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Review Article

Review report on mammalian dental defect (enamel hypoplasia) in different groups of mammals

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Abstract
Enamel hypoplasia is a mammalian tooth malady characterized by reduction in the thickness of its enamel. Enamel hypoplasia is an environmental and physiological stress indicator for the insults an animal has faced during its growth and development. It also points out the health status of a mammal during different phases of its life span. The article outlines the dental enamel hypoplasia studies in low and high crowned mammals. It also depicts the diversity in feeding habitat of mammals having positive results for occurrence of this tooth malady. The present review correlates the research studies that have been conducted in deciduous as well as permanent dental material of modern, archeological and palaeontological animals belongs to multiple orders of class Mammalia and also provides a road map for comparative analysis of dental health in different mammalian taxons.

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INTRODUCTION

Enamel hypoplasia (EH) studies can deliver a unique perception of physiological and environmental stress events that an animal has encountered during its growth phase. Enamel is the hardest mammalian tissue and marks or depressions that once develop on enamel remain unaltered even during process of fossilization. So EH can be a highly admirable stress marker for the life history of modern, archeological or extinct animals. The EH studies are relatively new as the oldest recorded study on the topic was on analysis of EH in *Canislups* (Dog) by Mellanby. (1929).

EH is a type of dental defect defined as the thinning of enamel (Goodman and Rose, 1990).EH is caused by a physical interference in the ameloblasts formation during dental development process. Enamel formation follows two phases, secretary and maturation (mineralization) phase respectively (Hillson, 1986). In the secretary phase EH incidence takes place. Enamel formation started from crown and moves downward towards root crown junctionas shown in Fig. 1 (Goodman and Rose, 1990). FDI; Federation Dentaire International (1982) has categorized EH into pits, grooves and areas missing enamel. Pits and grooves can be single or multiple. Semicircular Enamel Hypoplasia (SEH) and Linear Enamel Hypoplasia (LEH) are two main sorts of area missing enamel.

The area missing enamel has advantage over other two types that it can be examine macroscopically while other two types of EH can only be analyzed microscopically. The age of the animal during a stress episode in its ecosystem can be accessed on the basis of position of area missing enamel on tooth crown relative to the tooth-crown junction (Goodman *et al.,* 1980; Suckling, 1989).

Linear enamel hypoplasia can be diagnosed on the basis of single or multiple bands on enamel surface (Goodman and Rose, 1991; Skinner and Goodman, 1992).Following available EH studies on different mammalian taxa point out the different type of samples that can be used for EH study and also narrate the groups of mammals in which this disorder is reported.

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Enamel Hypoplasia in Human

Lukacs (1991) studied prevalence and pattern of expression of localized (circular) hypoplasia in primary dentition.The results show that 34.5% children has EH and in these children occurrence of EH is comparatively high in mandible, unilateral expression of EH is more frequent than bilateral expression and the defect has no significant association with age, sex or social status. The occurrence of enamel defects in patients of Chennai Hospital, India is 22.2 %, specifically 38% studied cases has enamel hypoplasia. The type of dentition wise ratio of this defect was 11%, 10%, 06% and 04% in upper incisor, upper canines, lower premolar and upper second molar respectively. The incidence of this defect is high in upper than in lower dentition (Challammal and Dharman, 2016).

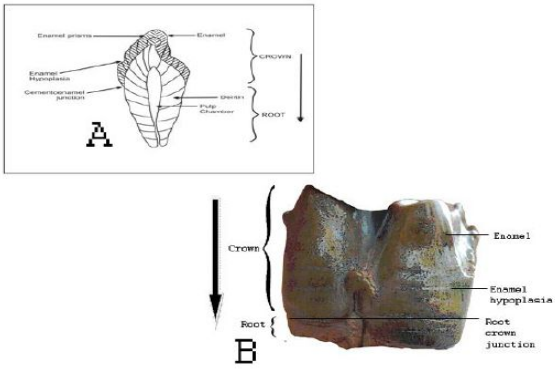

Figure. 1. (A) Hypothetical tooth demonstrating the process of enamel formation (Goodman and Rose, 1990; Franz-Odendaal *et al*., 2004). (B) Diagrammatic representation of Rhinocerotid molar. The vertical arrow (extreme left) indicates the direction of crown development (addition of enamel) from tip to base (taken from Roohi *et al.,* 2015)

Littleton and Townsend (2005) stated in an Australian population study that frequency of EH is five times high in 1955-1960 as compare to 1890-1929 cohort. Occurrence of EH was observed in both primary as well as permanent teeth. An EH study was conducted at Hasan Sadikin Hospital Bandung, Gambia, control group included the children with normal birth weight and experimental group has the children with low birth weight. No EH was there is control group. In experimental group occurrence of EH is high on arches of both sides (Soewondo and Effendi, 2012). A cohort study by Stayton *et al.* (2001) reported that 3%, 2% and <1% of the children has one, two and three or four teeth affected with EH. Only one case was there that have more than four teeth with EH. Occurrence of the defect was comparatively high in mandible and its frequency was highest in deciduous second molar and lowest in deciduous incisors (Table I).

Enamel Hypoplasia in Non-human Primates

Monkeys experience more stress due to physiological or nutritional stress and *Cebus* of semi deciduous forests has more EH than that of coastal region individuals but no variation in occurrence of EH has noted down with variation in annual rainfall of the studied habitats, Table I (Chollet and Teaford, 2010).

Enamel Hypoplasia in Artiodactyls

In *Sivatherium hendeyi* existence of EH is significantly high in permanent teeth as compare to deciduous one. Permanent dentition has both linear and nonlinear enamel hypoplasia but in case of deciduous teeth only occurrence of nonlinear enamel hypoplasia was observed. Both these types of EH existence is highest in m3 as compare to other type of teeth in this Pliocene giraffid (Franz Odendaal *et al*., 2004).

In EH study on 10^{th}-11^{th} century domestic pig jaw fragment no enamel defect was observed on deciduous fourth premolar but severe EH was analyzed on upper half crown of upper first molar (Teegen and Kyselý, 2016).

Upex *et al.* (2012) described the modifications required in currently in practice EH analysis methodologies for high crowned mammals. Along with this they conducted a comparative analysis of modern and archeological tooth samples of caprine. 147 and 77 teeth were analyzed for presence of EH in North Ronaldsay modern caprines and archeological samples of Knap respectively. 79% of the living and 49% of the archeological caprines has occurrence of EHin the studied samples that indicates that the living North Ronaldsay caprine populations are suffered with more stress as compared to the ancient caprines of the area (Table I).

Enamel Hypoplasia in Perissodactyls

Siwalik outcrops are a good source of Neogene mammals (Waseem *et al*., 2016). Roohi *et al*. (2015) research work depicts that 5% of the fossilized teeth included in study of

Siwalik rhinoshave EH. The observed EH can be categorized into single LEH, multiple LEH and SEH. Maximum seven bands of EH are observed on a third molar. The analyzed materials is collected from wide range of the Siwaliks of Pakistan. Theresults describe that incidence of EH is high in samples with chronological age 23-20, nearly 16, 12-08 and nearly 02 Myr.

Table I: Enamel hypoplasia studies in mammals

Study Area	Species	Age (years)	Sample Size	Type of Dentition Analyzed	Enamel Hypoplasia (%age in in individual)	Reference
Pakistan	*Homo sapiens* (Human)	05-08	113	Deciduous teeth	34.50	Lukacs (1991)
USA	*Homo sapiens* (Human)	4.6 (Mean Value)	698	Deciduous teeth	06	Stayton *et al.* (2001)
South Africa	*Sivatherium hendeyi* (Short necked giraffid)	----------	1759	Mandibular teeth	83.18	Franz-Odendaal*et al.* (2004)
India	*Homo sapiens* (Human)	11-50	450	Deciduous and permanent teeth	38	Challammal and Dharman (2016)
Czechia, Europe	*Susdomesticus*(Domestic Pig)	09 Month	Single sample	Right Upper Jaw fragment	……..	Teegen and Kyselý (2016)
Australia	*Homo sapiens* (Human)	----------	446	Dental Casts	----------	Littleton and Townsend (2005)
Gambia	*Homo sapiens* (Human)	09-48 month	147 low birth weight children and 350 normal birth weight Children	Deciduous teeth	……	Soewondo and Effendi (2012)
United Kingdom	*Ovisaries* (Seep)	……	147	Modern mandibular teeth	79%	Upex et al. (2012)
			77	Archeological mandibular teeth	49%	
Pakistan	Siwalik species of Rhino	……..	846 fossils	Deciduous and Permanent teeth	05%	Roohi et al. (2015)
Brazil	*Cebus sp.*	…….	144 animals	…….	……	Chollet and Teaford. (2010)
London	*Canislups* (Dog)	……	……	……..	……..	Mellanby. (1929)

This high occurrence of EH indicates that climatic and vegetation variations of these time spans implicated high impact on health status of these animals (Table I).

Enamel Hypoplasia in Carnivores

Mellanby (1929) reported indent of EH on the tooth enamel of dogs and he also observed that the defect has association with deficiency of vitamin A and D (Table I).

DISCUSSION AND CONCLUSION

EH is a dental defect that can be a reliable marker for stress that an animal has faced during its tooth development. The both physiological as well as environmental stress can be an etiology for occurrence of EH in mammals. Physiological stress events include diseases, vitamin A deficiency, Rickets and mineral deficiency while climatic and nutritional changes are the environmental stress events. As EH is observed in animals of varied dietary patterns, *i.e.,* herbivores (grazer and browsers), carnivorous and omnivorous mammals so in a community that has different types of feeding interaction EH analysis can predict successful feeding interactions in the habitat of these animals. EH is also present in archeological and palaeontological dental material of mammals so environmental conditions of the past can be traced out with the help of EH. EH is a stress marker so is an excellent source of comparative analysis for extent of effect for varied nutritional and ecological stressors in different taxons of mammals. As the defect is present in both deciduous as well as permanent teeth so EH on the deciduous teeth can be used to trace out the stress events faced by an animal during its early development as well as the stress encountered by its mother. EH presence on the permanent teeth is a tool to find out the nutritional as well as environmental stresses.

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