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Contribution of antemortem tooth loss (AMTL) and dental attrition to oral palaeopathology in the human skeletal series from the Yean-ri site, South Korea

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Abstract: Antemortem tooth loss (AMTL) and degree of dental attrition are thought to be closely related to dental caries and periodontitis, not only in ancient human skeletal remains but also in modern humans. We examined these features in the Yean-ri skeletal series (AD 4rd to 7th centuries), South Korea. There is no significant difference between males and females in AMTL and degree of dental attrition, so the male and female data in the present study were pooled. However, a significant difference in the AMTL rate was observed between individuals of different ages, particularly in the posterior teeth of the lower jaw. A significant increase in AMTL was seen with increasing age. The degree of dental attrition was also correlated with age and was closely related to dental eruption. The prevalence of occlusal dental caries was low in the Yean-ri skeleton. Yean-ri people ate food that was much harder than the food eaten by modern day people; therefore, their dental attrition was considerable. Occlusal dental caries is speculated not to have occurred in an individual with occlusal surfaces, such as severe attrition. In other words, occlusal dental caries might have occurred in young people, but it would not have been found in individuals beyond a certain age, as dental attrition progressed with aging. If dental attrition was considerable, slight occlusal dental caries could have disappeared due to dental attrition, as in the modern Nigerian cases. Furthermore, severe dental attrition in archaeological samples was closely related to caries sites.

Keywords: Antemortem Tooth Loss, Dental Attrition, Yean-ri, Dental Paleopathology, Dental Paleoepidemiology, South Korea

1. Introduction

The Yean-ri site is located 9 km northeast of Gimhae City, South Korea. Human skeletal remains were excavated from this site between 1976 and 1980. Reports about these remains were published by the Busan National University Museum in 1985 and 1993 [1, 2]. According to these publications, the Yean-ri site dates to the 4th to early 7th centuries, AD. This time period corresponds to the Three Kingdoms period of Korea in the Gaya region and approximately to the Kofun period in Japan. We recently reported the presence of dental caries in these human skeletal remains [3]. In recent years, more detailed studies have been conducted on antemortem tooth loss (AMTL) and dental attrition [4-15]. Much paleoepidemiological information on dental caries can be obtained from AMTL and dental attrition data.

In the present study, AMTL and dental attrition states were examined in the human skeletal remains from the Yean-riKofun group in South Korea. The purposes of this study were to elucidate the rate of AMTL and dental attrition as they relate to the field of oral health and to

examine the dental paleoepidemiological factors to which the Yean-ri people were subjected.

2. Materials and Methods

The Yean-ri site is located 9 km northeast of Gimhae City, South Korea [3] (Fig. 1). Archeological exploration was performed at this site from 1976 to 1980, and human skeletal remains from 210 bodies were excavated; however, few individuals were well preserved. In the present study, teeth from a total of 54 individuals, including 17 males, 29 females, and 8 individuals of undeterminable sex or age, were examined. Sex and age were determined based on the reports of Kim et al. [1, 2].However, the methods of sexing and aging were not described in detail; thus, in this study, we estimated the age at death and determined the sex of these materials. If the pelvis was present, sex was determined using the angle of the greater sciatic notch [16]

Fig. 1. *The location of Yean-ri site, South Korea. The Yean-ri site is located 9 km northeast of Gimhae City, South Korea. The geography of Gimhae is characterizedby the Nakdonggang river, which divides into two andflows southward into the South Sea. A wide delta is created bysedimentation from the river. The elevation at the site is 60 m. Ingeneral, ancient burial mounds were built on hills, but the Yean-rigravesites were built on mostly flat land. In the Gimhae region, analtitude of 2 m above sea level is thought to have been under thesea until 1,300 years ago.*

Fig. 2. *The severe dental attrition often found in Yean-ri skeletal series.If cariouslesions were mild, the lesions could havedisappeared dueto progression of attrition.*

And Phenice's non-metric method for the os pubis [17]; if the pelvis was not present, sex was determined from the size of the mastoid process, the development of the brow ridge, and the condition of the occipital protuberance. Age was estimated comprehensively using the condition of the pubic symphyseal surface, which changes with age [18], closure of cranial sutures [19], and degenerative changes in bone, such as ripping and deformation of vertebrae.

Individuals of known sex were further examined after being subdivided into two age groups: the early middle age

group (ca. 20-39 years) and the late middle age and elderly group (ca. 40 years and over). No significant differences between males and females within each age group were observed. Therefore, AMTL and dental attrition were examined in a sex-pooled sample.

AMTL data were collected from alveolar bone. A tooth was considered present when its corresponding tooth socket was present (postmortem tooth loss [PMTL]; Fig. 2).

A tooth was considered absent (AMTL) when its alveolar bone was clearly resorbed up to complete closure of the socket. A chi-square test was used to test for significant differences in AMTL rate.

Dental attrition level was determined using Tochihara's method and classified into eight levels [20]. Please refer to Fujita [21] for a detailed schematic diagram of attrition levels. Comparison of attrition levels by age was performed using the Mann-Whitney U test.

3. Results

3.1. AMTL

The number of AMTL cases, the number of observable teeth (alveolar bone was preserved, enabling observation of AMTL), and the rate of AMTL are shown in Table 1. No significant difference in the AMTL rate of maxillary canines was observed between the early middle age group and the late middle age and elderly group. The AMTL rate of maxillary molars was higher in the late middle age and elderly group than in the early middle age group (Chi sq = 5.732, P = 0.017). No significant difference in the AMTL rate of total maxillary teeth or of mandibular canines was observed between the early middle age group and the late middle age and elderly group. The AMTL rate of mandibular premolars was higher in the late middle age and elderly group than in the early middle age group (Chi sq = 9.280, P = 0.002) as was the AMTL rate of mandibular molars (Chi sq = 20.168, P = 0.000). The AMTL rate of total mandibular teeth was higher in the late middle age and elderly group than in the early middle age group (Chi sq = 35.075, P = 0.000). The total (all maxillary and mandibular teeth) AMTL rate was higher in the late middle age and elderly group than in the early middle age group (Chi sq = 28.009, P = 0.000).

3.2.Dental Attrition

Table 1. Antemortem tooth loss by age group and tooth type.

	Early middle age			Significance	Late middle age and elderly		
	N of AMTL	N of Observable teeth	% AMTL	vs	N of AMTL	N of Observable teeth	% AMTL
Maxilla							
Incisors	7	99	7.0	–	0	53	0
Canines	3	50	6.0	n.s.	1	27	3.7
Premolars	6	99	6.0	–	0	50	0
Molars	16	118	13.6	*	19	58	32.8
Total	32	366	8.7	n.s.	20	188	10.6
Mandible							
Incisors	4	108	3.7	n.s.	3	56	5.4
Canines	0	56	0	–	2	29	6.9
Premolars	5	112	4.5	**	14	60	23.3
Molars	25	152	16.4	***	46	81	56.8
Total	34	428	7.9	***	65	226	28.8
Grand total	66	794	8.3	***	85	414	20.5

n.s.: not significance, *: P<0.05, **: P<0.01, ***: P<0.001

Table 2. Degree of dental attrition by age group and tooth type.

	Early middle age			Late middle age and elderly			Zcal	P value
	N	Average	SD	N	Average	SD		
Maxilla								
Incisors	65	4.2	0.87	25	5.2	0.59	5.670	0.000
Canines	37	4.1	0.97	17	5.2	0.66	4.210	0.000
Premolars	73	3.1	1.23	27	4.8	1.17	5.924	0.000
Molars	94	3.3	1.33	29	4.8	1.47	4.651	0.000
Mandible								
Incisors	80	4.1	0.68	35	5.3	0.56	7.646	0.000
Canines	48	4.2	0.79	20	5.5	0.51	5.973	0.000
Premolars	96	3.3	1.04	37	4.7	1.07	5.844	0.000
Molars	116	3.5	1.24	30	5.0	1.09	5.908	0.000
Total	609	3.6	1.15	220	5.0	0.99	14.948	0.000

The percentage of the 829 observable teeth with dental attrition and the average and standard deviation (SD) attrition level by tooth type are shown in Table 2. In all tooth types in both the maxilla and mandible, dental attrition levels were higher in the late middle age and elderly group than in the early middle age group. The dental attrition level was statistically significantly higher in the late middle age and elderly group than in the early middle age group in the Yean-ri skeletal remains (Z=4.210-14.948, P = 0.000). Dental caries in the Yean-ri skeletal series occurred most frequently on the NRAS (neck and/or root of the approximal surface), which accounted for 76% of dental caries overall. The next highest incidence was on the AS (approximal surface) at 12%. There was a significant difference between the total incidence of coronal and root caries. Root caries occurred more frequently than coronal caries (Chi sq = 18.155, p = 0.000).

4. Discussion

AMTL is closely associated with aging, and dental caries and periodontal disease are thought to be the causes of such loss. Detailed data analysis showed that there was no change in AMTL with aging for maxillary teeth, excluding molars. In mandibular teeth, there was a significant difference in AMTL with aging for premolars and molars, but not for canines. The incidence of AMTL was significantly higher (at the 0.1% level) in the mandibular teeth compared to the maxillary teeth. In the Yean-ri people, the incidence of caries was higher in the maxillary teeth than in the mandibular teeth [3]. Although loss of maxillary teeth could have been associated with caries, it is speculated that the major cause of such loss was periodontal disease. Wasterlain et al. reported that the incidence of AMTL was high for molars[22]. This result was consistent with the incidence of caries. They also reported that the incidence of AMTL was low for the anterior teeth. Eshed et al. reported that the incidence of AMTL was higher for the maxillary teeth than for the mandibular teeth[23]. This result was consistent with ours. Cusina and Tiesler speculated that the cause of AMTL was caries [24]. Leiverse et al. examined AMTL and periodontal disease but did not clearly state the major causes of AMTL [25]. AMTL is thought to have multiple causes, including caries. There are some theories about the cause of AMTL that vary among researchers. The authors have considered repeatedly the cause of AMTL in the human skeletal remains and feel that most originates in periodontal disease. It is believed that this applies to the Yean-ri human skeletal remains. Future studies should carefully examine the concept of AMTL. According to the Japanese National Survey of Dental Diseases of 1999 [26], the numbers of teeth present (numbers of remaining teeth) were 25.22-28.55 in individuals aged 20-49 years. These numbers were lower than the numbers of teeth present in author H.F.'s investigation of the people in the Kofun, Kamakura, and Muromachi periods [27]. Author H.F. also reported on a study that showed that an unexpectedly large number of teeth remained in people of the Edo period [28]. Thus, the aforementioned investigation showed that a large number of teeth remained in people from periods earlier than the Edo period. The notion that "people of long past ages lost more teeth at younger ages" is clearly untrue, and it is not supported by studies of ancient skeletal remains in Japan or by studies of the Yean-ri skeletons in South Korea.

Leiverse et al. did not consider the relationship of dental attrition with caries [25]. The results of Eshed et al. revealed that teeth that erupted earlier had a higher level of dental attrition [23]. It is very interesting that this result is similar to ours [29, 30, 5]. However, our speculation on the relationship between dental caries and dental attrition is that the incidence of caries was low because dental attrition was severe due to a poor diet and a diet consisting of hard foods. We were probably first to report that, in ancient people, carious lesions were less likely to occur on occlusal surfaces flattened by severe attrition and that mild carious lesions disappeared due to severe attrition, and teeth likely became sound [29, 31] (Fig. 3). Periodontal disease also occurred in ancient people, and root caries occurred on exposed roots.Their dental attrition was considerable.
Occlusal dental caries is speculated not to have occurred in an individual with occlusal surfaces, such as severe attrition. In other words, occlusal dental caries might have occurred in young people, but it would not be found in individuals beyond a certain age, as dental attrition progressed with aging. If dental attrition was considerable, slight occlusal dental caries could have disappeared due to dental attrition, as in the modern Nigerian cases [32, 33].

Fig. 3. *Root caries in Yean-ri skeletal series. The severe dental attrition and periodontal diseases prevent occlusal caries.*

5. Conclusions

When caries is examined in ancient human skeletal remains, one should note AMTL and the dental attrition level. In addition, AMTL and the dental attrition level are likely closely associated with oral health, including dental caries and periodontal disease. Physical anthropologists handle ancient skeletal remains just like those in this study. We studied these remains to compare ancient and modern people to understand various problems and to find new perspectives. If a good cooperative relationship can be established between the fields of modern dentistry and physical anthropology, there could be major contributions to dental and medical care for modern-day people.

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