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Influence of Circadian Rhythm on Enamel and Other Oral Tissues- A Narrative Review

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Abstract: Molecular mechanisms in regulating physiologic interactions in the human body are under the control of circadian rhythmicity. The modern lifestyle and adjusting to the globalized world have led to various imbalances and diseases. Adaptation of certain body functions according to age or environment keeps altering. Late hours, frequent travel, or some medications can confuse these primary clock genes and cause hormonal imbalance. The importance of clock genes adjustment to triggering factors of night and day time zones has a crucial role in the proper functioning of our body. Similar to the bone formation pattern, the circadian rhythm directly influences the hardest substance, the tooth enamel. Various transcription factors conduct these circadian rhythmicities through clock genes. Identifying new clock genes is in progress, and intraspecific gene variations regulate the clock proteins. Lag in the feedback system is possible if there is a possibility of alterations among the clock genes. If there is a disruption in these gene expressions, it can lead to several diseases. Aging and neurodegeneration-related diseases are also crucial in understanding circadian rhythm disturbances. Even the enamel or dentin-related disharmony related to circadian rhythms in clues of the molecular signals receiving day and night variability is possible. Specific geographical studies on the population may help understand the circadian rhythm and its effects on patterns of mineral deposition in teeth. These prove to help anthropologists though they could be more accurate greatly. This review focuses on the effects of circadian rhythm in enamel and its usage with various clock genes in other oral tissue functioning.

Keywords: Circadian rhythm, Clock genes, Enamel, Retzius periodicity, Cross striations

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1. INTRODUCTION

The rhythmic coordination between the human body and the external environment is fundamental to maintaining functional balance. The relationship between the several functions of the human physiologic system depends on the changes in the time of day and night. This biological clock, thus, is under the influence of the earth's rotating axis, known as the circadian rhythm. The location of the central circadian clock is in the suprachiasmatic nuclei in the region of the anterior hypothalamus, and the other clocks in the peripheral tissues support the central system. Human suprachiasmatic nuclei synchronize internal metabolic circadian rhythms to external light and dark cycles. Shorter light hours may alter neuron firing patterns in the suprachiasmatic nuclei via the light-sensitive retino-hypothalamic pathway. Various transcription factors conduct these circadian rhythmicities through clock genes. Identifying new clock genes is in progress, and intraspecific gene variations regulate the clock proteins. Lag in the feedback system is possible if there is a possibility of alterations among the clock genes. If there is a disruption in these gene expressions, it can lead to several diseases.[1-4] Enamel is harder calcified tissue than human bone and is valuable in crime investigations and forensic studies. The formation of enamel is unique to determining the age of crown completion. The presence of retzius lines and cross striations in enamel are helpful for identification purposes.[5,6] The striae periodicity indicates the time for everyday enamel secretion between the two incremental lines, known as cross-striations. They run across prisms perpendicularly, indicating a 24-hourly rhythm of enamel formation. There are constant similarities for all teeth of an individual; differences in number exist between and within species and between two individuals. The rhythmicity can differ in every person depending on their body mass, metabolism, temperature, diet, or hormones. The suprachiasmatic nucleus depends on the hypothalamic nuclei and vasoactive intestinal peptides to release cortisol, melatonin, and body temperature. There are also associations in heart rate, blood pressure, and incremental lines. The body mass is also generally dependent on the central control of lamellar pattern bone formation, just like the enamel incremental line formation. The vagal pathways are the ones controlling the body mass central sympathetic system of body mass. Hence, circadian rhythms play an essential part in human physiological regulation and diseases as it involves many circadian rhythm genes. The circadian rhythm-oriented disruption in normal physiology due to changes in the transmission of the biochemical signals to be treated understanding the mechanism of the related pathways. Some of the clock genes due to disharmony lead to an increase in developing cancer, also angiogenesis promoting further tumor progression. Aging and neurodegeneration-related diseases are also important in understanding circadian rhythm disturbances. Even the enamel or dentin-related disharmony related to circadian rhythms in clues of the molecular signals receiving day and night variability is possible.[7-12] This review mainly focuses on the importance of circadian rhythms in the enamel and factors influencing the role of clock genes in enamel and other oral tissues.

2. INCREMENTAL LINES

Initially, the mineral content is low when the enamel secretion begins; as formation continues, the enamel crystals increase, and the mineral content rises. During enamel matrix formation, the ameloblasts have two particular sites, first at the base of the tomes process forming the interprismatic enamel. The other one at the one side of the distal portion of the tomes process forms the matrix of the enamel rod. Ameloblasts show differences in the rate of enamel matrix secretion that reflect an incremental pattern in the enamel deposition. The neonatal line is a hallmark of before and after the birth of enamel; deposition can be found in deciduous teeth and sometimes in the first permanent molar. Thus it is a valuable landmark in forensic anthropological studies. Rhythm periodicities are under the control of several influencing intrinsic and extrinsic factors. Due to various disturbances during enamel formation after birth, there are variations in the incremental line formation. Variations in gender, ethnicity, body mass, and metabolic rate are common. Studies on gender effects show higher periodicities in the south African sample. Generally, the female population has a faster rate of enamel secretion daily. They also divulge the teeth if exposed to any chemicals, the presence of any diseases, or the diet.[10-14]

3. CROSS STRIATIONS

Cross striations indicate deposition by ameloblast in a day. There are several methods, from counting the cross striations directly or dividing the distance between the two long periods by the distance between cross striations. Studies prove that circadian rhythms control gene expression during enamel or dentin formation. Different proteins are present in the secretory and maturation stages of ameloblasts. They are related to the cyclical gene production for certain essential cell functions. However, few studies show that cyclical-specific genes for enamel formation relate to the peripheral clock of circadian Regulation. Literature studies show that the differences in the periodicities of cross striations and incremental lines depend on the light exposure as different geographical locations experience different time intervals and duration of light exposure. Incremental lines in bone lamellae also show similar characteristics as enamel. The time taken for enamel formation is the distance between the dentin and the outer enamel. Transcription factors that encode these clocks are necessary for Regulation by circadian rhythms. Also, they have a role in the differentiation of ameloblasts and odontoblasts.[13-16]

4. VARIOUS CLOCK GENES

Collagen in dentin shows double the production in 12hr in daylight than the same number of hours at night. Regulation of promoter activity in clock genes is related directly to the circadian rhythm. The clock genes are the ones maintaining the circadian rhythms, like Circadian Locomotor Output Cycles Kaput (Clock), Period 1 (Per1), Period 2 (Per2), Period 3 (Per3), and others. The interlocked loops of transcriptional and translational feedback are the main cause of the function of biological clocks at the molecular level. The three main clock genes are E-box, RORE, and DBPE; the most familiar is the Per 1 promoter in the E-box part of the binding site to CLOCK/BMAL1. PERs and CRYs, inhibit the pathway. Their output signals cause repetitive patterns along with other transcriptional factors. Pituitary adenylate cyclase-activating polypeptide(PACAP) in retinal ganglionic cells produces PER gene expression. Physiological disturbances are common in disrupting these main clock genes like BMAL1 leading to neurodegeneration and deviation in the normal

sleep cycle altogether, inhibiting the central clock squad.
Zeitgeber cues like light or other regular external activities such as eating are essential in maintaining the circadian rhythms. Thus entrainment is necessary for regular periodicity. There might be several reasons for variations in rhythmic periodicity. The anatomy and microstructure influence these variations in periodicities. Likewise, higher periodicity results in thicker enamel formation.[17-21] The various microstructure of teeth and bone follow the same rhythmic pattern of deposition, the relationships of retzius lines depending on the metabolic activities based on circadian rhythm. Thus it affects the mineral composition and the normal functions of primitive cells. The differences in the deposition due to several factors may result in variations. The outer and internal enamel defects or accentuated striae result from the same. It is easier to obtain the chronology from the accentuated striae of retzius than from the external perikymata markings. The variations can affect the enamel matrix's composition and the ameloblast cells' proper functioning. Histological study of the teeth has become easier with laser confocal microscopy. Specific geographical studies on the population may help understand the circadian rhythm and its effects on patterns of mineral deposition in teeth. These prove to help anthropologists though they could be more accurate greatly.[22,23]

5. CIRCADIAN RHYTHM AND OTHER ORAL TISSUES

Clock genes also influence the salivary glands saliva secretion. There is a direct link between the disturbances associated with saliva flow, salivary gland diseases, and circadian rhythms. So relating to the maintenance of homeostasis in the oral environment, the importance of omics in circadian rhythm is essential in research related to head and neck pathologies. They control the cell proliferation in p53; cyclin B1 shows a direct link involving the circadian rhythm. The clock genes are essential in regulating functions in many other tissues, including oral epithelium, periodontal and alveolar bone. It is interesting to note that many studies indicate the circadian clock gene PER1 with squamous cell carcinoma, and this particular gene can help understand the pathogenesis associated. Proteins encoding the important clock genes form the circadian oscillator and rhythms. Many studies indicate the relationship of change in these clock genes to tumorigenesis.[24-30] It is noticed that in gastric, prostate, and breast cancer cases, the higher expression of PER1 and PER2 directly impacts the better prognosis of the patients—also, the downregulation of BMAL1 in colorectal pancreatic and ductal adenocarcinoma. The CRY1 and CRY2 genes are related to prostate and breast cancer. Few studies show a decrease in the expression of clock genes in oral squamous cell carcinoma like PER1,2,3 CRY2 and BMAL1. In vitro studies have related the decrease in PER1, leading to cell proliferation apoptosis and invasion. The clock gene suppression PER1 and p53 gene has a definite role in advancing squamous cell carcinoma. Disturbances in the cell cycle that relays mainly on the Cyclin-CDK-cyclin-dependent kinase inhibitor regulatory network and the decrease in the PER clock genes lead to a decrease in the tumor suppressor gene expression. Smooth conduction of rhythm is controlled by molecular signals from cells and tissues that synchronize the time of manifestation. An imbalance in circadian rhythm can bring upshots in the body's normal functioning. Metabolic syndrome is one of the presentations of such a disorder due to direct contact with light at night. Directing circadian rhythms in the treatment of certain diseases can be of immense help to humankind.[31-40]

6. TOOTH FORMATION TIMES

The physiological sequence of the human body is related to tooth formation times. The teeth eruption coincides with skeletal maturation, thyroid, growth hormones, and adrenal cortex activity. The total deposition of enamel or dentin and formation rate is time-dependent on the clock genes—variations in an ameloblastic deposition concerning circadian rhythm cause the different prism thickness and composition. The time taken for the deposition of the initial mineral formation slows down soon after the main cusps for the maturation of the mineralization to proceed. The enamel structure influences the determination of prism structural patterns.[41,42]

7. USES OF THE INCREMENTAL LINES/CROSS STRIATIONS

These incremental lines and cross striations help determine the time taken for the crown formation. They are usually observed under SEM, backscattered electron imaging, and polarized microscope studies of thin ground sections. These growth markings can be very useful to standardize the growth rate of hard tissue formation in different regions and can also be used in the forensic application for identification. Cross striations and time intervals can add to crown formations' deposition patterns. It is one of the useful methods to analyze the age by the cross striations in still enamel-forming teeth. The gap between the striae intervals varies from 6 to 12 days. They predict the age at death and specify the time taken for the two incremental lines to form and pathologies. [41-43]

8. CONCLUSION

A study on large-scale data is necessary to understand the importance and implication of enamel depositional patterns. In recent years the secretion of various hormones and their triggering factors under circadian rhythms have been untangling. Future studies might help prevent numerous pathologies, including those in the head and neck. Understanding the environmental changes affecting circadian rhythms and their influence on human beings can greatly help. Further prevention of long-term changes causing an imbalance in the molecular signaling can lead to a better understanding of these clock genes in terms of prevention, progression of pathologies, and future therapeutics.

9. AUTHORS CONTRIBUTION STATEMENT

Reshma Amin conceived the study and was responsible for the overall direction, analysis, and planning. Reshma Amin and Vinisha S Pousya carried out the implementation. Reshma Amin took the lead in writing the manuscript. Vinisha S Pousya and Krishna Prasanth Baalann provided critical feedback, reviewed, and helped in the final corrections of the manuscript.

10. CONFLICT OF INTEREST

Conflict of interest declared none.

11. REFERENCES

1. Papagerakis S, Zheng L, Schnell S, Sartor MA, Somers E, Marder W et al. The circadian clock in oral health and diseases. J Dent Res. 2014 Jan;93(1):27-35. doi: 10.1177/0022034513505768, PMID 24065634.
2. Vitaterna MH, Takahashi JS, Turek FW. Overview of circadian rhythms. Alcohol Res Health. 2001;25(2):85-93. PMID 11584554.
3. Ebisawa T. Circadian rhythms in the CNS and peripheral clock disorders: human sleep disorders and clock genes. J Pharmacol Sci. 2007;103(2):150-4. doi: 10.1254/jphs.fmj06003x5, PMID 17299246.
4. Kyriacou CP, Peixoto AA, Sandrelli F, Costa R, Tauber E. Clines in clock genes: fine-tuning circadian rhythms to the environment. Trends Genet. 2008 Mar 1;24(3):124-32. doi: 10.1016/j.tig.2007.12.003, PMID 18243399.
5. Antoine D, Hillson S, Dean MC. The developmental clock of dental enamel: a test for the periodicity of prism cross-striations in modern humans and an evaluation of the most likely sources of error in histological studies. J Anat. 2009 Jan;214(1):45-55. doi: 10.1111/j.1469-7580.2008.01010.x, PMID 19166472.
6. Mahoney P. Incremental enamel development in modern human deciduous anterior teeth. Am J Phys Anthropol. 2012 Apr;147(4):637-51. doi: 10.1002/ajpa.22029, PMID 22331636.
7. Lacruz RS, Hacia JG, Bromage TG, Boyde A, Lei Y, Xu Y et al. The circadian clock modulates enamel development. J Biol Rhythms. 2012 Jun;27(3):237-45. doi: 10.1177/0748730412442830, PMID 22653892.
8. Stavrianos C, Papadopoul C, Vasiliadis L, Dagkalis P, Stavrianou I, Petalotis N. Enamel structure, and forensic use. Res J Biol Sci. 2010;5(10):650-5. doi: 10.3923/rjbsci.2010.650.655.
9. Bromage TG, Lacruz RS, Hogg R, Goldman HM, McFarlin SC, Warshaw J, et al. Lamellar bone is an incremental tissue reconciling enamel rhythms, body size, and organismal life history. Calcif Tissue Int. 2009 May 1;84(5):388-404. doi: 10.1007/s00223-009-9221-2, PMID 19234658.
10. Tan SHX, Sim YF, Hsu CS. The difference in striae periodicity of Heilongjiang and Singaporean Chinese teeth. Front Physiol. 2017 Jun 29;8:442. doi: 10.3389/fphys.2017.00442, PMID 28706489.
11. Mahoney P, Miszkiewicz JJ, Pitfield R, Schlecht SH, Deter C, Guatelli-Steinberg D. Biorhythms, deciduous enamel thickness, and primary bone growth: a test of the Havers-Halberg Oscillation hypothesis. J Anat. 2016 Jun;228(6):919-28. doi: 10.1111/joa.12450, PMID 26914945.
12. Maiese K. Moving to the rhythm with clock (circadian) genes, autophagy, mTOR, and SIRT1 in degenerative disease and cancer. Curr Neurovasc Res. 2017 Aug 1;14(3):299-304. doi: 10.2174/1567202614666170718092010, PMID 28721811.
13. Smith TM. Experimental determination of the periodicity of incremental features in enamel. J Anat. 2006 Jan;208(1):99-113. doi: 10.1111/j.1469-7580.2006.00499.x, PMID 16420383.
14. Reid DJ, Dean MC. Variation in modern human enamel formation times. J Hum Evol. 2006 Mar 1;50(3):329-46. doi: 10.1016/j.jhevol.2005.09.003, PMID 16300817.
15. Athanassiou-Papaefthymiou M, Kim D, Harbron L, Papagerakis S, Schnell S, Harada H, et al. Molecular and circadian controls of ameloblasts. Eur J Oral Sci. 2011 Dec;119(Suppl 1); Suppl 1:35-40. doi: 10.1111/j.1600-0722.2011.00918.x, PMID 22243224.
16. Simmer JP, Papagerakis P, Smith CE, Fisher DC, Rountrey AN, Zheng L, et al. Regulation of dental enamel shape and hardness. J Dent Res. 2010 Oct;89(10):1024-38. doi: 10.1177/0022034510375829, PMID 20675598.
17. Zheng L, Seon YJ, Mourão MA, Schnell S, Kim D, Harada H, et al. Circadian rhythms regulate amelogenesis. Bone. 2013 Jul 1;55(1):158-65. doi: 10.1016/j.bone.2013.02.011, PMID 23486183.
18. McFarlane G, Guatelli-Steinberg D, Loch C, White S, Bayle P, Floyd B, et al. An inconstant biorhythm: the changing pace of Retzius periodicity in permanent human teeth. Am J Phys Anthropol. 2021 May;175(1):172-86. doi: 10.1002/ajpa.24206, PMID 33368148.
19. Nakahata Y, Yoshida M, Takano A, Soma H, Yamamoto T, Yasuda A et al. A direct repeat of E-box-like elements is required for the cell-autonomous circadian rhythm of clock genes. BMC Mol Biol. 2008 Dec;9(1):1-. doi: 10.1186/1471-2199-9-1, PMID 18177499.
20. Hannibal J, Jamen F, Nielsen HS, Journot L, Brabet P, Fahrenkrug J. Dissociation between light-induced phase shift of the circadian rhythm and clock gene expression in mice lacking the pituitary adenylate cyclase-activating polypeptide type I receptor. J Neurosci. 2001 Jul 1;21(13):4883-90. doi: 10.1523/JNEUROSCI.21-13-04883.2001, PMID 11425915.
21. Ray S, Valekunja UK, Stangherlin A, Howell SA, Snijders AP, Damodaran G, et al. Circadian rhythms without the clock gene Bmal1. Science. 2020 Feb 14;367(6479):800-6. doi: 10.1126/science.aaw7365, PMID 32054765.
22. Egan KJ, Knutson KL, Pereira AC, von Schantz M. The role of race and ethnicity in sleep, circadian rhythms and cardiovascular health. Sleep Med Rev. 2017 Jun 1;33:70-8. doi: 10.1016/j.smrv.2016.05.004, PMID 27908540.
23. Antoine D, FitzGerald CM, Rose JC. Incremental structures in teeth: keys to unlocking and understanding dental growth and development. Biol Anthropol Hum Skeleton. 2018 Sep 11:225-56.
24. Zheng L, Seon YJ, McHugh J, Papagerakis S, Papagerakis P. Clock genes show circadian rhythms in salivary glands. J Dent Res. 2012 Aug;91(8):783-8. doi: 10.1177/0022034512451450, PMID 22699207.
25. Adeola HA, Papagerakis S, Papagerakis P. Systems biology approaches and precision oral health: a circadian clock perspective. Front Physiol. 2019 Apr 16;10:399. doi: 10.3389/fphys.2019.00399, PMID 31040792.
26. Chen ST, Choo KB, Hou MF, Yeh KT, Kuo SJ, Chang JG. Deregulated PER1, PER2, and PER3 gene expression in breast cancers. Carcinogenesis. 2005;26(7):1241-6. doi: 10.1093/carcin/bgi075, PMID 15790588.
27. Stevens RG, Hansen J, Costa G, Haus E, Kauppinen T, Aronson KJ, et al. Considerations of circadian impact

for defining 'shift work' in cancer studies: IARC Working Group Report [IARC Working Group report]. Occup Environ Med. 2011;68(2):154-62. doi: 10.1136/oem.2009.053512, PMID 20962033.
28. Hsu CM, Lin SF, Lu CT, Lin PM, Yang MY. Altered expression of circadian clock genes in head and neck squamous cell carcinoma. Tumour Biol. 2012;33(1):149-55. doi: 10.1007/s13277-011-0258-2, PMID 22081375.
29. Oh EY, Yang X, Friedman A, Ansell CM, Du-Quiton J, Quiton DF, et al. Circadian transcription profile of mouse breast cancer under light-dark and dark-dark conditions. Cancer Genomics Proteomics. 2010;7(6):311-22. PMID 21156964.
30. Lee S, Donehower LA, Herron AJ, Moore DD, Fu L. Disrupting circadian homeostasis of sympathetic signaling promotes tumor development in mice. PLOS ONE. 2010 Jun 7;5(6):e10995. doi: 10.1371/journal.pone.0010995, PMID 20539819.
31. Relles D, Sendecki J, Chipitsyna G, Hyslop T, Yeo CJ, Arafat HA. Circadian gene expression and clinicopathologic correlates in pancreatic cancer. J Gastrointest Surg. 2013 Mar;17(3):443-50. doi: 10.1007/s11605-012-2112-2, PMID 23254314.
32. Zeng ZL, Luo HY, Yang J, Wu WJ, Chen DL, Huang P, et al. Overexpression of the circadian clock gene Bmal1 increases sensitivity to oxaliplatin in colorectal CancerBmal1. Clin Cancer Res. 2014 Feb 15;20(4):1042-52. doi: 10.1158/1078-0432.CCR-13-0171, PMID 24277452.
33. Jiang W, Zhao S, Jiang X, Zhang E, Hu G, Hu B et al. The circadian clock gene Bmal1 acts as a potential anti-oncogene in pancreatic cancer by activating the p53 tumor suppressor pathway. Cancer Lett. 2016 Feb 28;371(2):314-25. doi: 10.1016/j.canlet.2015.12.002, PMID 26683776.
34. Mao Y, Fu A, Hoffman AE, Jacobs DI, Jin M, Chen K, et al. The circadian gene CRY2 is associated with breast cancer aggressiveness possibly via epigenomic modifications. Tumour Biol. 2015 May;36(5):3533-9. doi: 10.1007/s13277-014-2989-3, PMID 25740058.
35. Markt SC, Valdimarsdottir UA, Shui IM, Sigurdardottir LG, Rider JR, Tamimi RM, et al. Circadian clock genes and risk of fatal prostate cancer. Cancer Causes Control. 2015 Jan;26(1):25-33. doi: 10.1007/s10552-014-0478-z, PMID 25388799.
36. Chen R, Yang K, Zhao NB, Zhao D, Chen D, Zhao CR, et al. Abnormal expression of PER1 circadian-clock gene in oral squamous cell carcinoma. Onco Targets Ther. 2012;5:403-7. doi: 10.2147/OTT.S38508, PMID 23226027.
37. Zhao Q, Zheng G, Yang K, Ao YR, Su XL, Li Y et al. The clock gene PER1 regulates the clock gene network in human oral squamous cell carcinoma cells. Oncotarget. 2016 Oct 25;7(43):70290-302. doi: 10.18632/oncotarget.11844, PMID 27602964.
38. Li HX, Fu XJ, Yang K, Chen D, Tang H, Zhao Q. The clock gene PER1 suppresses the expression of tumor-related genes in human oral squamous cell carcinoma. Oncotarget. 2016 Apr 4;7(15):20574-83. doi: 10.18632/oncotarget.7827, PMID 26943040.
39. Wang Q, Ao Y, Yang K, Tang H, Chen D. Circadian clock gene Per2 plays an important role in cell proliferation, apoptosis, and cell cycle progression in human oral squamous cell carcinoma. Oncol Rep. 2016 Jun 1;35(6):3387-94. doi: 10.3892/or.2016.4724, PMID 27035749.
40. Nirvani M, Khuu C, Utheim TP, Sand LP, Sehic A. Circadian clock and oral cancer. Mol Clin Oncol. 2018 Feb 1;8(2):219-26. doi: 10.3892/mco.2017.1518, PMID 29435282.
41. Shellis RP. Utilization of periodic markings in enamel to obtain information on tooth growth. J Hum Evol. 1998 Oct 1;35(4-5):387-400. doi: 10.1006/jhev.1998.0260, PMID 9774501.
42. Kierdorf H, Kierdorf U, Frölich K, Witzel C. Lines of evidence–incremental markings in molar enamel of Soay sheep as revealed by a fluorochrome labeling and backscattered electron imaging study. PLOS ONE. 2013 Sep 6;8(9):e74597. doi: 10.1371/journal.pone.0074597, PMID 24040293.
43. Christopher Dean M. Tooth microstructure tracks the pace of human life-history evolution. Proc Biol Sci. 2006 Nov 22;273(1603):2799-808. doi: 10.1098/rspb.2006.3583, PMID 17015331.