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A case study of oral and dental diseases (stomatopathy) in the late medieval period of Thuringia, Central Germany

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Abstract

Interpreting dental "health" in archaeologically discovered skeletal assemblages is difficult due to the lack of patient history, unclear pathological processes, broad etiologies, and cultural understanding of hygiene. Analysis of oral pathology is often part of bio-archaeological and paleo-pathological studies. Although accurate, oral health can also provide insights into general or systemic health. This article examines pathological conditions of the oral cavity in the medieval period and evaluates the paleopathological conditions of the oral cavity. This article investigates the relationship between oral health and health in the past by examining the relationship between oral pathology and mortality in a cemetery sample from medieval Germany. The skull was found during excavations at the archaeological department of the Erfurt Monument Conservation Office in the northern Sulze district of the central German state of Thuringia and may date from the 13th to the 14th century. The current study suggests that stomatopathy can be used as an informative indicator of general health in past populations, which examines an individual's oral and dental pathologies from the late Medieval Age. The analysis focused on odontological analysis and some dental parameters such as tooth wear, caries, and periodontitis.

Keywords: Archaeozoology, Central Germany, Dental health, Medieval Age

Introduction

The health and lifestyle of past people are reflected in dental remains. Dental remains are a valuable source of information about diseases, nutrition, and social stratification of different populations and different spaces and times (Lopez et al., 2012). They are particularly useful as an aid for interpreting the lapses in living conditions and habits between areas and times, and the change (gradual or abrupt) of cultural traditions. For example, the transition from Roman culture to the early Medieval Age was reflected in changes in the incidence of dental diseases, such as dental caries, abscesses, antemortem tooth loss, calculus, alveolar resorption, attrition, enamel hypoplasia, and also dental wear, hypoplastic defects, and chipping (Belcastro et al., 2007; Lopez et al., 2012). Teeth represent the hardest tissue of the human body and are more resistant to chemical and physical destruction than any other element of the skeleton. Therefore, dental and oral diseases (Stomatopathy) provide essential information on the health status of past populations over different periods. Many factors influence such conditions, reflecting differences in diet, alimentary behavior, physiological and hormonal aspects, access to medical care, and social roles (Giuffra et al., 2020). We can evaluate oral health and diet composition and selection from a good parameter: the frequency of carious lesions in past populations (Mant & Roberts, 2015; Pezo & Eggers, 2012; Pedergnana & Huber, 2024). Paleo-pathology involves the study of diseases of the past. Various oral and dental pathologies are frequently analyzed in bio-archaeological and paleo-pathological investigations of the skeletal remains of past populations. These pathologies include dental caries (i.e., cavities), enamel hypoplasia, periodontal disease, and ante-mortem tooth loss (Witte & Bekvalac, 2011). As a descriptive term, health is often used in the bio-archaeological literature to refer to evidence of change in fossils. However, the World Health Organization considers psychological and social factors as important in health assessment, in addition to diseases in the body (WHO, 1948). Reitsema and McIlvaine (2014) also noted that in a variety of diseases, many of the pathological changes observed in bones and tissues can be caused by oral health measures becoming more important, the lack of patient history, medical records, and environmental conditions leading to inconsistencies in the use of concepts, understanding of disease etiology, and collection of observations in bio-archaeological contexts (Pilloud & Fancher 2019; Zejdlik et al., 2019). Bio-archaeologists are equipped to meet this challenge by using different methods to integrate cultural and biological data to investigate paleopathology. Even the examination of bones can provide information about many connections. Age, sex, height, stature, and facial features can often be easily reconstructed (Alt, 1997; Herrmann et al., 1990). The human skeleton also preserves important information about a particular individual's social and biological characteristics (Böcker et al., 2004; Schreiber, 1986; Zejdlik et al., 2019). The dental treatments found in ancient Egyptian documents were horrific. Many pharaohs suffered from oral diseases that caused them to die quickly. It can also be seen that this serious complaint influenced the patient's political decision. This question is important. The present skull was recorded from excavations carried out in 1996 by the city archaeological department of the Erfurt Monument Protection Office (Lower Monument Authority) in the development of the work area north of the Sulze junction proper to the Sulze area. The bones came from the church apse and were dated to the 13th century. The bones were used as a sample here because of the good pathological findings, the etiology's completeness, and the disease process's effective development. How unhealthy people felt about their oral health in the Middle Ages is unclear. Literature related to oral 'health' during the medieval period is often derived from skeletal assemblages and the interpretations of modern researchers. That is the problem with the casual use of the word 'health'. It is temporally and socially complicated to define. In the case of the medieval oral condition, dental medicine and hygiene made important advancements during the medieval period. From that, we argue that we can infer that the numerous treatments for dental pain and dental hygiene resulted from medieval concern for oral care (Zejdlik et al., 2019). Such archaeological finds provide insights into past health conditions and diseases in humans and animals. A reliable distinction between different animals and human bones is a prerequisite; however, it is important to note that interpretation of such findings should always be done cautiously, as different diseases can cause similar symptoms, and modern diagnostic techniques in archeo-zoology are limited (Hunger & Leopold, 1978; Karl & Safi, 2024a; 2024b). Khodadoust et al. (2013) illustrated and interpreted the dental and oral diseases in the Medieval Age in Persia from a book written in Persian by Abubakr Rabi ibn Ahmad al-Akhawayni al-Bokhari and his book, Hidayat al-Mutallimin fi-al-Tibb (Learner's Guide to Medicine). There are two chapters related to oral and dental diseases in the Hidayat: a chapter on dental pain and a chapter on buccal pain. Akhawayni's views on dental diseases and treatments are mainly based on anatomical principles and are less influenced by humoral theory, and no mention of charms, magic, and amulets. The false idea of dental worms cannot be seen in his writings. Using an anesthetizing fume, natural antiseptic, cutting the dental nerve to relieve the pain, and keeping the tooth extraction as the last resort deserve high praise. The advantage of oral health indicators for bio-archaeological studies is that, given the highly mineralized nature of teeth, they provide a relatively durable record of the patterns of health within past populations (Roberts & Cox, 2003). Many anthropological studies examine oral pathologies as a proxy measure for general health. Several studies have demonstrated that enamel hypoplasias, enamel defects that reflect interruptions in enamel formation as a result of physiological stress, are reflective of general levels of health (Goodman & Rose, 1990; Boldsen, 2007; Witte & Bekvalac, 2011), and many studies use enamel hypoplasia as a non-specific indicator of stress or health in skeletal samples. But do other oral diseases frequently observed in anthropological studies still provide more information about oral health? Are oral diseases a result of the health model? The current article is an attempt to increase our understanding of stomatopathy in the Medieval Age in central Europe and its management. This would increase our historical understanding of the dental and oral problems that existed in the Medieval Age in central Europe.

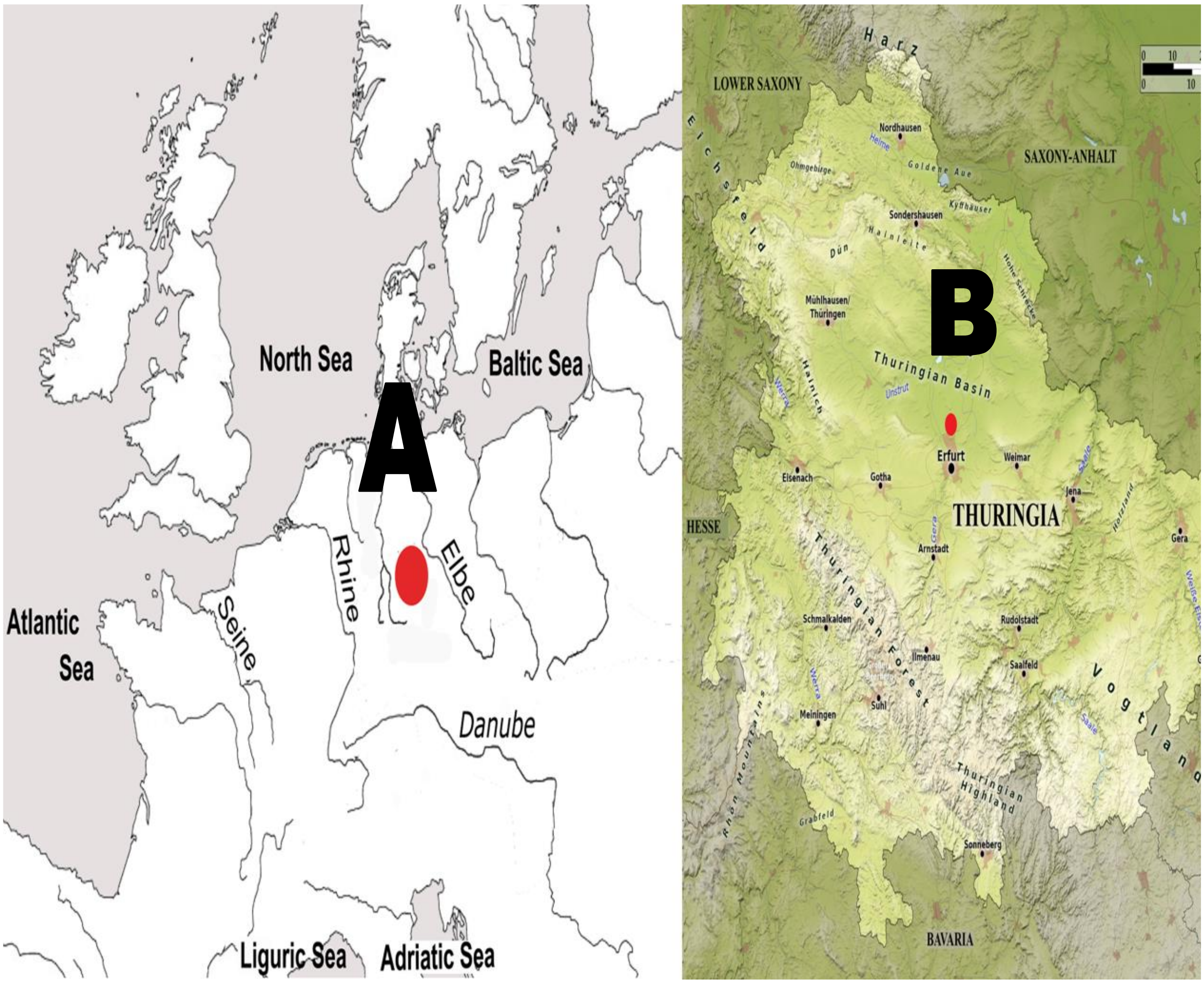

Figure 1. (A) Location of the Thuringian Province in central Germany, **(B)** Position of the locality north of the Sulze, near the town of Erfurt

Material and methods

A human skull with complete jaws and teeth was recovered from a grave complex in the cemetery around the church Apse ruins in the Sulze village, in Thuringia in 1996, which was destroyed by construction work. The depth of the find could be dated to the level of Medieval graves (13th-14th centuries). The images were taken with a Sirona 2D/3D hybrid device Orthophos XG 3D (Fig. 2). All measurements were taken using anthropological measuring devices such as double calipers, circles, and precision measuring tape per international standards.

Figure 2. Sirona 2D/3D hybrid device Orthophos XG 3D in Dr. med. dent. George Gabbour Dental practice in Erfurt

Geographical context

The present skull was recorded from excavations carried out in 1996 by the city archaeological department of the Erfurt Monument Protection Office (Lower Monument Authority) in the development of the work area north of the Sulze junction proper to the Sulze area. The bones came from the church apse and were dated to the 13th century. Geographic coordinates 52º 01´ 59´´ N 11º 02´ 36´´ E (Fig. 1). Relevant materials have already been published by Jelitzki (2012-13), Karl (1997, 2012-13), Karl, Tichy & Müller (2006).

General pathological and anatomical conditions of the oral cavity

Periodontal diseases include diseases of the dental environment. The bone surrounding the tooth has broken down. The receding gums expose the necks of the teeth; the teeth become loose and eventually fall out. These diseases can affect one or more teeth or entire groups of teeth and the entire jaw. The process takes place in two stages or forms:

1. Periodontitis primarily originates from the gum line. The symptoms include swelling, drainage of pus under pressure, and frequent light bleeding (acute course).
2. Periodontitis appears in the early stages of gum recession without any inflammatory changes. Some of the teeth are partially exposed. The predominant factors are the indentation of the teeth into existing gaps and the dissolution of the bone (chronic course).

Both forms often merge into one another and can coexist, and have internal or external causes. The internal ones can be metabolic diseases (diabetes, gout), disorders of internal secretion, and vitamin metabolism, the external ones can be vitamin C deficiency, tartar deposits, protruding crowns, over-under-incorrect loading during individual chewing phases, or night-time teeth grinding. Occasionally, although previously more common, inflammation of the maxillary sinus (sinusitis) occurs. In these cases, the inflamed root tips lie directly beneath the maxillary sinus (maxillary sinus), and sometimes they even protrude into it. The loss of such a tooth, usually the second premolar or a molar, can lead to the opening of the maxillary sinus. If foreign bodies such as root residues get into the maxillary sinus, acute or chronic inflammation will certainly follow. It is accompanied by a blockage of the nose, eczema at the nasal entrance, a circumscribed dull feeling of pain that increases with exertion or a change in position of the head, also headaches, fatigue, possibly an increase in temperature, and smelly pus discharge. These diseases of the oral cavity listed here can be the starting point for a focal infection. In the case of a focal infection, bacteria and their toxins are spread from a source of infection via the blood and lymphatic system to distant organs or the entire organism. Secondary symptoms of the disease then appear, some of which can have their own character. In around 15% of all cases today, the source is said to be in the dental system. In principle, every organ can be affected by a focal infection. The heart and vascular system, as well as the muscular and joint system (rheumatic diseases), are particularly frequently affected. Persistent fatigue, headaches, insomnia, nerve function disorders, and digestive system disorders can be signs. If a tooth is deprived of its nutritional organ, the pulp, there is a compelling possibility of bacteria staying in the root canal, which destroys the bone tissue surrounding the latter. Under the premise that there are around 58 root canals in a complete set of teeth, the high danger that lies in the dental system as an entry point for germs becomes clear (Fig. 3).

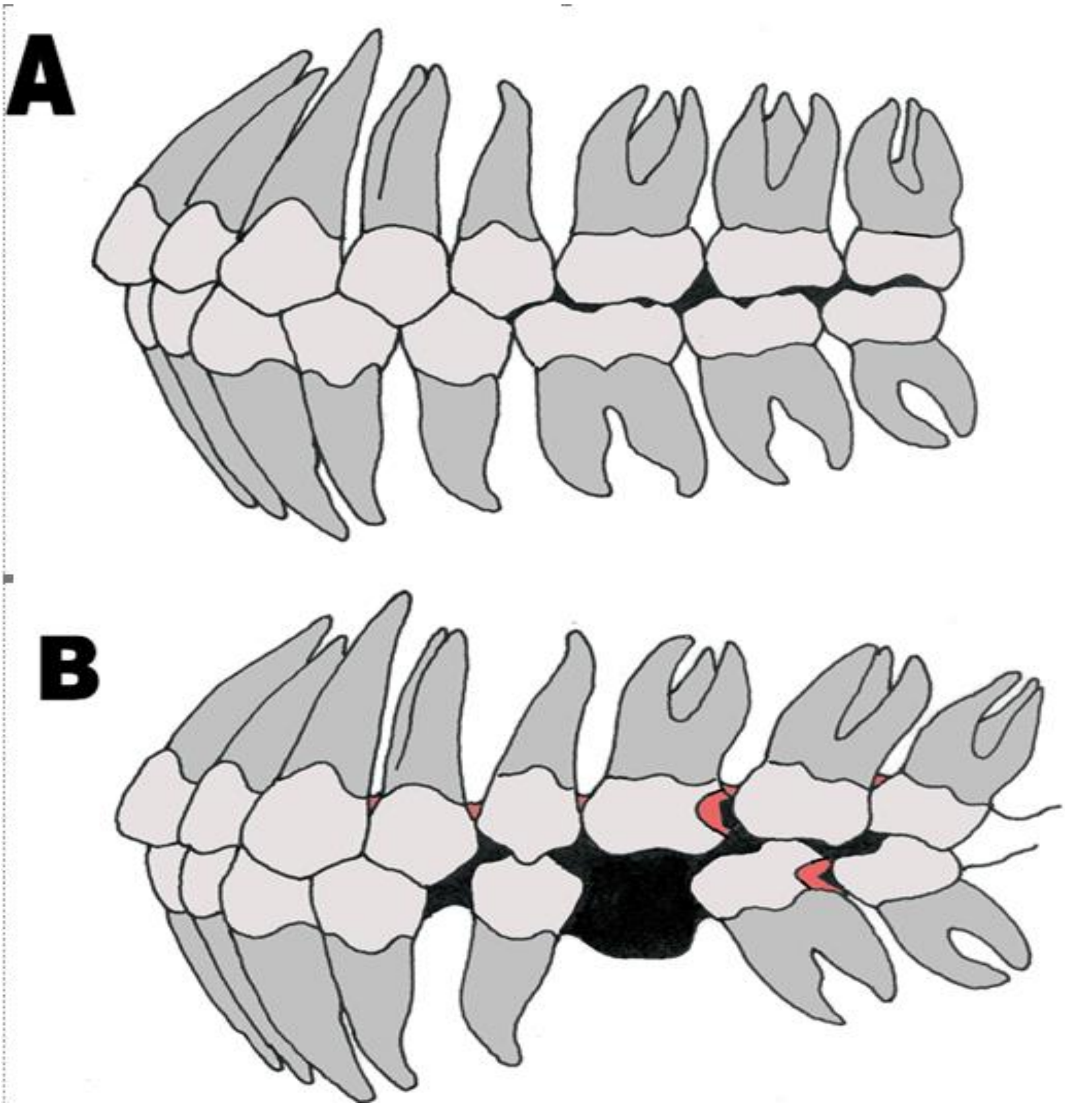

Figure 3. Comparison to the biostatistics of the human dentition according to Schuhmacher, 1983. **(A)** Normal occlusion, **(B)** Disturbed occlusion after loss of the lower M1. A case study of an individual from the Sulze village near Erfurt

Description of the material

The two parts of the jaw show such impressive pathological findings that allow a reconstruction of the course of the disease up to death so it is justified to present them in detail (Fig. 4).

Dentition

UJ	X	X	M_1	P_2	X	C	I_2	I_1	I_1	I_2	C	P_1	P_2	X	X	X
LJ	M_3	M_2	X	P_2	P_1	C	I	I	I_1	I_2	C	P_1	P_2	X	M_2	M_3
				dexter									**sinister**			

(UJ= upper jaw; LJ= lower jaw; X= missing during lifetime; I= incisive; C= canines; P= premolar; M = molar.)

Upper jaw

The upper middle incisors (I1) have been ground down on the cutting surface to create areas of 9x3 mm, the dentin is exposed. The corresponding anterior alveolar walls are thin and, on the left, may have already been destroyed to such an extent that the root was exposed. The upper lateral incisors (I2) are worn in the same way. The areas are 6x2 mm. The upper canine (C) is even further sanded down. There are no longer any cusps or side humps detectable. A clear abrasion trough is formed on the right. The chewing surface of the left upper first premolar (P1 sin.) has also been ground down to the dentin and no longer reveals any surface structures. The right one is missing except for a small root fragment still stuck in the inner alveolar wall. The entire surface of the tooth socket of this P1 is severely eroded and the walls are eaten away. The fracture surface of the root stump shows tartar and the rear outer area of the fracture edge shows a ground facet, which clearly shows that the defective tooth was still in use. The upper P2 shows pronounced abrasion troughs, as does the upper M1 dex. On a rear upwardly inclined cut facet. Otherwise, the grinding is not as strong as with the other teeth. The corresponding M1 sin. missing. Here only the enlarged tooth socket can be seen, the inner wall of which has been breached by inflammation. The compartment of the posterior inner root still contains its fragment, which has broken through upwards into the maxillary sinus. The upper M2 and M3 are completely missing and the alveoli are closed again, although the newly formed bone surface shows some structural defects.

Lower jaw

The teeth in the lower jaw, although also ground down to the dentin, are far more complete than in the upper jaw. Only the two lower M1s are missing here. At the level of their closed alveoli lies the axis of a slight bend, which slightly angles the front part of the lower jaw with the front teeth. Just like on the upper jaw, tartar is widespread here. The thick armor forms on the front teeth. The outer surface of the upper chin area is notched in the alveolar region of the anterior teeth. The outer walls of the tooth sockets of the front teeth appear as raised ridges.

Abrasion levels

	Level 0&1	Level 2	Level 3	Level 4
Upper jaw		P_2, M_1	I, C	P_1 dex.
Lower jaw		M_2, M_3	I, C, P, M_2	

According to Saller's (1957) five-point scale: 0 = no wear; 1= enamel affected, but cusps still visible; 2= the darker dentin is exposed in individual areas; 3= the entire enamel of the chewing surface has been ground away; 4= Crown worn down to near root neck.

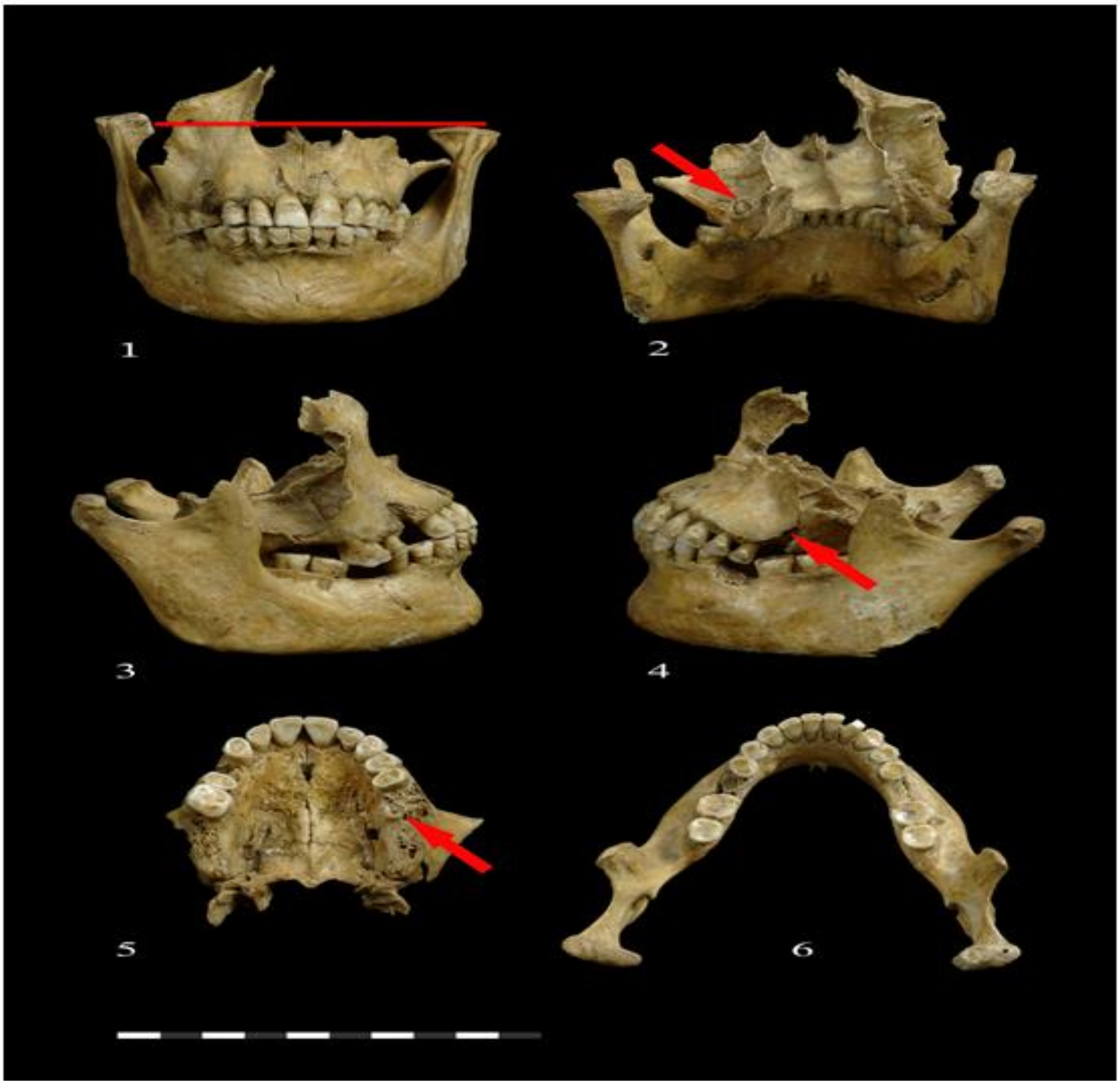

Figure 4. Upper and lower jaws from the Sulze village. 1: Lateral dex.; 2: Frontal; 3: Lateral sin.; 4: Palatal maxilla; 5: Sinus maxilla sinistra with bone defect and remaining root tip of the M1 sin. 6: Mandibles (Lower jaw with teeth). Note the palatal axis twisted to the left

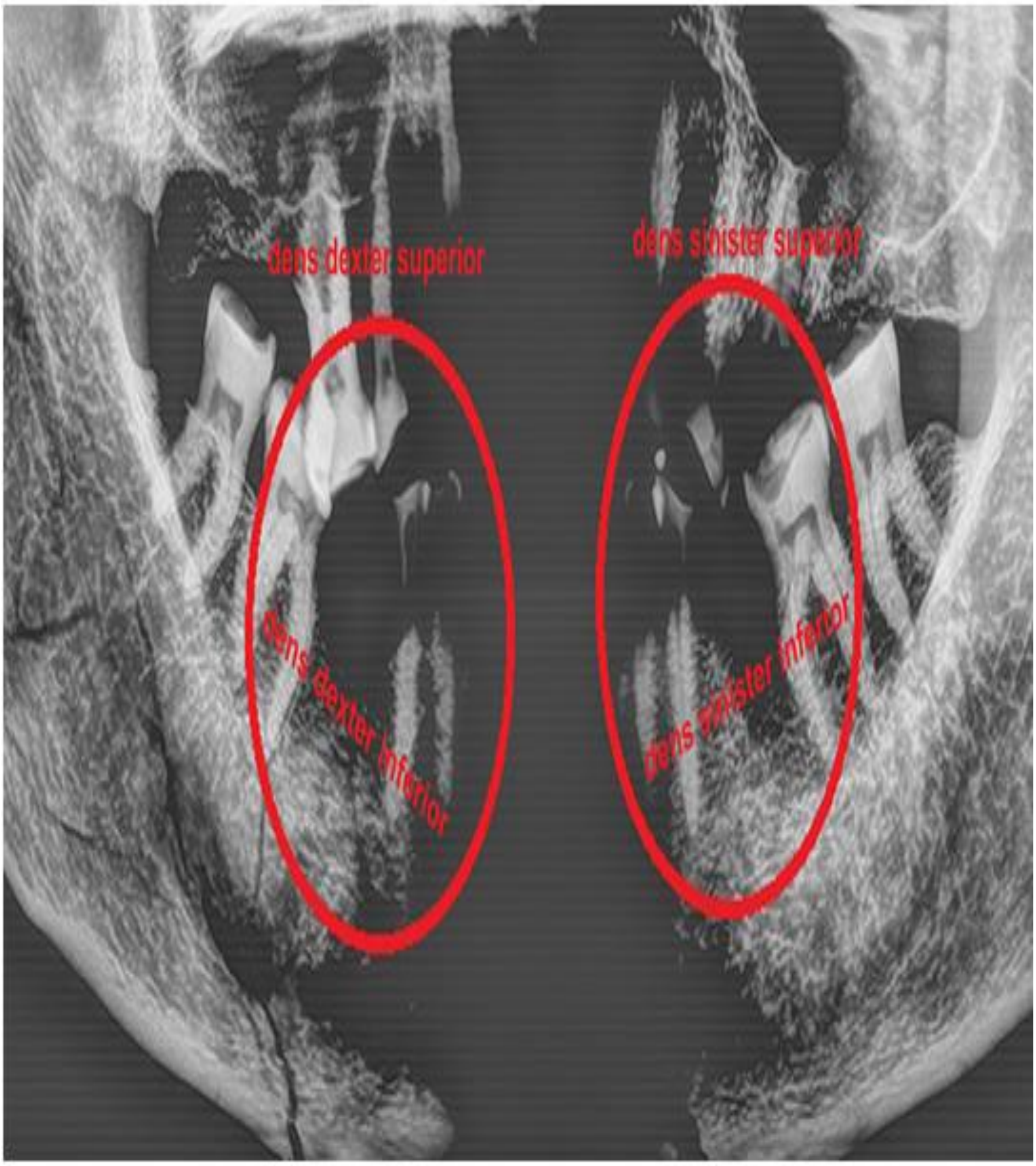

Figure 5. The two right and left-sided dentition erosion holes (Debris cavities) around the first lost P1

Results

According to the range of variations in the jaw indices given by Saller (1957), the following conditions can be determined for the present studied sample of skull:

- The maxilla-alveolar index of 106.66 falls in the spectrum of x-109.9, corresponding to a dolichuran type;
- the palatal index of 74.07 falls in the spectrum of x-79.9, which corresponds to a narrow-gauge type (lepto-staphylinid);

- the palatal cavity index of 30.00 falls in the range of 28.0-39.9, which corresponds to a medium-high palate type (Ortho-staphyline);
- The length-width index of the mandible of 64.91 falls in the spectrum of x-97.9, which corresponds to a dolichostenomandibular type.

These features, which generally represent narrow and long-headed skulls, combined with the rather small teeth (especially in the lower jaw), suggest that these could be the remains of a woman's skull. The lower jaw weight is 87.5 g. The stronger development of the body and the angle of the branch, on the other hand, suggest a male individual. In this, probably more likely case, the smaller dimensions on the upper jaw and in the alveoli and tooth areas of the lower jaw could be explained by growth disorders of the bone as a result of pathogenic processes. A reliable determination of gender is therefore not possible. Based on the degree of chewing of the teeth and taking into account the severe pathological changes, an individual's age at death of around 30 years can be assumed. In the present case, the remaining traces on the bones allow a reconstruction of the course of the disease up to and including death. For this purpose, a chronology of events will be drawn up based on the introductory summary of the etiology of dental and jaw diseases and their significance as sources of infection. This must have as its starting point the functional structure of the teeth, with each tooth having a specific shape and size determined by its specific function. The tooth size varies relative to the dimensions of the crowns. The incisors are furthest from the pivot point of the lower jaw and are the smallest. As you approach the pivot point, the size of the teeth increases, meaning that the molars in the force field of the chewing muscles are the largest. The dental crowns increase in diameter from anterior to posterior while decreasing in height, except for the canine. In the lower jaw, the tooth sizes increase from the incisors to M1 and then decrease again to M3. An even distribution of pressure and tensile forces on the jaw prevents overloading of the periodontium. If a gap bite is left untreated, the teeth tilt and migrate, but the teeth opposite the gaps also grow out. As mentioned at the beginning, such changes ultimately lead to periodontal damage and even the loss of teeth. The gapless dental arch is therefore of fundamental importance, and its lack is the cause of the dramatic course of the disease in the present individual from Wüste Sulze. In addition to the age-related loss of the periodontium, there is also a lack of oral hygiene due to cultural and historical reasons. The process, which lasted over a long period of life, probably began with fissure caries in the two lower M1s, which ultimately led to their loss. This process has also spread to the two lower M2, which are the only ones that still show small traces of fissure caries. The loss of the M1, the largest tooth in the lower row of teeth, was probably the decisive event. The top two M2 and M3 were also probably lost early on in this way. This can be concluded from the completely closed alveoli. Since there is an asymmetrical displacement of the left maxilla to the lower left, an early disappearance of the left M2 and M3 is more likely than that of the corresponding right. This also includes a remodeling that deflects the dorsoventral axis several degrees to the left across the median palatal suture, causing the contact points of all remaining teeth to shift. The contact point of the upper I1 is now above that of the lower I1 and I2. The normal tooth-to-two-tooth relationship was broken and shifted to a nearly one-tooth-to-one-tooth relationship. So, the normal occlusion largely no longer existed. Another consequence of these tooth losses and bone displacements was increased wear and tear on the upper M1 sinus. through the lower M2 and M3. Maybe at the same time, Dex was running on the upper P1. Severe periodontitis/periodontal disease, which may have been caused by the remaining root tip of an erupted carious tooth. Since there is an alkaline environment in the oral cavity right from the stage of periodontitis, the caries attack is stopped in its chronic course, as caries needs an acidic environment. The carious remains must therefore be the oldest findings. The posterior inner root of the superior M1 sin. It was probably stuck in the alveolus for a long time because, as described above, it shows a ground facet on the rear inner edge that could only have arisen through use, and, in terms of its location, is from the M2. was caused. Similar to P1 sin. It happened with the M1 dex. Due to the remaining remnants of the outer roots, a periodontal progression occurs. These roots have not been passed down (Fig. 5). The final event in the upper jaw area, the penetration of the infection into the inner root of the M1 sin, was probably unsurpassed in terms of drama. In the maxillary sinus sinistra is partial destruction of the bone wall (Fig. 4). As explained at the beginning, general sepsis is to be assumed, which may ultimately lead to rapid and painful death, accompanied by endocarditis. Furthermore, it can be noted that the massive one-sided shift in chewing activity to the right, caused by the caria at M2 sin., resulted in excessive stress on the dexter mandibular condyle. The compactness of the corresponding joint bone can represent this stress. Deformation of the lower jaw can also be seen due to the one-sided chewing activity, as well as a stronger development of the pterygoid process due to the temporalis muscle located here. In such severe forms of periodontitis/periodontosis, a vitamin deficiency disease such as scurvy must also be considered as an underlying disease (Herrmann et al. 1990). In addition to fatigue, paleness, and arm and leg swelling, these deficiency symptoms also manifest themselves in loosening of the teeth, gum ulcers, and bleeding. In the present lower jaw, all alveolar areas, including those of the anterior teeth, are affected. The course of abrasion can be assumed to range from a primary demastication caused by abrasives in the food to a secondary predominant attrition as a result of changed occlusion conditions resulting from the massive tooth losses. Especially when using grinding stones made of limestone or sandstone (proven as excavation finds), a high proportion of grindable mineral food additives can be expected. For the prehistoric grinding methods and millstone types, especially in the Thuringia area (Gall, 1994).

Attachment: Measuring sections, Angle, Dental arches, Indices

54	Nose width	25,00
60	Maxilloalveolar length	60,00
61	Maxilloalveolar width	64,00
61(1)	Posterior maxilloalveolar width	66,00
61(2)	Vordere Maxilloalveolarbreite	46,50
62	Palate length	54,00
62a	Straight-line removal of the oral cavity from the tip of the posterior nasal spine	42,00
62(1)	Anterior maxillary palate length	39,00
63	Palate width	(40,00)
63a	Largest width (here middle M1)	40,50
63(1)	Final palate width	64,50
63(2)	Anterior palate width	33,50
64	Palate height	12,00
64a	Anterior palate height	11,00
65	Condylar width of the lower jaw	114,00
65(1)	Coronoid width of the lower jaw	113,00
66	Angular width of the lower jaw	93,50
67	Anterior mandibular width	50,50
68	Length (depth) of the lower jaw	74,00
68(1)	Distance between the most prominent point of the anterior chin plate and the most posterior condylar surfaces	105,00
69	Chin height	32,50
69(1)	Height of the corpus mandibulae	33,00
69(2)	Distance of the alveolar edge from the lower edge at the level of M2	32,50
69(3)	Thickness or width of the mandibular body	12,00
70	Branch height	58,00
70a	Distance of the highest point of the capitellum mandibulae from the lower edge of the bone	57,00
70(1)	Anterior branch height (coronoid height)	66,00
70(2)	Smallest branch height	50,50
70(3)	Height (depth) of the mandibular notch	15,00

71	Branch width	37,00
71a	Smallest branch width	31,00
71(1)	Width of the Incisura mandibulae	37,00
79	The branch angle of the lower jaw	121°
80	Dental arch length of the upper jaw (right only up to M1)	41,50
80a	The dental arch length of the lower jaw	52,00
80(1)	Dental arch width upper jaw/lower jaw	56,00/ 80,50
80(2)	Dental length of the lower jaw	41,50
80(3)	Molar length (M1 missing)	28,00
154	Maxilloalveolar index	106,66
158	Palate index	74,07
159	Palate height index	30,00
162	Width-length index of the lower jaw	64,91
162	Height index of the lower jaw	100,00
163	Index of the mandibular ramus	63,79
163a	Smallest branch height/smallest branch width	61,38
164	Width index of the lower jaw	82,74
165	Index of the Incisura mandibulae	40,54
166	Height-thickness index of the corpus mandibulae	36,36
167	Dental arch index of the lower jaw	154,80

Conclusion

In this paper, we tried to interpret the oral paleo-pathology of a medieval individual skull, which was recorded in 1996 by the city archaeological department of the Erfurt Monument Protection Office (Lower Monument Authority) in the developmental work from the church Apse, north of the Sulze District of Thuringia, and was dated to the 13th century. This skull was studied for stomatopathy in light of some dental parameters (such as tooth wear, tartar, calculi, dental caries, etc.), as these parameters are signs of the overall nutrition of an individual. Therefore, in many cases, they can be more related to the social status of the individuals. For example, many carious lesions in wealthy individuals may indicate increased access to expensive carbs, such as honey and other sweets. Due to various taphonomic factors, what archaeologists excavate today is only a part of this fraction, as the Medieval cemetery represents only a portion of the population at its establishment. More importantly, the anthropological literature is often sub-sampled for studies like the one presented here. These conditions would limit the description of public behavior and lifestyle.

Studies comparing oral health and its severity would indicate different lifestyles and diets of other groups in the past, and more effort into this guideline would provide a different picture of past society. An element that may help in such interpretations is the presence of grave goods in early medieval cemeteries. The number of teeth lost in the antemortem could be associated with severe carious lesions resulting in pulp necrosis and tooth shedding, not only with age or periodontal disease.

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Declaration of competing interest:

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Alt, K. W. (1997). Odontologische Verwandtschaftsanalyse: Individuelle Charakteristika der Zähne in ihrer Bedeutung für Anthropologie, Archäologie und Rechtsmedizin. Fischer Verlag.

Belcastro, M. G., Fornaciari, G., Mallegni, F., Mariotti, V., Consiglio, C., & Facchini, F. (2007). Continuity or discontinuity of the lifestyle in central Italy during the Roman Imperial Age–Early Middle Ages transition: Diet, health, and behavior. American Journal of Physical Anthropology, 132(3), 381–394. https://doi.org/10.1002/ajpa.20536

Böcker, W., Denk, H., & Heitz, P. (Eds.). (2004). Lehrbuch pathologie und repetitorium pathologie (3rd ed., p. 1092). Urban & Fischer in Elsevier. https://isbnsearch.org/isbn/3437423819

Boldsen, J. L. (2007). Early childhood stress and adult age mortality: A study of dental enamel hypoplasia in the medieval Danish village of Tirup. American Journal of Physical Anthropology, 132(1), 59–66. https://doi.org/10.1002/ajpa.20467

Gall, W. (1994). Betrachtungen zu den Mühl- und Reibesteinen aus den Beständen des Museums für Ur- und Frühgeschichte am Thüringischen Landesamt für Archäologische Denkmalpflege in Weimar. Alt-Thüringen, 261–279.

Giuffra, V., Milanese, M., & Minozzi, M. (2020). Dental health in adults and subadults from the 16th-century plague cemetery of Alghero (Sardinia, Italy). Archives of Oral Biology, 120, 104928. https://doi.org/10.1016/j.archoralbio.2020.104928

Goodman, A. H., & Rose, J. C. (1990). Assessment of systemic physiological perturbations from dental enamel hypoplasias and associated histological structures. Yearbook of Physical Anthropology, 33, 59–110.

Herrmann, B., Gruppe, G., Hummel, S., Piepenbrink, H., & Schutkowski, H. (1990). Prähistorische Anthropologie: Leitfaden der Feld- und Labormethoden. Springer.

Hunger, H., & Leopold, D. (1978). Unterscheidung von Menschen- und Tierknochen. In H. Hunger & D. Leopold (Eds.), Identifikation (pp. xx–xx). Springer. https://doi.org/10.1007/978-3-642-66994-1_8

Jelitzki, F. (2012–2013). Sulza, Stadt Erfurt: Eine mittelalterliche Wüstung mit Kirchengrundriss. Alt-Thüringen, 43, 201–213.

Karl, H.-V. (1997). Prähistorische Anurenreste (Amphibia, Anura) von der alten Siedlung Sulza bei Erfurt. Mauritiana, 16(2), 299–305.

Karl, H.-V. (2012–2013). Die Kleinwirbeltiere aus der mittelalterlichen Kirchenruine der Wüstung Sulza bei Erfurt. Alt-Thüringen, 43, 215–217. http://www.thueringen.de/th2/denkmalpflege/service/publikationen/arch/AT/

Karl, H.-V., & Safi, A. (2024a). A probable case of actinomycosis (lumpy jaw disease) with pseudo joint formation in dwarf cattle from the late medieval in Wysburg, Germany. International Journal of Biological Research, 11(1), 28–31.

Karl, H.-V., & Safi, A. (2024b). Erstnachweis von Bukranien aus der Niederlausitz bei Luckau/Łukow, Lkr. Dahme-Spreewald, in Brandenburg. Veröffentlichungen zur brandenburgischen Landesarchäologie, 50, 347–352.

Karl, H.-V., Tichy, G., & Müller, R. (2006). Prähistorische Vogel- und Eischalenfragmente der Wüste Sulze bei Erfurt. Vogelwarte, 44, 183–190.

Khodadoust, K., Ardalan, M., Pourabbas, R., & Abdolrahimi, M. (2013). Dental and oral diseases in medieval Persia: Lessons from Hedayat Akhawayni. Journal of Medical Ethics and History of Medicine, 2(6), 9.

Lopez, B., Pardiñas, A. F., Garcia-Vazquez, E., & Dopico, E. (2012). Socio-cultural factors in dental diseases in the medieval and early modern age of northern Spain. Homo, 63(1), 21–42.

Mant, M., & Roberts, C. (2015). Diet and dental caries in post-medieval London. International Journal of Historical Archaeology, 19, 188–207.

Pedergnana, A., & Huber, R. (2024). Social status and oral health in early medieval Switzerland: The case of the Baar-Früebergstrasse site (Canton Zug, Switzerland). Journal of Archaeological Science: Reports, 54, 104455. https://doi.org/10.1016/j.jasrep.2024.104455

Pezo, L., & Eggers, S. (2012). Caries through time: An anthropological overview. In M.-Y. Li (Ed.), Contemporary approach to dental caries (pp. xx–xx). InTech. https://doi.org/10.5772/38059

Pilloud, M. A., & Fancher, J. P. (2019). Outlining a definition of oral health within the study of human skeletal remains. Dental Anthropology, 32(2), 3–11.

Reitsema, L. R., & McIlvaine, B. A. (2014). Reconciling "stress" and "health" in physical anthropology: What can bioarchaeologists learn from the other subdisciplines? American Journal of Physical Anthropology, 155, 181–185.

Roberts, C. A., & Cox, M. (2003). Health and disease in Britain from prehistory to the present day. Sutton Publishing.

Saller, M. (1957). Lehrbuch der Anthropologie in systematischer Darstellung mit besonderer Berücksichtigung der anthropologischen Methoden (Vol. 1, 3rd ed.). Fischer Verlag.

Schreiber, D. (Ed.). (1986). Spezielle Pathologie (Parts 1–2, pp. 658–1452). Fischer Verlag.

Schuhmacher, G.-H. (1983). Odontographie: Eine Oberflächenanatomie der Zähne (4th ed.). Barth.

Witte, S. N. D., & Bekvalac, J. (2011). Oral health and frailty in the medieval English cemetery of St. Mary Graces. American Journal of Physical Anthropology, 142(3), 341–354. https://doi.org/10.1002/ajpa.21228

World Health Organization. (1948). Preamble to the constitution of the World Health Organization. Official Records of the World Health Organization, 2, 100. https://www.who.int/about/who-we-are/frequently-asked-questions

Zejdlik, K., Bethard, J. D., Nyárádi, Z., & Gonciar, A. (2019). The medieval Transylvanian oral condition: A case study in interpretation and standardization. Dental Anthropology, 32(2), 77–88.