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AN OVERVIEW ON DEVELOPMENT OF PALAEOPATHOLOGY IN THE INDIAN SUB-CONTINENT

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ABSTRACT

"Our basic research interest is to reconstruct biological dynamics of earlier living human populations and clearly a sample of dead people is not the same as a sample of living people. What is less clear is how significant this difference is and what mechanisms can be used or developed to minimize the effect of this difference on the interpretation of our data (Ortner, 2003)

BACKGROUND

Palaeopathology essentially can be defined as the study of (logos) ancient (palaeo) suffering (pathos) in both humans and other animals. It is a discipline that aims to trace the origin, evolution and history of disease over long periods of time through pathological changes which represent diseases suffered in life and observed in human remains buried at archaeological sites (Fig. 1). Other definitions of Palaeopathology includes; 'Investigation of the disease affecting human ancient population for better understanding of the process of human adaptation led to the development of palaeopathology which is also considered as a holistic study of humans in their physical environment' (Roberts and Manchester 1995). 'Paleopathology encompasses the study of disease, both human and nonhuman, in antiquity using a variety of different sources including human mummified and skeletal remains, ancient documents, illustrations from early books, painting and sculpture from the past, and analysis of coprolites' (Ortner 2003: 23).

The term palaeopathology was first implemented by Shufeldt in 1892, which literally explain as 'ancient suffering'. However Sir Marc Armand Ruffer (1913) is considered as the father of modern palaeopathology. He defined palaeopathology as "the science of the disease which can be demonstrated in human and animal remains of ancient times" (as cited in Zimmerman and Kelley, 1982). Palaeopathology is thus the study of effects of the past pathogens that have their signature on the bones

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Figure 1: Child skeleton in situ from Medieval site Balupur

and teeth (Tavares, 1997). Palaeopathological studies aimed at the understanding and the process of the evolution of disease and their impact and role in the human biologic and social history (Zimmerman and Kelley, 1982). The discipline illustrates how people interacted with their environment and adapt to it over time and also contribute to the knowledge in the modern medicine (Roberts and Manchester, 1995).

PALAEOPATHOLOGY IN ARCHAEOLOGY AND ITS DEVELOPMENT

In 1964, C. Wells despite criticism awaken archaeologists to the potential of studying palaeopathology on human remains. In archaeological context palaeopathology helps to understand the health practices of the population, diseases frequencies related to occupation, subsistence strategy and climatic changes and how the population adapted (Tavares, 1997). Initially the principal emphasis of palaeopathology was on the descriptions of individual cases, primarily in order to demonstrate the diagnosis of specific conditions and to help establish the antiquity of various diseases. In recent decades, although the individual case study still has a place, there has been a greater emphasis on population studies, which results in the divergent from medico-historical orientation to addressing archaeological questions. A dominant theme is now evaluating disease frequencies at a population

level and integrating this with cultural data pertaining to the populations under study from archaeological (or historical) sources in order to address questions of broader archaeological interest (Mays and Pinhasi, 2008).

The history of palaeopathology in many ways parallels the development of most other scientific disciplines. Much of the early research was no more than an anatomical account of the abnormal conditions with little attempt to explore the biological or pathological significance of what was being described. Towards the end of the 19th century the question of the origin of syphilis began to be debated with an intensity that continues today. This debate marks one of the earliest attempts to use archaeological human remains to resolve an important biomedical problem (Otner, 2003).

There are many sources of evidence of disease in the past and the main primary source is human remains. These skeletons provide evidence of some of the diseases but most anomalies are not visible on them, including malaria, small pox any many other infections or viruses and lesions related to soft tissues. In some cases like mummies or human remains from certain environment preserves skin, organs which enables detection of diseases from soft tissues. The secondary sources include literature, art representations and folk traditions. If secondary sources are present for the archaeological site then it may be possible to integrate the skeletal data for disease in the past populations (Roberts, 2009).

For the interpretation, diagnosis and influence of diseases, variables such as individual's living environment, diet, work (occupation), conflict, and the ancient means of curing and mending has to be considerate (Roberts, 2009). The discipline is of a gradual development from the traditional methods to scientific methods and at present the methodologies have developed sophisticated means to study the past diseases. Some of the major scientific methods implemented in the studies are: histological method of analysis, radiography, bio-molecular analysis which include stable isotope analysis and ancient DNA analysis (Roberts, 2009).

Palaeopathologists have the benefit of being able to study the remains of the diseased directly, although usually only in fraction, and this ability may be the only factor in their favour. The principal disadvantage that constrains palaeopathologists is that their study is restricted largely to those diseases that affect the skeleton. Thus, it is generally impossible or rare chances for palaeopathologists to determine the cause of death of those they examine (Waldorn, 2008). Determining the cause of death is often a speculation (Roberts and Manchester, 1995). The other major problem is that there is no agreed system for diagnosing disease in the skeleton to which all (or even the majority of) palaeopathologists subscribe, thus rendering comparisons between different studies somewhat arbitrary at best, and invalid at worst (Waldorn, 2008). The population studied are dead and may not be representative of the living group and sample representatively is difficult to assess (Roberts and Manchester, 1995).

There are other issues as well while discussing the palaeopathology. The bone reacts in a very limited ways to any disease. The pattern of bone changes may give clue for understanding aetiology to a certain extent. The other problem related to the interpretation of individual health from the skeletal evidence. It was first mentioned by James Wood, George Milner, Henry Harpending and Kenneth Weiss in 1992. It is presumed that if certain lesions are present, then the skeleton is deemed to have been unhealthy at the time of death, and at the same time if the skeleton does not show any lesions, then the individual is labeled as healthy. This is called as osteological paradox where individuals who lived long enough to manifest skeletal lesions were healthier than those who died of an illness before it could manifest in their skeletons (Wood *et al.*, 1992). Thus a high prevalence of skeletal lesions may indicate not an unhealthy population but one in which disease was regularly survived for long enough to cause bone changes. By contrast, a population showing few skeletal lesions may do so not because they were generally healthy, but because their resistance to disease was too poor for them regularly to survive it long enough for bone lesions to develop (Pinhasi and Bourbou, 2008).

PALAEOPATHOLOGY AND THE INDIAN SUB-CONTINENT

The first initiative of the study of paleo-anthropology on the Indian Sub-continent was the quest for hominid fossils by different researchers. However, these fossil records were scanty but the Indian sub-continent yielded enormous evidence of human skeletal remains starting from the Mesolithic to Historical age (Walimbe, 2011). The study on the Human Skeletal record were not fully developed till 1970's as the main focus of these studies was to establish the ethnic identity of the remains, their relationships with contemporary populations and their racial categorization. The cranium was the focal point of discussion and postcranial bones were collected but only used for age, sex and the stature estimations (Mushrif-Tripathy, 2014).

From 1970's onwards the field of skeletal biology developed from the descriptive and classificatory stage to a stage where the dead can speak volumes and factors like adaptation were considered as one major factor of population differences (Walimbe, 2011; Mushrif-Tripathy, 2014). The development in the field resulted into important concepts of adaptation, growth, diet and nutrition and their effects on the skeletons which were further analysed, led to a better understanding of the ancient populations. Bio cultural approach was included in the field where ethnographic studies on the health, diet, occupation, diseases etc. were observed which gave an impetus in the discipline (Mushrif-Tripathy, 2014). The Previous studies were focused only on the adult specimen and the infant and sub- adult bones were discarded. The inclusion of these specimens change the research perspective as the individual's history of illness in the delicate period can be observed more easily in sun-adults than the mature adult bones. The consequences of change in research strategy can be seen in two major aspects, first is the interpretation about biological affinities and the second is identification of pathological conditions (Walimbe, 2011).

Palaeopathology before 1980's was primarily limited to gross lesions like dental carries, ante-mortem tooth loss or obvious factures. In the later stage, new techniques developed and important pathologies such as congenital (present at birth) and acquired (developed during life) diseases were observed (Walimbe, 2011). Different kinds of stress indicators and trauma were identified such as Harris lines, occupational stress markers, traumatic lesions, degenerative conditions etc were observed and analysed scientifically.

Earlier reports on racial affinities of the people of India was summarised by Guha (1931). In 1938, Guha and Basu reported on the human remains recovered from Mohenjo-daro and in 1954 Sarkar gave a racial classification of India, however all these studies were based on racial and biological variations among the Indian population. One of the earliest reporting on the study of palaeopathology was made by D. N. Banerjee in the Journal of Indian Medical Association in 1941. The interdisciplinary approach adopted by Dr. Irwati Karve to work on various bio-cultural, ethno-historical and palaeo-anthropological issues led to the initial introduction of a more elaborate research in the country. In order to understand the biological variations and to know the nature of prehistoric movement in India, Dr. Karve initiated studies on human skeletal remains from the Mesolithic site Langhnaj in 1945 (Walimbe, 2007).

However, the study of human skeletal remains in India made its mark in 1960's when Ehrhardt and Kennedy who worked on the analysis of the Human Remains at Langhnaj (1965) and in the same year Kennedy and Malhotra studied the Nevesa skeletal series. Malhotra studied Chandoli and Tekkalakota skeletons in 1965. In the following decade, Kennedy gave an anatomical description of two crania from Ruamgarh (1972), an ancient site in Dhalbhum, Bihar. Lukacs in 1978 worked on the culture- ecology and pattern of dental disease in Neolithic-Chalcolithic populations and in 1980 studied the morphology and pathology of the Apegaon mandible. In the same year Kennedy gave a preview of Prehistoric Skeletal Record of Man in South Asia.

From 1980's onwards the study of human skeletal remains in India showed a tremendous development with more scientific studies being conducted and pathological conditions observed. Basu and Pal (1980) while reporting Burzahom skeletal remains, described trepanation, a kind of surgical operation performed during Neolithic period. Lukacs (1981) worked on dental pathology and nutritional patterns from the megalithic site of Mahurjhari. He also worked on dental disease and dietary patterns of ancient Harappans (1982, 1990) and contributed on the issue of tooth size variation in prehistoric India (1985a) and crown dimensions of permanent teeth from Chalcolithic Inamgaon (1985b).

Till now there are around 200 sites have given human skeletal evidence from India ranging from Mesolithic to Early Modern period. Out of that around 60 sites have been extensively studied. Some of the eminent scholars who worked on the human skeletal remains form this decade to present are Lukacs (1994, 1996, 1998, 2002,

and 2004), Lukacs and Pal (1992, 1993 and 2003), Lukacs and Badam (1976 and 1981), Lukacs and Mishra (1996, 1997, 2000 and 2002), Lukacs and Walimbe (1984a, 1984b, 1986, 1998, 2000, 2005 and 2007), Lukacs *et al.*, 1982 and 2001, Hemphill *et al.*, 1991, Kennedy (1992), Kennedy *et al.*, 1991, 1993, 1992 and 2002, Lovell (1994, 1997, 1998, 2014a and 2014b) Mushrif and Walimbe (2000, 2005a, 2005b and 2012), Mushrif-Tripathy *et al.*, 2003, 2008, 2009a, 2009b, 2011, 2012, Robbins *et al.*, 2004, 2006, 2007, 2012, 2013, Sankhyan and Weber (2001), Sankhyan and Schug (2011), Walimbe (1986, 1988, 1990, 1993a, 1993b, 1993c, and 1996), Walimbe and Lukacs (1992), Walimbe and Paddayya (1999), Walimbe and Shinde (1995), Walimbe and Mushrif (1999), Walimbe *et al.*, 1991 and 2001.

The studies have focused on two questions; first the impact on health by transition from hunting gathering Mesolithic population to early agro-pastoral Neolithic-Chalcolithic communities. The change in the diet and establishment of thickly populated villages had adverse impact on the human skeleton. The age at death in hunting gathering population is higher in comparison with the early agro pastoral communities is evident in skeletal record. The reason behind this seems to be a combination of factors. The high incidence of pathol-ogies in later farming communities is due to a nutritionally poor diet which consisted mostly of cereals and/or root crops. The hunter-gatherers probably ate both meat and forest products whereas the agriculturists had a narrow choice of food with nothing to supplement their diet if and when their crops failed. For example, the evidenced nutritional stress in the Deccan Chalcolithic populations (Lukacs *et al.*, 1986; Walimbe and Gambhir, 1994; Walimbe and Lukacs, 1992; Walimbe and Tavares, 1996; Tavares, 1998) was probably caused by the deficiency of nutrients in staple crops, periodic famines evidenced by archaeological data, food shortages and high infection rates due to population growth (Walimbe and Tavares, 2002).

The physiological stress is seen on the skeletal record of these farming communities indicating synergistic relation between malnutrition and disease, coupled with low acquired resistance for a disease. Walimbe and Tavares in their article discuss the issue while unfolding the scope and development of human skeletal studies in India. They have summarized "…General or cumulative stress is reflected in higher mortality rates, decreased ages at death, retarded body growth, reduced robusticity and stature, and reduced sexual dimorphism. Increased dental crowding and dental asymmetry can be indicative of severe or chronic stress. Periodic indicators of stress provide information on the age at which stress episodes occurred. Two common examples of such periodic stress indicators are Harris lines, i.e. disruption in linear bone growth, and enamel hypoplasia, i.e. disruption in tooth enamel matrix formation. Some diseases leave more specific indicators of stress on bone and teeth. Infectious diseases, nutritional deficiencies, traumatic and degenerative lesions are classified in this category. Porotic hyperostosis, *cribra orbitalia* (vitamin C deficiency) (Fig. 2) and iron deficiency anemia indicate nutritional stress. Specific infectious diseases, such as trepo-nema (yaws/syphilis), tuberculosis and leprosy, or non-specific infectious lesions like periosteal reactions, osteomyelitis (inflammation of

Figure 2: ***Cribra orbitalia*** **(iron deficiency) on orbital roof of child from Iron Age Kodumanal**

bone) can be diagnosed. Traumatic lesions such as fractures, dislocations and artificially induced deformities are caused by physical force or by contact with blunt or sharp objects. Degenerative conditions like osteoarthritis (joint disease) and vertebral osteophytosis (vertebral lipping) are common in old individuals. Dental pathologies like caries, attrition, alveolar resorption (abscess in jaw bone), tartar accumulation and premature tooth loss, all reflect dietary habits. Incidences of these pathologies have been documented in some populations, indicating high research potential of the Indian skeletal evidence" (Walimbe and Tavares, 2002).

The problem of Aryan invasion has been very sensitive issue for Indian from historical, archaeological and anthropological point of view. It was interpreted that Aryan was responsible for the decline of Harappan Civilization (3500 to 1500 BCE). The hypothesis was based on the scattered skeletal remains excavated at the site of Mohenjo Daro.

The so called invasion also is in question from palaeopathological point of view. If we considered the evidence from disarticulated skeletal remains from Mohenjo-daro, one should be able to get some traumatic marks on bones. The Harappan skeletal collection has been restudied by Kennedy (1984, 1994) in the light of the new methodological approaches in the field of forensic anthropology and palaeopathology. He offers a very critical judgement in this regard. He states "when present, marks of injury are quite specific in their appearance, both microscopic

and macroscopic analyses revealing tell-tale features which are not to be confused with abrasions or other marks of erosional and post-mortem origin.....To be sure, individuals victimized by trauma may not bear the marks of their assailant or his weapons on their skeletal tissue (as with cases of drowning, strangulation, poisoning, cardiac arrest due to fright, etc.); but in cases of genocide (like military engagements, mass executions, ritual sacrifices) where multiple victims are involved it is usual for some individuals of a group to reveal marks of traumatic stress on their bones and teeth" (Kennedy, 1984). Death by an axe or sword may not be registered on the bone if the wound is superficial and if only the soft parts are traumatised. But it is reasonable to expect actual wound-marks in case of unceremonious slaughter, which are not present in Mohenjo-daro specimens.

The proposition of a traumatic end of Harappan culture (Mohenjo-daro in particular) is based on essentially an archaeological evidence of disorderly disposal of dead rather than on the skeletal evidence of trauma. In this case the problem of interpreting the disarray of skeletons becomes more complicated. This haphazard mode of disposal of dead might have had some social implications rather than solely pathological. Anthropology or archaeology has no conclusive answer to this puzzle at present. It may be mentioned that some scholars believe that the Mohenjo-daro individuals exhibit a unique pattern of regional phenotypic variability with striking differences setting them apart from skeletal series at other Harappan sites. It has been claimed that the skeletons in question may belong to a post-Harappan period and share no direct biological affinity with the population of the mature Harappan phase (Gadgil and Thapar, 1990; Walimbe, 2011b)**.** Therefore, Aryan invasion is not a fact but fallacy (Kennedy, 1984; Walimbe, 2011; Mushrif-Tripathy, 2014).

Reanalysis of skeletal collections have yielded new evidences of pathologies which are helping in understanding of bygone populations. Studies on Balathal specimen indicate that lepromatous leprosy was present in India by 2000 B.C. This evidence represents the oldest documented skeletal evidence for the disease from India (Fig. 3). The presence of leprosy in skeletal material dated to the post-urban phase of the Indus Age suggests that if M. leprae evolved in Africa. Later the disease migrated to India before the Late Holocene, possibly during the third millennium B.C. at a time when there was substantial interaction among the Indus Civilization, Mesopotamia, and Egypt. This evidence should be impetus to look for additional skeletal and molecular evidence of leprosy in India and Africa to confirm the African origin of the disease (Robbins *et al.*, 2009).

It is interesting to collaborate skeletal data with literary sources. India provides textual evidence from at least 2000 years known as Vedic literature. The origin of the Atharva Samhita (1200-1000 B.C) dates from the period when Brahmanism had become dominant (Weber, 1892), provide reference to leprosy (Bloomfield 2004) and supports the suggestion that this ancient text is the earliest historical reference to the disease, its pathogenesis and treatment. At the same time Kushtha is the Sanskrit word referred to a plant used to treat leprosy and tuberculosis (rajayaksma) in Atharva Veda.

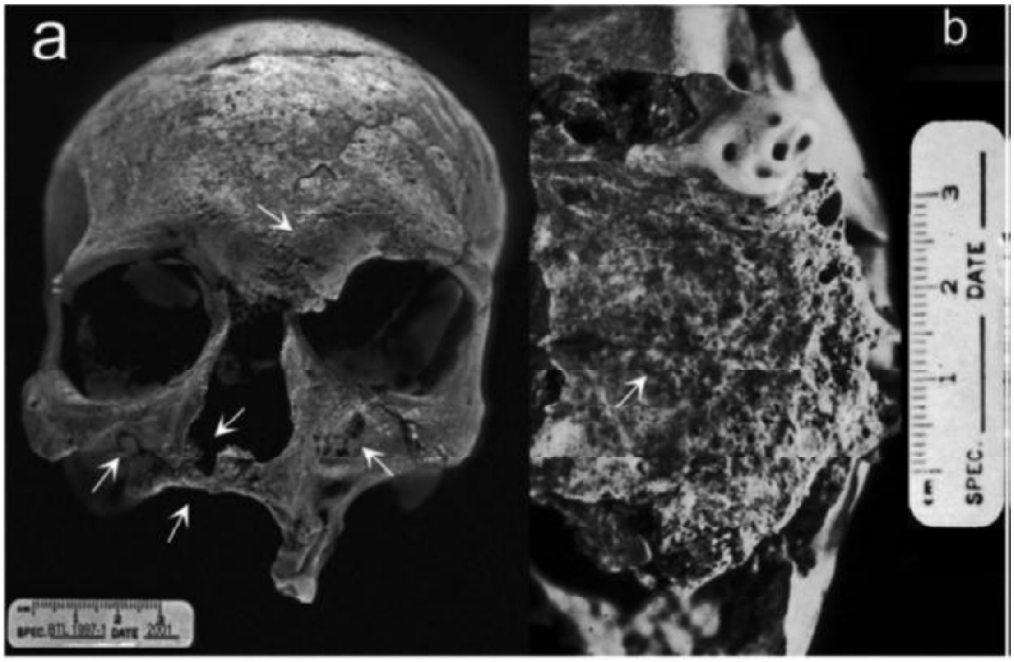

Figure 3: Leprosy from Chalcolithic Balathal

"Born by night art thou, O plant, dark, black, sable.

Do thou, that art rich in colour, stain this leprosy, and the grey spots! …

The leprosy which has originated in the bones and that which has originated in the body and upon the skin, the white mark begotten of corruption, I have destroyed with my charm.'' *(pg. 19)"*

Understanding the biological process at the end of the Indus civilization it is noticed that the prevalence of infection and infectious disease increased through time. Risk for infection and disease was uneven among burial communities. Corresponding mortuary differences suggest that socially and economically marginalized communities were most vulnerable in the context of climate uncertainty at Harappa. Observations of the intersection between climate change and social processes in proto-historic cities offer valuable lessons about vulnerability, insecurity, and the long-term consequences of short-term strategies for coping with climate change (Robbins *et al.*, 2013).

While describing the Harappan population in 'A peaceful realm? Trauma and social differentiation at Harappa'(Robin *et al.*, 2012), mentions that the prevalence and patterning of cranial injuries, combined with striking differences in mortuary treatment and demography among the three burial areas indicate interpersonal violence in Harappan society was structured along lines of gender and community membership. The results contradict the dehumanizing, unrealistic myth of the Indus

Civilization as an exceptionally peaceful prehistoric urban civilization. The interpretations seem to be amplified to some extent, as these observations are based on not very large sample. Harappans lived in large cities for more than 2000 years at one particular area. They were practicing different ways for disposal of dead and not merely by burial. These other practices have been identified at different sites like Harappa, Sanuali, Farmana. The analysis was based on the skeletal remains of 160 individuals. Cranial trauma affected 4% of the total number of crania from Cemetery R-37; 50% of the crania from Area G; 38% of the crania from Cemetery H Stratum II; and there were no affected individuals from Cemetery H Stratum I. In all, 17% of the adult male crania were affected and 22% of the adult female crania were affected. Of 11 immature individuals studied, 18% were affected. These figures itself indicates that it is quite difficult to say for entire population based on such a small sample.

It is interesting to see the presence of maxillary sinusitis, an infection to maxillary floor, in archaeological populations from protohistoric (1500 B.C.) and medieval (around 17th century) India and to understand it from socio-economic perspective (Fig. 4). There are 269 individuals studied from six sites, but only 74 individuals (79 maxillae) were available for inspection. The observations also show that 9 out of 79 maxillae (11.39%) are affected. The study shows that a dental origin of the pathology is more common in males than in females. Various reasons have been encountered as etiology behind sinusitis and both males and females have infections. Two young individuals show maxillary sinus pathology of dental origin. Exposure to polluted air from domestic activities such as cooking and contact to dust or smoke and other particles present in the surrounding environment and certain vocations could be a vital cause of respiratory tract infections, including maxillary sinusitis. Leprosy can be one of the reasons, for at least one individual in present sample.Considering the ethnographic aspects, the study reveals that inflammation possibly caused by inhaling polluted air for a long duration or because of dental

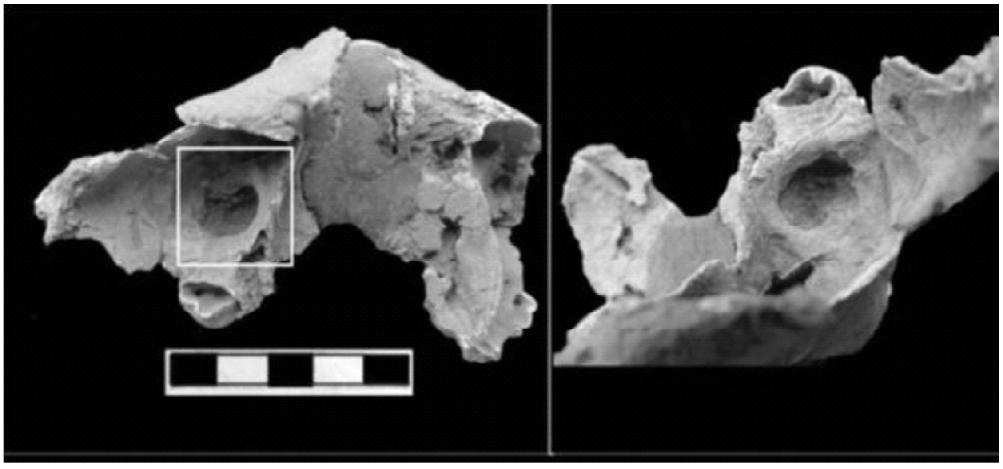

Figure 4: Maxillary Sinusitis from Chalcolithic Nevasa

disease. Also, apart from pollution in domestic zones, external pollution because of vocation is also discussed in this study using relevant ethnographic parallels (Mushrif-Tripathy, 2014).

Recent advances in technology have improved our understanding about past population. Isotopic studies conducted on enamel from Harappan site of Farmana have given evidence of early age migration pattern. Strontium and lead isotope ratios allow us to reinterpret the Indus tradition of cemetery inhumation as part of a specific and highly regulated institution of migration. Intra-individual isotopic shifts are consistent with immigration from resource-rich hinterlands during childhood. Furthermore, mortuary populations formed over hundreds of years and composed almost entirely of first-generation immigrants suggest that inhumation was the final step in a process linking certain urban Indus communities to diverse hinterland groups. Additional multi disciplinary analyses are warranted to confirm inferred patterns of Indus mobility, but the available isotopic data suggest that efforts to classify and regulate human movement in the ancient Indus region likely helped to structure socioeconomic integration across an ethnically diverse landscape (Valentine *et al*., 2014).

The present research is now concentrating on trying to find the ancient DNA from different skeletal remains. It is also trying to find the DNA of pathogens of viruses. India provides big challenge in this task as the bone and DNA preservation is not very good. The humid and fluctuating climate creates big challenge and it will take some time to develop the technology to overcome this problem. In recent years many new skeletal evidences have come forward and they are being discussed in recent anthropological research. Many new finding have come to light which provides better understanding of ancient population.

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