

Review Article

Neonatal Line: A Valuable Evidence to Prove Female Infanticide

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ABSTRACT

Female infanticide is a widespread social problem in India. Majority of the cases of infanticide goes unreported, as there is a lack of proper evidence. It is very essential to distinguish live birth from stillbirth, to prove a case of infanticide. However, by the time, the mortal remains of the child are available for forensic examination, the body is decayed and putrefied; hence, soft-tissue evidence is lost. Although the chronological age of the child can be estimated by skeletal parameters, they cannot differentiate live birth and stillbirth. Thus, in such cases, the neonatal line is a valuable tool to prove female infanticide.

KEY WORDS: Female infanticide, forensic odontology, live birth, neonaticide neonatal line, stillbirth

INTRODUCTION

Female infanticide is a widespread social problem in India, and many Asian countries such as Bangladesh, China, Nepal, Pakistan, and South Korea.^[1] Infanticide is defined as the killing of a child under the age of 1 year and the term neonaticide is used when the child is killed within 24 h of birth.^[2,3] Female infanticide is the intentional killing of baby girls due to the deep-rooted patriarchal customs that perpetuate male preference in India.^[2]

It has been reported that up to 50 million girls are missing from India's population, with a very low sex ratio at birth of 940 females per 1000 males, India has the largest number of missing women.^[1,4] Brutal acts, such as gender selection followed by termination of a female fetus, female neonaticide, and female infanticide, have resulted in a condition called "Female Deficit Syndrome" in India, which in turn leads to adverse social, political, and economic problems.^[5]

CHALLENGES IN THE INVESTIGATION OF FEMALE INFANTICIDE

Majority of the crime remains hidden from the outside world, and those cases which are brought before the law remains unproven due to the lack of proper evidence.^[6,7] The main aim of forensic investigation in infanticide is to provide evidence against the claim of stillbirth.^[6,7] A strong evidence to prove a case of infanticide requires the differentiation of live birth from stillbirth. The independent existence of a child can be proved by the changes occurring in lungs, heart, and the surrounding vessels at birth. However, in a majority of the cases, the soft-tissue remains are decomposed, and the body is putrefied, by the time, it is retrieved for forensic investigation, and only skeletal remains are available for investigation.^[6,7]

Diagenesis of the small and incompletely mineralized infant skeleton remains, makes the accurate estimation of the age of the child, difficult.^[8] If the skeletal remains are intact, various skeletal parameters provide an accurate estimation period of gestation of the child. However, it cannot distinguish live birth from stillbirth and cannot provide valuable evidence of the independent existence of the child. Thus, in such circumstances, developing teeth provides a reliable estimate of the age of the child.^[8,9]

The high endurance of teeth to adverse physical conditions, such as heat, cold, fire, and chemicals, make the assessment of the developing teeth a viable tool for forensic investigation. They can also be acquired from fossilized remains and render a vast amount of metric and morphologic data relating to hominid evolution.^[9]

IMPORTANCE OF DENTAL DEVELOPMENTAL DATA IN FORENSIC INVESTIGATIONS

Dental development data are good predictors of age from approximately 10 weeks of intrauterine life (IUL) until the early twenties, as they are based on formative or development changes such as (a) soft-tissue proliferation premineralization sequences, (b) histological mineralization, (c) incremental patterns of dentin and enamel formation, (d) the emergence of teeth into the oral cavity, and (e) apical closure of the roots. Among these developmental data, the incremental patterns of enamel, are of great use in the investigation of female infanticide, as the child is killed immediately or within a few days of birth.^[9]

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NEONATAL LINES

The various stages of growth, during the development of the dentition, follow a very precise pattern, particularly before and after birth.^[9] The mineralization of dental hard tissue such as enamel, dentin, and cementum follows a rhythmic pattern of active formation and rest.^[6,7] An artifact called striae of Retzius are formed when the ameloblasts lay the enamel in an incremental pattern.^[6,9] At birth, the deciduous tooth germs are not completely developed and the enamel is only partially mineralized.^[6] The ameloblasts are very sensitive to environmental changes, thus, the physiological alteration in the cellular activity of ameloblasts at birth results in the formation of an accentuated incremental line known as the neonatal line.^[6,7] It has also been hypothesized that the neonatal line can be formed due to the decrease in plasma calcium levels during the first 48 h after birth, along with the trauma during birth.^[10]

NEONATAL LINE – A VITAL EVIDENCE FOR LIVE BIRTH

The sudden change from intrauterine to the extrauterine environment results in physiological stress, this, in turn, alters the dimension, direction, and degree of mineralization of the enamel prisms.^[6,7,9] The neonatal line is an optical phenomenon produced due to these alterations. The neonatal line separates prenatal enamel (regular and highly calcified) from postnatal enamel (less regular and less homogeneous in calcification), and also represent the rest enamel formed after birth. A substantial body of evidence suggests that the presence of the neonatal line in primary teeth indicates the independent existence of the infant, recording the event of live birth.^[7]

The deciduous tooth germs and the first permanent molar begin calcifying by the 20th week of IUL, and the mineralization continues for some time after birth.^[7,9] Hence, the neonatal line can be observed in all these teeth. Janardhanan *et al.* in their study, have described the incisors as the tooth of choice as neonatal line and the cross striations are visualized better in incisors when compared to canines and molars.^[7]

Hypomineralized line homogeneous to the neonatal line can be observed in dentin; however, the mineralization pattern and the nonreparative nature of enamel makes the neonatal line a distinct and reliable one when compared to the line in dentin.^[7]

IMPACT OF MODE OF DELIVERY AND METABOLIC STRESS ON NEONATAL LINE

Neonatal lines are caused by metabolic changes resulting from the experience that the infant undergoes at birth and during its neonatal life.^[11,12] In a study conducted by Eli *et al.*, the width of the neonatal line was found to be higher in infants born by an operative (difficult delivery) when compared to infants born by normal delivery.^[12] Furthermore, the thickness was the least in infants born by elective cesarian section, where there was no active birth process. Zanolli *et al.* have suggested that, more than the mode of delivery, the factors related to gestational length had an impact on the width of the neonatal line.^[13] In the study conducted by Hurnanen *et al.*, the width of the neonatal line was found to be inversely proportional to the duration of the delivery; and prolonged delivery process

Table 1: Literature on neonatal line observed in still born and live born infants^[6-8]

Author	Description
Smith P <i>et al.</i> , 2005 ^[8]	The neonatal line was demonstrated in fourteen infant remains that was obtained from a historic excavation site Ashkelon, suggestive of mass infanticide
Janardhanan M <i>et al.</i> , 2011 ^[7]	Neonatal line observed in deciduous incisors, obtained from an infant who died 6 days after birth, appeared scalloped in ground section Six cross striations were observed which corresponded to the number of days of survival of the infant The neonatal line that was observed in a control tooth (developing permanent molar) obtained from a 1½-year-old child which was extracted due to dentigerous cyst appeared straight in ground section
Srinivasan S <i>et al.</i> , 2017 ^[6]	No evidence of neonatal line was observed in the tooth germs of a stillborn baby A faint neonatal line was observed in the tooth germ of an infant which had died 10 days after birth The neonatal line was observed as a distinct clear birefringent band under polarized microscopy, in the primary tooth extracted due to pathological reason from a 5-year-old child

was suggested to inhibit the development of the neonatal line.^[14] Norén observed that infants born to diabetic mothers were found to be prone to hypocalcemia, showing thicker and less mineralized neonatal line.^[15]

APPEARANCE OF NEONATAL LINE IN DIFFERENT MICROSCOPES

1. Under the light microscope, the neonatal line was seen as a distinct dark line, closer to the outer surface of the enamel and the line was found to be running parallel to the outer surface.^[6,7]
2. Microradiograph analysis revealed hypomineralization in neonatal line, and the width of the neonatal line is reported as up to 30 µm^[7]
3. Under the polarized microscope, the neonatal line appears as a distinct positive birefringent band^[7]
4. Under scanning electron microscope (SEM), the neonatal line appears as an indistinct scalloped or nonscalloped white line. Table 1 shows the literature on neonatal line observed in still born and live born infants.^[6-8]

LIMITATIONS

A substantial body of evidence shows that the neonatal line can be visualized, only if the baby had survived for at least 2 days, however predominantly, a majority of the infanticide occur immediately after birth; thus, this is the major limitation in using the neonatal line as evidence for infanticide.^[7]

The light microscope can demonstrate neonatal line only after a significant amount of postnatal enamel has developed;

hence, it might be essential for the child to survive for 3 weeks for the neonatal line to be visible. However, in a study conducted by Janardhanan *et al.*, they were able to demonstrate the neonatal line in a baby who had survived for just 6 days, also the six incremental lines correlated with the 6 days of survival of the baby before death. Thus, according to Janardhanan *et al.*, numerous factors such as the axis of the tooth section, thickness of the section, and the light source used, might influence the detection of neonatal line. Whittaker and MacDonald have stated that SEM can distinguish postnatal enamel from prenatal enamel within a day or two after birth.^[7,16] In a study conducted by Srinivasan *et al.*, the neonatal line was best visualized under the polarized microscope, in a baby which had died 10 days later.^[6]

CONCLUSION

The presence of neonatal line, provides a vital evidence, about the period of separate existence, and the number of days, the infant had survived before the brutal act of infanticide, hence further research is required to detect it at the earliest, using specialized microscopic techniques. Further, it can be included in the routine postmortem protocol, as it can be used as stand-alone evidence against infanticide (in case of the absence of other soft tissue and hard tissue evidence), or it can be used as an adjuvant with other evidence and investigation, to prove a case of infanticide.

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CONFLICTS OF INTEREST

There are no conflicts of interest.

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