DOI: 10.18044/MEDINFORM.2026132.2440 ISSUE 2, 2026

Neanderthal Teeth: Morphology, Development, and Significance

Vladimir Panov

Department of Conservative Dentistry and Oral Pathology, Faculty of dental medicine,

Medical University –Varna

Abstract

Neanderthal teeth represent one of the most valuable sources of information for reconstructing the biology, behaviour, and evolution of Homo neanderthalensis. Due to the exceptional preservation of dental tissues, teeth provide insights into growth and development, dietary habits, physiological stress, health status, and patterns of daily activity. The present review summarizes current evidence regarding the morphology, development, wear patterns, and paleobiological significance of Neanderthal dentition. Studies of dental development suggest that Neanderthals may have exhibited slightly accelerated growth and maturation compared with modern humans, although some findings indicate only minor differences. Morphologically, Neanderthal teeth are characterized by large anterior crowns, robust roots, and complex enamel–dentine junctions, reflecting both genetic inheritance and adaptation to heavy mechanical loading. Pronounced dental wear and characteristic scratches on anterior teeth indicate frequent use of the mouth as a "third hand" during tool manufacture and material processing. Isotopic analyses, dental microwear, and dental calculus studies demonstrate that Neanderthal diets were more diverse than previously assumed, combining large-animal hunting with substantial consumption of plant foods. Pathological findings, including enamel hypoplasias, periodontal disease, abscesses, and evidence of possible primitive dental interventions, provide additional information about health and survival under harsh environmental conditions. Modern methods such as micro-computed tomography, virtual histology, and isotope analysis have considerably expanded our understanding of Neanderthal life history and adaptation. Neanderthal teeth constitute a key source for investigating human evolution and the biological relationship between Neanderthals and modern humans.

Keywords: Neanderthals; dental anthropology; dental wear; human evolution; diet; isotope analysis;

Introduction

Neanderthals (Homo neanderthalensis) occupy a special place in the study of human evolution. They inhabited Europe and parts of Western Asia for hundreds of thousands of years, with the earliest representatives appearing approximately 400,000 years ago and the last populations disappearing around 40,000 years ago. Modern humans arrived in Europe more than 45,000 years ago and coexisted with Neanderthals for at least 5,000 years (1).

For decades, Neanderthals were regarded as primitive and intellectually limited beings. However, advances in paleoanthropology, archaeology, and molecular genetics over recent decades have led to a substantial change in this perception. Accumulating evidence demonstrates that Neanderthals were successful representatives of the genus Homo, adapted to diverse ecological conditions and capable of developing complex behavioral survival strategies. They manufactured stone tools, used fire, hunted large animals in an organized manner, cared for sick and injured group members, and likely exhibited forms of symbolic behavior (2, 3).

Of particular interest are the close biological relationships between Neanderthals and modern humans. Genetic studies have shown that the two species not only coexisted in parts of Eurasia but also interbred with one another. As a result, most present-day populations outside Africa carry between one and two percent Neanderthal DNA in their genomes. These findings emphasize the close evolutionary relationship between the two human species (4).

Among the various categories of fossil remains, teeth occupy an especially important place. Due to the high mineralization of enamel, teeth are among the most durable structures in the human body and are often preserved even when the remaining skeletal elements are severely fragmented or destroyed. A significant proportion of current knowledge regarding Neanderthal biology derives from the study of teeth and jaws. These structures provide information not only about species-specific morphology, but also about growth and development, dietary habits, health status, physiological stress episodes, and aspects of behavior (5, 6).

Dental tissues represent a unique biological archive. The formation of enamel and dentin follows strictly regulated biological patterns, allowing reconstruction of growth rates and developmental timing. Growth lines preserved within dental tissues make it possible to estimate the age at formation of specific structures and to identify periods of physiological stress associated with malnutrition, disease, or other adverse factors. Analysis of dental wear reveals important aspects of diet and lifestyle, while microdamage on the anterior teeth provides evidence for their use as auxiliary tools in the processing of hides, plant fibers, and other materials (6, 7).

Over the last two decades, the possibilities for studying Neanderthal teeth have expanded considerably owing to the introduction of modern analytical methods. Micro-computed tomography enables non-destructive examination of the internal tooth structure and precise measurement of enamel thickness, dentin volume, and enamel–dentine junction morphology. Virtual histology allows reconstruction of growth processes, while isotopic analyses provide information regarding diet and mobility in ancient populations. These approaches have enabled a much deeper understanding of Neanderthal biology and adaptations compared with the methods available to researchers only a few decades ago (5, 8).

Aim

The aim of the present review is to summarize the main findings regarding the development, morphology, wear patterns, and paleobiological significance of Neanderthal teeth, as well as their role in reconstructing the lifestyle and evolution of Neanderthal populations.

DOI: 10.18044/MEDINFORM.2026132.2440 ISSUE 2, 2026

Materials and Methods

A narrative literature review was conducted using publications indexed in PubMed and Scopus, up to 2026. Keywords included “Neanderthal teeth,” “dental anthropology”. Original articles, review papers, and paleoanthropological studies focused on Neanderthal dentition and dental biology were included. Priority was given to recent studies employing modern imaging and analytical techniques such as micro-computed tomography, virtual histology, and isotopic analysis.

Results

Dental Development and Childhood in Neanderthals

Research on remains from Krapina (Croatia), dated to approximately 120–130 thousand years ago, indicates that the development of permanent teeth in Neanderthals was similar to or slightly accelerated compared with modern humans. Analysis of deciduous teeth reveals rapid formation of dental tissues before and immediately after birth. Tooth eruption likely began at the earliest ages observed in modern children, suggesting accelerated early development and early adaptation to independent feeding and survival (9).

A novel three-dimensional method for measuring enamel defects caused by physiological stress during childhood has shown that Neanderthals exhibited shallower defects compared with modern humans. This is attributed to the faster growth of their anterior teeth. Nevertheless, the frequency and severity of physiological stress appear to have been similar to those observed in early Homo sapiens populations (10).

As in modern children, the first deciduous teeth most likely erupted between the sixth and eighth month after birth, while a complete deciduous dentition was probably present by approximately three years of age. The principal differences from modern humans appear later in the tempo of growth and maturation. According to some authors, Neanderthals reached biological maturity earlier, whereas other studies report only minor differences compared with modern humans (11).

Permanent teeth likely erupted slightly earlier as well. The first permanent molars appeared at approximately five years of age, while the third molars (“wisdom teeth”) erupted between 15 and 18 years of age. Under the harsh climatic conditions of the Ice Age, more rapid maturation may have represented an adaptive advantage by enabling earlier participation in activities essential for group survival.

Studies of Neanderthal molar growth indicate that the timing of crown and root completion was broadly similar to that observed in modern humans. However, a more complex enamel–dentine junction morphology and a later peak in root growth rate have been identified, suggesting species-specific developmental characteristics in Neanderthal dentition (12).

Morphological Characteristics of Neanderthal Teeth

Neanderthals possessed some of the most distinctive teeth among representatives of the genus Homo. Their anterior teeth were large, with massive crowns and frequently exhibited pronounced

DOI: 10.18044/MEDINFORM.2026132.2440 ISSUE 2, 2026

"shovel-shaped" morphology. These characteristics have traditionally been interpreted as adaptations to high mechanical loading associated not only with mastication but also with the use of teeth in various non-masticatory activities.

A recent study employing finite element analysis on the incisors of the Neanderthal Le Moustier 1 and the early Homo sapiens specimen Qafzeh 9 demonstrated substantial differences in the distribution of mechanical stress. In the Neanderthal specimen, specific structures such as the labial convexity, lingual tubercle, and large root surface contributed to more efficient dissipation of mechanical loading. In early Homo sapiens, the absence of these characteristics was compensated for by thicker enamel, which reduced stress within the crown (13).

Additional evidence from Taddeo Cave in southern Italy indicates that all analyzed teeth exhibit morphological characteristics typical of Neanderthals. However, some results also revealed traits more similar to those of modern humans, suggesting greater variability in Neanderthal molar structure than previously assumed (14).

Table 1. Differences between Neanderthal and Homo sapiens dentition

Characteristic	Neanderthals	Homo sapiens
Size of anterior teeth	Relatively larger	Relatively smaller
Degree of wear	Highly pronounced	Less pronounced
Rate of development	Probably slightly faster	Slower
Enamel thickness	Variable	Usually thicker
Use of teeth as tools	Frequent	Rare
Timing of eruption	Earlier / similar	Standard
Rate of enamel formation	Faster	Slower
Age of M1 eruption	~5 years	~6 years
Root morphology	Massive	Smaller

Dental Wear and the Use of Teeth as Tools

One of the most remarkable characteristics of Neanderthal dentition is the pronounced dental wear observed even at a young age. The mouth appears to have functioned as a kind of "third hand." Using their anterior teeth, Neanderthals held animal hides, fibers, and other materials during processing, tool manufacture, and everyday activities.

Studies of remains from Moula-Guercy (France) have revealed the presence of linear enamel hypoplasia, indicating episodes of physiological stress experienced during childhood. Analyses of molar microwear suggest that their diet did not differ substantially from that of modern humans. At the same time, traces on the incisors indicate intensive use of the anterior teeth as working tools (15).

Similar findings have also been reported from remains discovered at Marillac (southwestern France). In addition to characteristic morphological features, evidence of paramasticatory activities and probable use of toothpicks for cleaning interdental spaces—an early form of oral hygiene—has been identified (16).

DOI: 10.18044/MEDINFORM.2026132.2440 ISSUE 2, 2026

Teeth as a Source of Information About Neanderthal Life

Modern imaging technologies allow the extraction of information that until recently was inaccessible. Through phase-contrast X-ray microtomography of dental cementum in Neanderthals from Krapina, it is possible to estimate age at death, probable sex, and episodes of physiological stress. This approach provides new opportunities for reconstructing the life history of individual Neanderthals (17).

Teeth can also provide information about the mobility of ancient populations. Strontium isotope analysis of Neanderthal teeth from Payre (Rhône Valley, France) indicates that the studied individuals grew up within the same region but also exploited neighboring mountainous territories. These findings contribute to a better understanding of mobility patterns and resource use among Neanderthal groups (18).

Right-Handedness and Brain Lateralization in Early Humans

Particularly interesting are the traces of stone tools found on anterior teeth. These marks were produced when material was held between the teeth while being cut with the opposite hand. The orientation of the scratches makes it possible to determine the dominant hand of the individual.

Studies of fossils from Sima de los Huesos and various European Neanderthal sites demonstrate a clear predominance of right-handedness in an approximate ratio of 9:1. This corresponds closely to the modern pattern of lateralization and suggests that the brain organization associated with language and fine motor skills emerged long before the appearance of Homo sapiens (19).

New Discoveries and Genetic Diversity

One of the most significant discoveries of recent years is the nearly complete dentition of an adult Neanderthal known as "Thorin," discovered in Grotte Mandrin, France. The individual lived approximately 44,500–42,250 years ago. In addition to typical Neanderthal characteristics, researchers identified the presence of two additional molars (distomolars)—a phenomenon not previously documented in a Neanderthal individual. This finding suggests greater morphological and genetic diversity among late Neanderthal populations than previously assumed (20).

Diet

For a long time, Neanderthals were regarded as almost exclusively carnivorous hunters. Stable isotope analyses of their bones and teeth indeed demonstrate that in many regions of Europe they occupied the ecological niche of apex predators and obtained a large proportion of their protein intake from large herbivores such as deer, bison, horses, and mammoths. Isotopic evidence from the Vindija site in Croatia, for example, indicates a dietary pattern similar to that of large carnivores within the same ecosystem (21).

In recent years, however, studies of dental calculus and dental microwear have altered the traditional view of the Neanderthal diet. Dental calculus samples from Neanderthals from Shanidar Cave (Iraq) and Spy Cave (Belgium) have revealed starch grains and phytoliths from various plants,

DOI: 10.18044/MEDINFORM.2026132.2440 ISSUE 2, 2026

including wild cereals, legumes, and dates. Some starch granules display evidence of thermal processing, suggesting that certain plant foods were cooked before consumption. These findings demonstrate that Neanderthals exploited a variety of plant resources and possessed knowledge of food preparation techniques (22).

A broader study of dental calculus from several Neanderthal populations in the Mediterranean region and the Balkans found that plant consumption was widespread regardless of local environmental conditions. This suggests that although meat occupied an important place in the Neanderthal diet, plant foods also constituted a significant dietary component (23).

Analyses of molar macrowear further demonstrate substantial regional differences in dietary behavior. While Neanderthals from northern and central Europe relied primarily on hunting large mammals, populations from Mediterranean regions utilized more diverse food resources, including small animals, marine organisms, and plant foods (24).

Fig. 1. Teeth and bone fragments. Late Paleolithic. From Bacho Kiro Cave, Historical Museum of Dryanovo

Dental Diseases

Like modern humans, Neanderthals suffered from various oral diseases. The study of these pathologies provides valuable information about their health status, diet, and living conditions. Among the most common findings are linear enamel hypoplasias—defects caused by disruptions in normal tooth development due to malnutrition, infections, or other physiological stress conditions during childhood. The presence of such alterations in numerous Neanderthal individuals indicates that they were frequently exposed to periods of environmental or health-related stress (25).

Dental caries appears to have been relatively rare among Neanderthals compared to later agricultural societies. This was likely due to the low content of refined carbohydrates and sugars in their diet. Nevertheless, isolated cases of carious lesions and dental infections have been documented at various European sites. Abscesses, inflammatory changes around tooth roots, and signs of periodontal disease have also been observed, particularly in older individuals (25).

The intense mechanical loading of the dentition resulted in pronounced wear of the occlusal surfaces and, in some cases, exposure of the pulp chamber. Compensatory changes in dental tissues

DOI: 10.18044/MEDINFORM.2026132.2440 ISSUE 2, 2026

and signs of chronic inflammatory processes have been identified in certain specimens. Such findings suggest that Neanderthals often continued using heavily worn teeth for many years (22).
Of particular interest is the evidence for deliberate care related to dental problems. In some individuals, characteristic grooves associated with the use of toothpicks for cleaning interdental spaces have been identified. Recent discoveries even suggest the possibility of primitive dental interventions. Analysis of a Neanderthal molar from Chagyrskaya Cave in Siberia revealed traces of intentional drilling with a stone tool intended to relieve pain caused by severe dental caries. If this interpretation is ultimately confirmed, it would represent the earliest known evidence of an invasive dental procedure in human history (26).

Limitations of Available Data and Methods

Despite advances in the study of Neanderthal teeth, interpretations must be made cautiously due to the limited number of well-preserved fossil specimens of Homo neanderthalensis. This restricts the possibility of fully generalizing the results. Furthermore, the methods used—microtomography, wear analysis, isotope studies, and enamel defect analysis—evaluate different aspects and are not always directly comparable, making it difficult to construct a unified model.
Another important limitation is the influence of individual variability and environmental factors, which may significantly affect results, especially in small samples. Therefore, current conclusions regarding development, diet, and behavior should be considered preliminary and subject to future refinement.

Conclusion

Neanderthal teeth are among the most informative and best-preserved sources for studying this extinct human species. Through their analysis, researchers can reconstruct growth and maturation rates, dietary habits, health status, and various aspects of behavior. The available evidence demonstrates that Neanderthals possessed distinctive dental morphological features related both to heredity and to adaptation to Ice Age environments.
Studies of dental development suggest possible differences in maturation rates compared to modern humans. Analyses of wear patterns and pathological changes reveal intensive use of the anterior teeth as tools, as well as diverse dietary strategies. Modern methods such as microtomography and isotope analysis have significantly expanded knowledge of Neanderthal biology. Teeth therefore represent a key source for understanding human evolution and our own place within it.

References

1. Sümer AP, Rougier H, Villalba-Mouco V, et al. Earliest modern human genomes constrain timing of Neanderthal admixture. Nature. 2025 Feb;638(8051):711-717. doi: 10.1038/s41586-024-08420-x. Epub 2024 Dec 12. PMID: 39667410; PMCID: PMC11839475.

DOI: 10.18044/MEDINFORM.2026132.2440 ISSUE 2, 2026

2. Hublin JJ. The modern human colonization of western Eurasia: when and where? Quaternary Science Reviews. 2015;118:194–210. doi:10.1016/j.quascirev.2014.08.011.
3. Stringer C, Galway-Witham J. When Neanderthals and Homo sapiens met. Nature. 2018;555(7695):214–215. doi:10.1038/d41586-018-02332-x.
4. Prüfer K, Racimo F, Patterson N, Jay F, Sankararaman S, Sawyer S, Heinze A, Renaud G, Sudmant PH, de Filippo C, et al. The complete genome sequence of a Neanderthal from the Altai Mountains. Nature. 2014;505(7481):43–49. doi:10.1038/nature12886.
5. Guatelli-Steinberg D. What Teeth Reveal About Human Evolution. Cambridge: Cambridge University Press; 2016.
6. Hillson S. Teeth. 2nd ed. Cambridge: Cambridge University Press; 2005.
7. Irish JD, Scott GR, editors. A Companion to Dental Anthropology. Chichester: Wiley-Blackwell; 2016.
8. Dean MC. A comparative study of cross striation counts in extant non-human primates and fossil hominins. Journal of Human Evolution. 2006;50(3):294–302. doi:10.1016/j.jhevol.2005.10.003.
9. Mahoney P, McFarlane G, Smith BH, Miszkiewicz JJ, Cerrito P, Liversidge H, Mancini L, Dreossi D, Veneziano A, Bernardini F, Cristiani E, Behie A, Coppa A, Bondioli L, Frayer DW, Radovčić D, Nava A. Growth of Neanderthal infants from Krapina (120-130 ka), Croatia. Proc Biol Sci. 2021 Nov 24;288(1963):20212079. doi: 10.1098/rspb.2021.2079. Epub 2021 Nov 24. PMID: 34814754; PMCID: PMC8611323.
10. McGrath K, Limmer LS, Lockey AL, Guatelli-Steinberg D, Reid DJ, Witzel C, Bocaege E, McFarlin SC, El Zaatari S. 3D enamel profilometry reveals faster growth but similar stress severity in Neanderthal versus Homo sapiens teeth. Sci Rep. 2021 Jan 12;11(1):522. doi: 10.1038/s41598-020-80148-w. PMID: 33436796; PMCID: PMC7804262.
11. Nava A, Lugli F, Romandini M, Badino F, Evans D, Helbling AH, Oxilia G, Arrighi S, Bortolini E, Delpiano D, Duches R, Figus C, Livraghi A, Marciani G, Silvestrini S, Cipriani A, Giovanardi T, Pini R, Tuniz C, Bernardini F, Dori I, Coppa A, Cristiani E, Dean C, Bondioli L, Peresani M, Müller W, Benazzi S. Early life of Neanderthals. Proc Natl Acad Sci U S A. 2020 Nov 17;117(46):28719-28726. doi: 10.1073/pnas.2011765117. Epub 2020 Nov 2. PMID: 33139541; PMCID: PMC7682388.
12. Macchiarelli R, Bondioli L, Debénath A, Mazurier A, Tournepiche JF, Birch W, Dean MC. How Neanderthal molar teeth grew. Nature. 2006 Dec 7;444(7120):748-51. doi: 10.1038/nature05314. Epub 2006 Nov 22. PMID: 17122777.
13. Najafzadeh A, Hernaiz-García M, Benazzi S, Chen B, Hublin JJ, Kullmer O, Pokhojaev A, Sarig R, Sorrentino R, Vazzana A, Fiorenza L. Finite element analysis of Neanderthal and early Homo sapiens maxillary central incisor. J Hum Evol. 2024 Apr;189:103512. doi: 10.1016/j.jhevol.2024.103512. Epub 2024 Mar 10. PMID: 38461589.
14. Benazzi S, Viola B, Kullmer O, Fiorenza L, Harvati K, Paul T, Gruppioni G, Weber GW, Mallegni F. A reassessment of the Neanderthal teeth from Taddeo cave (southern Italy). J Hum Evol. 2011 Oct;61(4):377-87. doi: 10.1016/j.jhevol.2011.05.001. Epub 2011 Jun 16. PMID: 21683429.
15. Hlusko LJ, Carlson JP, Guatelli-Steinberg D, Krueger KL, Mersey B, Ungar PS, Defleur A. Neanderthal teeth from Moula-Guercy, Ardèche, France. Am J Phys Anthropol. 2013 Jul;151(3):477-91. doi: 10.1002/ajpa.22291. Epub 2013 Jun 4. PMID: 23737145.
16. Garralda MD, Maureille B, Le Cabec A, Oxilia G, Benazzi S, Skinner MM, Hublin JJ, Vandermeersch B. The Neanderthal teeth from Marillac (Charente, Southwestern France): Morphology, comparisons and paleobiology. J Hum Evol. 2020 Jan;138:102683. doi: 10.1016/j.jhevol.2019.102683. Epub 2019 Nov 22. PMID: 31765984.
17. Cerrito P, Nava A, Radovčić D, Borić D, Cerrito L, Basdeo T, Ruggiero G, Frayer DW, Kao AP, Bondioli L, Mancini L, Bromage TG. Dental cementum virtual histology of Neanderthal teeth from Krapina

DOI: 10.18044/MEDINFORM.2026132.2440 ISSUE 2, 2026

(Croatia, 130-120 kyr): an informed estimate of age, sex and adult stressors. J R Soc Interface. 2022 Feb;19(187):20210820. doi: 10.1098/rsif.2021.0820. Epub 2022 Feb 23. Erratum in: J R Soc Interface. 2024 Feb;21(211):20240069. doi: 10.1098/rsif.2024.0069. PMID: 35193386; PMCID: PMC8864341.

18. Moncel MH, Fernandes P, Willmes M, James H, Grün R. Rocks, teeth, and tools: New insights into early Neanderthal mobility strategies in South-Eastern France from lithic reconstructions and strontium isotope analysis. PLoS One. 2019 Apr 3;14(4):e0214925. doi: 10.1371/journal.pone.0214925. PMID: 30943255; PMCID: PMC6447223.

19. Lozano M, Estalrrich A, Bondioli L, Fiore I, Bermúdez de Castro JM, Arsuaga JL, Carbonell E, Rosas A, Frayer DW. Right-handed fossil humans. Evol Anthropol. 2017 Nov;26(6):313-324. doi: 10.1002/evan.21554. PMID: 29265662.

20. Fuchs J, García-Tabernero A, Rosas A, Camus H, Metz L, Slimak L, Zanolli C. The dentition of a new adult Neanderthal individual from Grotte Mandrin, France. J Hum Evol. 2024 Nov;196:103599. doi: 10.1016/j.jhevol.2024.103599. Epub 2024 Oct 2. PMID: 39357284.

21. Richards MP, Pettitt PB, Trinkaus E, Smith FH, Paunović M, Karavanić I. Neanderthal diet at Vindija and Neanderthal predation: the evidence from stable isotopes. Proc Natl Acad Sci U S A. 2000 Jun 20;97(13):7663-6. doi: 10.1073/pnas.120178997. PMID: 10852955; PMCID: PMC16602.

22. Henry AG, Brooks AS, Piperno DR. Microfossils in calculus demonstrate consumption of plants and cooked foods in Neanderthal diets (Shanidar III, Iraq; Spy I and II, Belgium). Proc Natl Acad Sci U S A. 2011 Jan 11;108(2):486-91. doi: 10.1073/pnas.1016868108. Epub 2010 Dec 27. PMID: 21187393; PMCID: PMC3021051.

23. Li Q, Luo K, Su Z, Huang F, Wu Y, Zhou F, Li Y, Peng X, Li J, Ren B. Dental calculus: A repository of bioinformation indicating diseases and human evolution. Front Cell Infect Microbiol. 2022 Dec 12;12:1035324. doi: 10.3389/fcimb.2022.1035324. PMID: 36579339; PMCID: PMC9791188.

24. Fiorenza L, Benazzi S, Tausch J, Kullmer O, Bromage TG, Schrenk F. Molar macrowear reveals Neanderthal eco-geographic dietary variation. PLoS One. 2011 Mar 18;6(3):e14769. doi: 10.1371/journal.pone.0014769. PMID: 21445243; PMCID: PMC3060801.

25. Topić B, Raščić-Konjhodžić H, Cižek Sajko M. Periodontal disease and dental caries from Krapina Neanderthal to contemporary man - skeletal studies. Acta Med Acad. 2012;41(2):119-30. doi: 10.5644/ama2006-124.45. PMID: 23331387.

26. Zubova AV, Zotkina LV, Olsen JW et al. Earliest evidence for invasive mitigation of dental caries by Neanderthals. PLoS One. 2026 May 13;21(5):e0347662. doi: 10.1371/journal.pone.0347662. PMID: 42127021; PMCID: PMC13170851.

Corresponding author:
Vladimir Panov
Department of Conservative Dentistry and Oral Pathology, Faculty of dental medicine,
Medical University -Varna;
E-mail: vladimir.panov@mu-varna.bg