Korea continues to increase, they have not yet been properly investigated due to various circumstances.

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The analysis of human bones excavated from archaeological sites in Korea has been mainly conducted by doctors with professional anatomical knowledge (Na 1963; Kim et al. 1985, 1993) but recently anthropologists and archaeologists have provided scientifically useful information by participating in these studies (Hong 1994; Park et al. 1999; Im 2001; Lee 2001; Park 2002).

Along with the increase in human bone analysis in recent years, studies on the cultural aspects of excavated skeletal remains have been actively pursued (Jeong 1996; Park 2006; Kim 2007). Human teeth are of significance in archaeological and physical anthropological studies because they are more robust than bone due to their enamel jackets. Thus, they are more likely to be discovered even after being buried for long periods in prehistoric and historic sites.

Studying the morphology of these teeth is a key focus of comparative anatomy, paleozoology, odontology, forensic medicine, zoology, and physical anthropology. Just as mainstream anthropometrics were incorporated into biological anthropology, or as the research methods of genetics and ecology have been employed in physical anthropology since the 1950s, dental morphological analysis is also expanding the discipline of anthropology, currently comprising an essential part of dental anthropology (Butler 1939; Dahlberg 1971). Teeth found in archaeological contexts play critical role in archaeology and physical anthropology in that we can examine dietary patterns in fossil humans and stages of their cultural evolution by including genetic analyses of human skeletal remains in dental anthropology (Hu et al 1999; Kim et al. 2000). Moreover, the morphological complexity of human teeth is valuable clue for assessing the genetic lineage of the individual because it reflects complex aspects of evolution and the genetic traces of ancestors. It was recently used to trace ancestry by studying a genetic disease showing morphologic abnormalities such as congenital dental defects or dental malformation (Iscan 1989).

In addition, metric and non-metric traits of human teeth vary depending on genetic or environmental factors. These traits are used as essential clues for determining the physical characteristics of an ethnic group, identifying the sex, and age of an individual, or tracing migration routes of people. Finally, these traits may reveal the relationships between ethnic groups and other groups in surrounding regions (Scott & Turner 1971).

This paper classifies metric values and non-metric traits of human teeth excavated from archaeological sites and discusses what we can learn through dental anthropological analyses of these traits. We also examine how human teeth can be used in archaeology by summarising human teeth that were reported in Korean and foreign literature. In cases in which the strict collection of data and precise analysis of human skeletal remains are not done in archaeological excavations due to factors such as the lack of researchers or other conditions, Korean archaeologists would benefit from learning methods of conducting basic analyses of these materials. These straightforward steps can be used to widen the scope of study on skeletal remains including teeth. They may also be useful for the identifying potential relationships of surrounding human groups or the migration routes of certain ethnic groups.

Methods for studying human teeth

Collection and records of human teeth

The collection of teeth is conducted according to the procedures used for the human skeleton (e.g., Kim 2009). This is because teeth are generally excavated from a burial in archaeological sites, in which the teeth are associated with other skeletal remains. The skeleton can be evaluated properly only when its immediate collection and subsequent laboratory analysis are executed correctly. It is preferable to remove a skeleton from a site as soon as possible because the remains may deteriorate or become damaged. Before recovering such remains, a strategy for recording and excavation should first be established. Similarly, anyone other than essential personnel should be prohibited from approaching the burial site. Before excavating the site, all meaningful contextual information should be recorded in writing and photographs.

Suitable tools should be carefully used when excavating a burial site. In some cases, wood or bamboo tools are preferable, and brushes of various sizes and strengths are required. After the skeleton is exposed, excavators should closely observe changes in the color and texture of soil, damage by rodents or plant roots, terrain, rotten plants, trees, insects, and the presence of charcoal and artificial structures such as lids or beads. The angle of the skeleton, orientation of the body and head, depth of bones from the surface and other circumstantial details should be recorded.

It is necessary to examine all sediment covering the skeleton because teeth are often separated from the encasing bone. The condition of the alveolar bone shows whether teeth were removed after burial, but they can be recovered through the careful sieving of excavated sediments. Teeth are more clearly visible if the sieving is done with water.

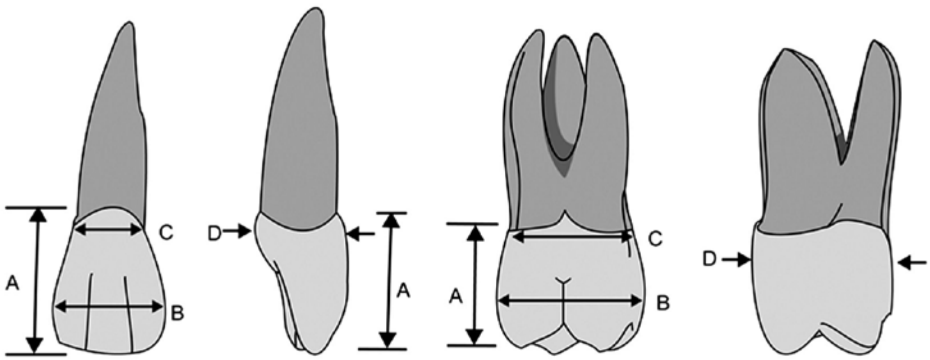
Tooth-wear often provides clues about the skeleton's origin. In many cases, the teeth of modern people are less worn than those found in ancient skeletons. If possible, detailed site records should be made because circumstantial information is quite important for correctly determining the time of burial and origin of the skeleton. Finally, prior to transporting skeletal remains, they should be packed with sufficient padded material to prevent them from shifting in the container. Heavy and robust remains should be placed at the bottom of the container. Attention should be paid to the fragile facial parts of the cranium. The skull and lower jawbone should be separated and packed accordingly, so teeth do not fall out of their original positions in the mandible during transport.

Metric analysis methods

Many researchers have presented various methods to measure teeth (e.g., Martin 1928; Selmer-Olsen 1949; Moorrees 1957; Goose 1963). Traits such as height and length are commonly used to indicate the size of the teeth. Diameter, width, or area are also measured. In particular, traits such as height are excluded from measurement because teeth of ancients humans are more extensively worn and the height would thus be irrelevant and incomparable to other specimens.

Metric analysis is an efficient method for facilitating the comparison between specimens because it uses generally defined measuring points and methods. Each tooth size belongs to a category of average sizes specific to that ethnic group; therefore, the metric size of one group can be revealed through an appropriately sized sample. However, in addition to the numerous measurement methods available, we must also consider other approaches.

For measuring teeth, digital callipers (Mitutoyo Co. Japan) are used and four traits are measured among those presented by Zubov (1968). An average value in millimeters (mm) is obtained by measuring one item twice, and pairs of measurements showing large differences are measured again. Several indices and units were constructed from metric values obtained in this study, and these are used as essential anthropological indicators. The following unit (modules), indices, and measurement of general teeth used in dental anthropology were applied here (Figure 1).



Legend: A. Crown length; B. Mesio-distal diameter of the crown; C. Mesio-distal diameter of the crown cervix; D. Facio-lingual diameter of the crown

Figure 1: Tooth measurement points (Pang 2004)

1) Crown length

For crown length, the distance from tooth face surface, bend ridge to cutting edge(front tooth) or protoconid cusp top (molar) are measured.

2) Mesio-distal diameter of the crown

For the mesio-distal diameter of the crown, we measured the longest distance between the bend ridge inside the crown and distal surface bend ridge parallel to the face surface of the teeth. Cases of excessive wear on the adjacent tooth surface are excluded from the measurement target.

3) Mesio-distal diameter of the crown cervix

For the mesio-distal diameter of the crown cervix, the closest distance between the inner surface of the crown and tooth root boundary and distal surface parallel to the face surface of the teeth are measured.

4) Facio-lingual diameter of the crown

For the facio-lingual diameter of the crown, the longest distance between the bend ridge of the face surface and metaconid bend ridge is measured to be perpendicular to the surface at which the mesio-distal diameter of the teeth was measured.

5) Module of the crown (mcor): VL (cor) + MD (cor) / 2

The module of the crown is the relative size of the head and can be calculated through the average value of facio-lingual diameter and mesio-distal diameter. Normally, the full size is calculated only when crown height is considered but the height value that can be calculated through wear is limited. Therefore, the module of the crown is used in relative comparison or for descriptive purposes.

When classifying modern people with the module of the crown, the following criteria are applied. A small tooth type is < 10.20 mm; the middle tooth type is 10.20-10.49 mm; and the large tooth type is > 10.50 mm. The small tooth type is also shown to be 10.0 mm, primarily among southern Europeans.

The large tooth type appears frequently in groups mainly living in equatorial areas and the South Pacific. The large tooth type value is a maximum of 11.75 mm and is often seen in Australian Aborigines. Inuit and Native Americans also exhibit large tooth types. Mongoloids and Northern Europeans mainly have the middle tooth type.

6) Index of the crown (I cor): VL (cor) / MD (cor) x 100

This generally refers to the ratio of the mesio-distal diameter to the facio-lingual diameter of the molar crown. As the index of the crown is higher, the crown looks longer in the facio-lingual direction when viewed from the top. The index of the crown in modern humans always exceeds 100 in the maxillary molar, while it has values of < 100 in the lower jaw. Anthropoids and early hominids show a value close to 100. This value increases over time and the mesio-distal diameter of Upper Palaeolithic and Mesolithic people becomes relatively smaller at approximately 130 or 150.

In the maxillary molar, the average crown index in modern humans is approximately 120; Europeans have values around 125 and Mongoloids show < 120. In the lower jaw, the crown index increases as the mesio-distal diameter is reduced and Neanderthals show values of around 100. It then decreased: the average mandibular molar crown index of modern humans is 90-100. However, the mandibular first molar exceeds 100 in some cases. Criteria for the crown index classification of mandibular molars are as follows (Hrdlička 1923): the long tooth type is 90.0; the middle tooth type is 90.0-99.9; and the short tooth type is > 100.

7) Absolute crown size (robustness, Rb): VL (cor) x MD (cor)

This trait reflects the overall crown size with the module of the crown and is a characteristic often used in paleo-anthropology.

8) Relative crown size (incisor index, canine index)

This comprises the ratio of the mesio-distal diameter of mesial incisors to the mesio-distal diameter of maxillary lateral incisors (incisor index: MD (*cor*)I^2 / MD (*cor*)I^1 x 100) and the ratio of mesial canine length to the mesio-distal diameter mandibular lateral canines (canine index: MD (*cor*)P^2 / MD (*cor*)P^1 x 100). In the evolutionary process, the size of lateral incisors is reduced and is thus helpful for identifying reduction in the size of the jaw.

The incisor index among Europeans is quite small, approximately 75-78; in Mongoloids approximately 82-84; and among equatorial peoples approximately 78-82(median values). Differences in the incisor index according to sex are also evident, being lower among women than men.

The canine index is generally investigated on mandibular teeth. The values of most modern people exceed 100 and exceptional cases, people in polar regions show < 100. The canine index among fossil hominins (*Homo erectus, Homo heidelbergensis*) is < 100, while Australopithecines show values > 100, significantly higher than in modern humans.

9) Step-index of the crown (Si, step-index)

Over the human evolutionary process, the first molar is considered to be the tooth least likely to be altered (Selmer-Olsen 1949). Among metric traits, the mesio-distal width maintains its genetic characteristics well because it is the least affected tooth. Based on these characteristics, the step-index is calculated as the ratio of the mesio-distal diameter of the first molar to that of canines and second and third molars. Deterioration of those teeth can be estimated when compared to the first molar. The step-index comprises the following four indices.

1. MD (*cor*)P^1 / MD (*cor*)M^1 x 100(first canine step-index)
2. MD (*cor*)P^2 / MD (*cor*)M^1 x 100(second canine step-index)
3. MD (*cor*)M^2 / MD (*cor*)M^1 x 100(second molar step-index)
4. MD (*cor*)M^3 / MD (*cor*)M^1 x 100(third molar step-index)

The frequency used in the first canine step-index is relatively lower than other indices. The second canine step-index observed in the lower jaw reflects an interesting fact in human evolution. As hominids have evolved, the second canine step-index steadily declined. In the evolutionary process from Australopithecines to modern humans, the most notable feature shown in teeth is the tendency of molarisation; for example Australopithecus: 100.6; *Homo erectus*: 91.0; *Homo neanderthalensis*: 85.0; *Homo sapiens*: generally 80 or below (some at 85). The results of a comparative study between modern ethnic groups are insignificant.

As the second molar became smaller while the first molar became bigger throughout human evolution, the third molar step index decreased. Modern ethnic groups showing a maxilla third molar index close to 100 have not been reported and fossil humans have an index of approximately 100. Therefore, it may represent an interesting anthropological feature that explains changing biological characteristics over human evolution. In particular, ethnic groups living near the equator are characterised by a higher third molar step-index and hence, the origin of primitive characteristics can be inferred from early in the human evolutionary process. Gender-specific traits are also evident, as the step-index in women tends to be lower than in men.

In summary, the step-index is used as a key dental anthropological indicator for explaining the human evolutionary process because it shows large variations over time.

Non-metric analysis methods

Non-metric traits of teeth are important for showing the differences among modern human groups and examining their genetic relationships with ancestral populations. Non-metric traits are largely categorized based on the number and position of teeth and diversity of the tooth shape. This latter trait provides critical information for identifying the differences between local groups and untangling genetic relationships. The following non-metric traits are commonly recorded.

1) Congenitally missing teeth

Teeth that are often missing include the third molar and maxillary lateral incisors. When lateral incisors are congenitally missing, the incisors adjacent to the eye tooth (canine) look similar in many cases. This phenomenon has been expressed more frequently over the last millennium and a frequency up to 20% was reportedly expressed in some groups.

In particular, congenital lack of the third molar occurs most often in Mongoloids with an expression rate up to 30%. In contrast, expression frequency is lowest among blacks in Africa. Congenital lack of the third molar is thought to have become steadily more common through the late Palaeolithic and Mesolithic until today (Brothwell et al. 1963) Other congenitally missing teeth (Tratman 1950) are very rare, but in the case of mandibular mesial incisors, the expression rate is relatively high among Mongoloids. However, the occurrence rate is less than 2%, remarkably lower than other teeth. Canines are often congenitally missing, but they show an expression rate of less than 3%.

When observing congenitally missing teeth, it is essential to distinguish between unerupted teeth and teeth lost prior to death. Unerupted teeth can be discerned in radiographs. Tooth loss before death can be determined if the dental alveolus is absorbed or characteristically bent and unbalanced; alveolar holes will be evident. If the lost tooth was in contact with the adjacent teeth at least once, traces are evident on the contact surface.

2) Snaggletooth

This refers to an irregular tooth and may be an incisor or molar. Its shape may or may not be similar to a normal tooth. This affects permanent and deciduous teeth, but the frequency among the latter is quite low.

3) Bilaterally rotated incisors(winging)

Most frequent among the mesial incisors, this trait refers to the 'twisting' of the lateral side toward the cheek. These are also known as V-shaped or wing-shaped teeth (Dahlberg, 1959; Enoki and Nakamyra 1959). An expression rate of up to 45% is known in the Mongoloid group, but rarely occurs in Europeans.

4) Peg-shaped teeth

Such teeth are abnormally small and resemble a peg. They mainly occur in maxillary lateral incisors. The trait may be due to a congenital defect. The expression rate of approximately 3% is seen in modern human groups and is slightly higher in Europeans.

5) Crowding of teeth

If permanent teeth are too crowded, one or two are pushed out of their normal positions. In this case, crowding occurs because the tooth sizes remain the same but the jaw size shrinks. Consequently, the alveolus becomes smaller: thus, teeth cannot erupt normally, and they sometimes become rotated. This trait occurs mainly in maxillary incisors.

6) Shovel-shaped incisors (shoveling)

This genetic characteristic is the most frequently studied among the morphological traits of teeth. After it was first mentioned by Hrdlička (1920), research showing a high frequency of this trait among Mongoloid peoples has been published (e.g., Hanihara 1966).

Shovelling refers to when the enamel of the edge of the mesial and distal incisors is extended toward the tongue. This lingual edge ridge is projected sufficiently to form the enamel border, creating a fossa in the lingual centre. Viewed from the lingual side, these incisors resemble a shovel. They are largely divided into four types depending on the degree of shovelling and the depth of the lingual fossa.

7) Double shovel-shaped incisors (double-shovelling, labial marginal ridges)

This trait refers to the extension of the enamel on the mesial and distal edge ridge of maxillary incisors toward the cheek and tongue (Dahlberg & Mikkelson 1947). The degree of expression varies; if is extensive on the buccal side, it is more projected because the development of the mesial edge is stronger than on the lateral side (Mizoguchi 1985). This trait is observed in incisors and canines but the expression rate of double shovelling is the highest in maxillary mesial incisors.

8) Canine distal accessory ridge

This characteristic refers to the accessory ridge of the distal surface on the lingual side of the mandibular canine. It is classified into five types depending on the degree of expression (Scott 1977). An expression rate of 20-60% is shown in modern human groups; a higher frequency is seen in Mongoloids and Native Americans with lower frequencies among Europeans.

9) Terra's tubercle

This additional tubercle occurs on the edge ridge of the inner surface of the maxillary first canine. It is also known as a marginal tubercle or dens evaginatus. It is generally seen on the inner surface, but appears on the mesial and distal surfaces in some cases. Among Koreans, the expression rate of Terra's tubercle on the inner surface was higher in ancient populations (Hu et al. 1999) in comparison to modern ones.

10) Carabelli's cusp

This abnormal tubercle appears on the lingual side of the protoconid of the maxillary first molar. It is also called the fifth cusp. The shapes of Carabelli's tubercle are diverse, ranging from small pits to complete cups. Several classification methods were devised by researchers including Dahlberg et al. (1956). Four classification methods of Scott and

Turner (2004) are generally used. Carabelli's tubercle is thought to be a feature stemming from recent evolutionary processes, and frequencies very among modern humans. This trait is not evident in fossil hominins.

11) Protostylid cusp

The protostylid refers to an accessory cusp occurring in front of the buccal side of the mandibular molar. It mainly appears in fossils such as Australopithecus and Meganthropus in Java, or Sinanthropus in China (Dahlberg 1951). No evidence of this trait is seen among modern people with the exception of the Pima Indians (southwestern United States), who exhibit frequency of 29.6% (Dahlberg et al. 1982).

12) Groove patterns of premolars

The shape of the lingual cusps in maxillary and mandibular canines is observed. In most cases, the upper jaw has one lingual cusp, but the number of lingual cusps in the mandible appears diverse. An occlusal groove pattern is determined depending on the number of lingual cusps and the occlusal groove shape. If the number of lingual cusps is one, it has an H or U shape; if it has two, it has a Y shape.

13) Cusp patterns of molars

The cusp shape and groove of molars have been utilised to describe the features among modern human groups including the relationships between their ancestors and descendants. The maxillary molar usually has three to four cusps with grooves dividing them. To record cusp size, Dahlberg (1951) classified the development of all four cusps into the "4" type the smaller size of hypocone into the "4-" type, the distal smaller cusp without hypocone into the "3+" type and no hypocone into the "3" type.

14) Mandibular molar occlusal cusp type

The occlusal cusp type of mandibular molar is determined by the number of cusps and grooves. There are generally 4-5 cusps depending on the type of groove. The types of grooves are classified into T, Y and X shape. Therefore, the occlusal groove types of mandibular molar are classified into the shapes of Y6, Y5, Y4, Y3, +6, +5, +4, X6, X5, X4 etc. (Zubov 2006). The Y5 type is found among most fossil hominins and the remaining types were recently developed in modern humans. Evolution from Y5 to +4 through +5 or Y4 is thought to be a general trend.

15) Mandibular molar distal trigonid crest

The presence of the crest connecting the protoconid-metaconid of the trigonid of mandibular molars is recorded. The lateral accessory ridge of the protoconid cusp and lateral accessory ridge of the metaconid cusp are often combined, forming a crest connected like a bridge.

16) Deflecting the wrinkle of the mandibular molar lingual front cusp

The occlusal ridge of the metaconid of mandibular molars generally leads straight from the cusp top toward the growth groove. However, a case in which this ridge is straight and refracted by being inclined toward the central fossa sometimes occurs. This trait rarely appears in the third molar. The expression rate among first and second molars is > 50% in Mongoloids and Native Americans, but does not exceed 15% in Europeans.

Research results of dental anthropological analysis

Research results from Korea

Broad studies on the presence of dental disease, human dietary habits, and morphological features of teeth were conducted by Jeong (1985) in Korea. This research included the size and shape of mandibular teeth in prehistoric humans. Using methods to reveal morphological characteristics of human teeth and evidence of prehistoric diets, the author estimated that humans in ancient times may have eaten relatively solid foods. Beyond these studies limited to individual archaeological sites, Hu et al. (1999, 2000) classified the teeth of various human groups including the Gaya, Goryeo, Joseon, and ancient groups to conduct an anthropological comparison. This represents the first study comparing morphological data from teeth across time. It examined the tooth features of ancient people and modern Koreans based on metric and non-metric traits. These results form the basis for further studies of morphological characteristics of the teeth among modern Koreans. However, this study is somewhat insufficient for comparison with ethnic groups in surrounding areas or examining dental morphological features in additional metric and non-metric traits

Mun (2002) analysed metric values of teeth to distinguish between male and female skeletons excavated from historical period (Goryeo-Joseon) tombs. They obtained the discriminatory power of 62.9-84.6% overall, 56.9-87.9% for men, and 40.0-86.7% for women. However, this method is applied only when the pelvis, skull, or humerus cannot be used for sex determination. It is also valuable when evaluating multiple human populations.

Pang (2010) compared Korean tooth assemblages excavated from archaeological sites containing Siberian ethnic groups. Excavation reports show that the frequency of the deflecting wrinkle of the lingual front cusp and distal trigonid crest observed in shovel-shaped incisors and mandibular first molars of Korean Peninsula inhabitants was the highest among the compared ethnic groups. In contrast, a low frequency of Carabelli's cusp was observed in maxillary molars. Changes in non-metric traits by age appeared to be significant. This may be the result of an influx of new genes to the population or a reflection of a local feature of Korean Peninsula inhabitants. Thus, this question can only be answered through interdisciplinary research comprising anthropology, genetics, archaeology and historical studies.

Koreans seem to show a combination of dental morphological features of Northeast Southeast Asian groups. Human remains from the Lake Baikal region including those of Buryat peoples were found to be closely related to the original Korean Peninsula inhabitants, thus supporting the theory of Siberian origin. Future interdisciplinary studies will help resolve these issues.

The following summarises several studies involving human teeth excavated from archaeological sites in Korea and various locations overseas.

The Busan Arch Island (Jodo) Ruins
Teeth were excavated from the Arch Island ruins by the National Museum in 1973. A forensic study of these remains was conducted, representing the first of its kind for archaeological remains in Korea (Kim 1976). Kim's publication provided details of method used to prepare teeth prior to analysis. For example, teeth were soaked in 10% acetone for 48 hours to remove impurities attached to tooth surfaces. Unerupted and incompletely calcified teeth were present. Fragments of enamel broken during processing were restored to their original state by using glue. Measurements were made on three specimens. Based on the anatomical shape and measurements of teeth and the mandible, these were estimated to be male. The occlusal tooth-wear indicated that these individuals consumed plants as their staple foods, despite being difficult to chew. This study shows how dental remains can be used to infer the dietary and cultural habits of ancient people.

Gyeongbuk Goryeong Jisandong Old Tombs
Age estimates of the buried individuals were based on teeth from the No. 35 grave and 32NW-2 grave among the Jisandong old tombs excavated by Keimyung University Museum in 1979. Results indicate that children aged between three and five years were buried there. Based on crown length measurements of these ancient deciduous teeth, their metric values appear slightly greater than those of modern infants.

Chungbuk Yeongcheon-ri Ruins
Research was conducted on human remains collected from the historical site located in Yeongcheon-ri Maepomyon Danyang-gun, Chungcheongbuk-do (Jeong 1985). They are currently under the protection of Professor Son Bo-Gi of the Museum Prehistoric Research Institute of Yonsei University. These remains comprised 33 portions (14 maxillae and 19 mandibles); 208 teeth remained in anatomical position and 152 were isolated.

Dietary habits were determined from the size and shape of teeth. In addition, scholars analysed dental caries, occlusal tooth-wear and traces in the buccal side of teeth resulting from ingested food.

Research results from overseas

Russia
Zubov (1968) and his protégé Haldeyeba (1979) greatly contributed to transforming dental anthropology as a field of interest in physical anthropology in Russia. They established the criteria for metric and non-metric traits and focused their research on examining the origins of ethnic groups using these methods. The metric values of teeth clearly show regional differences between ethnic groups. As a result of their results with metric data on Korean teeth, the tooth size of Koreans belongs to the middle tooth type and Europeans belong to the small tooth type. Therefore, the teeth of Koreans have typical Asian characteristics. The Evenki (formerly known as the Tungus) people are becoming relevant regarding the origins of Koreans. However, the Evenki have the small tooth type and are thought to be less genetically related to Koreans.

In addition, comparisons of non-metric tooth traits were made with Russian peoples from the surrounding area. Reports show that the typical dental characteristics of Koreans differ from those of the Chinese and Japanese including the high frequency of shovel-shaped incisors, the distal trigonid crest in the first molar, the deflecting wrinkle of the lingual front cusp, and the low frequency of Carabelli's cusp. This study provides valuable data about the origns and migration routes of Northeast Asian ethnic groups. Differences between ethnic groups as seen in ental traits did not form accidentally. Moreover, even the absolute size of teeth showing the degree of most the obvious degeneration shows differences between groups by the nature of the interaction and binding between genetic factors and functional factors between ethnic groups (Joel et al. 2011).

In their book, Zubov and Haldeyaba (1979) reported dental anthropological research results on ethnic minorities in Maritime Province, Russia. Their research focused on 15 traits in the teeth of 163 individuals in the regions of Krasny Yar, Mikhaylovka, and Agju. Results showed that ethnic minorities in the Maritime Province have typical features of Mongoloids including dental shovel-shaped incisors, crowding, six cusps in mandibular molars, and a high frequency of distal trigonid crests in the first molars.

United States of America

In the United States physical anthropology research focused on teeth has a long tradition with a profound impact on many scholars worldwide, including those in Korea. Researchers there have worked under the guidance of Richard Scott (University of Nevada, Reno) and Christy Turner (Arizona State University), who were especially influential in terms of learning the criteria for metric and non-metric traits.

Summarising extensive data collected by other scholars, Scott and Turner (2004) showed the affinity of ethnic groups in 21 regions based on 23 non-metric traits shown in the tooth crown and root.

Based on the data of Hanihara (1984, 1991, 1992), Turner published noteworthy results on the origins of the Japanese. He reported that the direct genetic relationship between present-day Japanese and Neolithic Jomon groups was non-existent based on dental morphological characteristics of nine individuals. This confirmed the theory on the origins of the Japanese based on teeth and skull data studied by Hanihara as well as the ancestral relationship of the Jomon for the Ainu.

Future research direction based on comparison of results

By clearly reflecting biological characteristics of modern humans, the metric and non-metric traits of teeth play a key role as anthropological indicators. In addition to the degree of tooth degeneration and its influence on metric characteristics and the degeneration of cusps, other useful non-metric traits include the frequency of congenitally missing teeth, the adhesion of tooth roots, reduction in molar rear space, overlapping teeth (Jang 1989), and reduction in absolute or relative size.

Among the key dental traits used in distinguishing Asians and Westerners, examples such as shovel-shaped incisors or Carabelli's cusp evolved in the distant human past, likely reflecting differences between hominin groups or gene flows. Those traits showing a wider distribution and higher frequency suggest a more ancient origin. Even in cases of poorly preserved human remains, teeth excavated from archaeological contexts are robust organic materials and thus more likely to be found intact. Therefore, they represent valuable resources for obtaining information on past humans including dietary habits, or sex and age of the buried individuals. As demonstrated in the results of Zubov and Turner, researchers must pay attention to the careful collection of teeth during excavations because they potentially provide key information on the origins and biological affinity of ethnic groups.

The awareness of the importance of human dental remains is quite low in Korea. However, as excavations accumulate data and scholars continue publishing research results, the scientific community will surely appreciate the value of these biological datasets for discussing the physical characteristics of past and present Korean Peninsula inhabitants.

Conclusion

Morphometric measurements of teeth are an efficient method to facilitate comparisons between human populations because they use generally defined measuring points. By evaluating published metric values for 10 tooth characteristics, we determined that teeth can be used to reveal the affinity between ethnic groups as well as to determine sex and to estimate age of individuals. Analyses of non-metric tooth traits should be combined with metric datasets, as the latter do not always fully reflect physical changes.

Non-metric morphological variations in human teeth potentially indicates characteristics specific to one ethnic group. Through a comparison of non-metric data of 16 traits observed in teeth, we evaluated whether the non-metric morphology of Korean teeth changed over time and if so, which traits illustrate this. Such data can be useful for showing cultural or physical characteristics of Koreans, e.g., dietary habits. In addition, it may provide clues about the origins and migration routes of Koreans through comparisons of data from people in surrounding regions.

This paper has summarised research results on human teeth excavated from archaeological sites from studies by Korean, Russian, and American scholars. We demonstrated how human dental remains and bones can be used in anthropological research. In situations in which the strict collection of data and precise analysis of human remains are not conducted at archaeological sites due to a lack qualified researchers or other conditions, scholars can refer to methods for identifying cultural and physical anthropological clues through human skeletal remains and teeth excavated from archaeological sites.

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Povzetek

Za antropologe, ki se ukvarjajo s arheološkimi, fosilnimi in forenzičnimi ostanki, da bi razumeli biologijo antičnih človeških skupnosti in sledili toku evolucije, je nujno, da posameznika identificirajo iz njihovih fragmentarnih ostankov, še posebej zob. Zobje so edinstveni med odpornimi anatomskimi deli fosilnih okostij, ki so bili izpostavljeni različnim silam skozi življenje posameznika. Dentalna antropologija je uporabna tudi za proučevanje živečih ljudi, pri katerem lahko uporabljamo številne tehnike, ki so v rabi za analiziranje starih ostankov. Ena izmed glavnih tem te discipline je preučevanje variacije velikosti in oblike zob, evidentiranih v odlitkih zobovij še živečih ljudi ali v lobanjah arheoloških in fosilnih vzorcev z uporabo metričnih meritev ter opazovanj nemerljivih lastnosti. Merljivi in nemerljivi podatki so bili zbrani iz objavljenih poročil o arheoloških najdiščih v Koreji in drugje. Ti podatki kažejo, da imajo Korejci, v nasprotju z vsemi ostalimi etničnimi skupinami, relativno veliko pogostnost več nemerljivih lastnosti. Zanimivo je, da imajo nižjo pogostnost Carabellijevih lastnosti v primerjavi z zahodnimi evrazijci. Glede na distribucijske vzorce lastnosti zob, imajo Korejci lastnosti, podobnim velikemu deležu populacij severovzhodne Azije in južnih skupin populacij severovzhodne Azije.

KLJUČNE BESEDE: dentalna antropologija, korejski zobje, sekalec v obliki črke, distalni trigonični greben, Carabellijeve značilnosti

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