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Research article

Dental adaptations of Bronze Age Harappans: Occlusal wear, crown size, and dental pathology

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ABSTRACT

Systematic study of dental attributes yields insights regarding diet and subsistence that cannot be gained from the archaeological record alone. This analysis documents occlusal tooth wear, tooth crown dimensions and dental pathology of an expanded dental sample from Harappa (2550–2030 cal BC; Pakistan). New floral and faunal evidence of subsistence indicates a mix of agriculture and pastoralism that can be integrated with evidence of dental attributes and disease to reveal the impact of Harappan diet on oral health.

An enlarged dental sample (58 specimens, 910 teeth) from mature phase Harappa was analyzed using Scott's quadrant wear system, measures of crown size, and prevalence of seven pathological dental lesions. All data were collected by the author using standard methods. Sex differences were found in wear, tooth size and prevalence of dental diseases. Females exhibit greater caries prevalence and antemortem tooth loss than men, an attribute associated with higher rates of pulp exposure and abscesses in women. At Harappa antemortem tooth loss results from penetrating caries, while in foragers the cause is severe occlusal wear. In contrast to early Holocene foragers of north India (Damdama, 8800–8600 BP), Harappans have greater occlusal wear, smaller teeth, and a distinct dental pathology profile.

1. Introduction

The dentition of 3rd millennium urban agriculturalists of the Indus Valley Civilization has been a topic of interest to archaeologists and anthropologists since skeletal remains were first recovered from Mohenjo-daro and published in the 1930s (Sewell and Guha, 1931; Guha and Basu, 1938). Yet paradoxically, and with few exceptions (Pal, 1981; Lukacs, 1992), the dental attributes of Bronze Age Harappan samples have not been approached from a problem-oriented, bioarchaeological perspective for over half a century. The goal of this analysis is to document variation in occlusal surface wear, tooth crown size and prevalence of pathological dental lesions in the skeletal sample from the type-site of the Indus Valley Civilization, Harappa (Punjab Province, Pakistan). These data are then used to assess Harappan dental adaptations to an agricultural mode of subsistence and to analyze sex differences in these adaptations. The final objective is to place the dental attributes of Bronze Age Harappans in context by comparing differences in occlusal wear, tooth crown size, and prevalence of dental diseases with South Asian skeletal series from different cultural, ecological and subsistence systems.

New perspectives on many aspects of the Indus Civilization include attention to the archaeological context (Shinde, 2016), the Harappan burial tradition (Kenoyer and Meadow, 2016), and bioarchaeology (Lovell, 2016), including affinities, skeletal pathology and chemical analyses. Migration patterns and mortuary practices in the Indus Valley have been investigated with stable isotopic data (Valentine, 2016) and evidence of an Aryan influence has been analyzed with data from archaeology, skeletal biology and molecular genetics (Danino, 2016). Notable by its absence from this list of recent research on the Indus Civilization is attention to the dental adaptations of the skeletal sample from Harappa. This situation is especially enigmatic because evidence from the dentition can reveal bio-cultural adaptations that cannot be derived from the archaeological record alone. The evidence from dental attributes will also permit a better understanding of how the dental adaptations of Harappans compare with earlier and later periods of South Asian prehistory.

The question of how well Harappans are dentally adapted to their bio-cultural environment is of more than regional interest because different cultigens and food preparation methods have been shown to differentially impact many dental and skeletal attributes (Powell, 1985; Tayles et al., 2009). Diet and nutritional status often have a significant impact on disruptions in growth and dental development (Guatelli-Steinberg, 2016), tooth wear (Burnett, 2016), tooth crown size (Kieser, 1990), dental disease (Tayles et al., 2009; Lukacs, 2012), and mandibular morphology (Hoover and Williams, 2016; Mays, 2015; Lukacs, nd; Von Cramon-Taubadel, 2011).

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Prior to this recent fluorescence of research on the Indus Civilization, the analysis of human skeletons from Harappan sites has had a long yet episodic history that has been documented elsewhere (Dales, 1992; Kennedy, 1992, 2002, 1984). This brief synopsis is focused on dental observations and methodological issues that compromised earlier studies and highlight the significance of the current analysis. Sewell and Guha (1931) analyzed skeletal remains from excavations at Mohenjo-daro (1922–1927) directed by Sir John Marshall, while skeletons recovered during the 1928-29 campaign, directed by Mackay, were analyzed by Guha and Basu (1938). These reports are essentially osteological in nature, but contain descriptive comments on dental remains as well. Observations were limited to specific topics such as, the nature and degree of dental attrition, the presence of specific pathological dental lesions, and the type of dental occlusion (e.g. edge-to-edge, over-bite). Early osteological analyses of Harappan skeletal samples were conducted in a typological racial paradigm (Chatterjee and Kumar, 1963a, 1963b; Guha, 1935; Sen, 1967; Kennedy 1995). The interpretation of Harappan dental attributes was similarly cast in a racial analytic framework. The comparative analysis of dental morphology and dimensions sought to establish the degree of racial affinity between Harappans, Australians and Melanesians, for example. In this analysis, variation in three dental attributes: tooth wear, crown dimensions and pathological lesions is analyzed to gain better insight into their relationship with diet and subsistence, and to enhance knowledge of sex differences in diet and mastication. Tooth wear among Bronze Age agriculturalists of South Asia has not been previously documented, yet is closely associated with subsistence and the type and frequency of dental diseases. An early preliminary report documented tooth crown dimensions for a small pooled-sex dental sample. Though the dental pathology of pre- and post-Harappan South Asians has been documented, a comparison of tooth wear, tooth size, and dental disease in urban agriculturalists of the Indus Valley (mature phase Harappa 5000 BP) and early Holocene foragers of the Ganges Basin (8800 BP) provides new perspectives and insights.

Knowledge of the dental attributes of prehistoric South Asians is critical to answering broader questions about regional and global patterns of dental variation and adaptation. Tooth wear and dental pathology are features of dental variation that yield valuable insights regarding diet and behavior of past populations. The focus of this study is the relationship between these dental attributes and subsistence among Bronze Age people of the Indus Valley site of Harappa. Preliminary reports on dental attributes of mature phase Harappans were based on skeletons excavated in 1987 and 1988 by the University of California (Berkeley) − Harappa Research Project (directed by the late George F. Dales). Dental data from the H87 and H88 excavation seasons filled a major lacuna in knowledge of Harappan dental adaptations by: a) establishing significant sex differences in dental diseases, b) advocating use of a 'caries correction factor' to compensate for antemortem tooth loss in estimating more precise tooth count caries rates, c) reporting tooth crown dimensions for a sex-pooled sample and a summed, cross-sectional tooth crown size of 1194 mm^2, and d) presenting non-metric dental trait frequencies and using them to assess biological distance of Harappans to other prehistoric groups in South Asia (Hemphill et al., 1991; Lukacs, 1989a). The H87/88 dental sample of 751 teeth (Lukacs, 1992; Table 1, p. 5) was the basis for: a) associating changes in prevalence of pathological dental lesions with the intensification of agriculture in the greater Indus Valley, b) recognizing significant inter-sex differences in the frequency of dental diseases among the Harappans, and c) identifying etiological pathways in cariogenesis that led to an innovative method of refining caries prevalence that accounts for inter-sample differences in the cause of antemortem tooth loss (Lukacs, 1995).

Following this initial but preliminary study, analysis of the biological attributes of ancient Harappans has progressed episodically and unevenly by sub-field. The analysis of Harappan dental attributes has been eclipsed in recent years by a focus on skeletal pathology. For example, spinal osteoarthritis, physical stress and trauma have been documented in the H87/88 skeletal sample from Harappa (Lovell, 1994, 2014a, 2016) and skeletal evidence of anemia (porotic hyperostosis, cribra orbitalia) was found in relatively low frequency (Lovell, 1998). A comprehensive descriptive analysis of skeletal pathology in that sample from Harappa (H87/88) is now available (Lovell, 2014b). Re-analysis of Harappan skeletal series, recovered prior to partition (1947) are housed at the Anthropological Survey of India (Kolkata) and reveal a higher prevalence of trauma (Schug et al., 2012; Kennedy, 2000) and infectious disease than recognized in earlier studies (Schug et al., 2013).

Table 1
Summary of sample sizes by excavation year, burial context and sex.

		Individual			Tooth count		
		H87/88	H95	total	H87/88	H95	total
Burial context	Primary	16	4	20	361	106	467
	Secondary	26	6	32	277	50	327
	Isolated	6	0	6	113	3	116
Totals		48	10	58	751	159	910
Sex	Male	17	6	23	281	63	395
	Female	19	3	22	288	36	324
	Unknown	6	1	7	182	9	191
Totals		42	10	52	751	159	910

H87/88 = sample from 1987 and 1988 excavation season. H95 = sample from 1994 excavation and previously unstudied specimens.

The documentation and comparative analysis of dental wear, tooth crown size, and pathology presented here is designed to complement these recent advances in knowledge of Harappan skeletal pathology. Additionally, these new data on mature Harappan dental variation will augment and up-date earlier, less systematic studies by Sewell and Guha (1931), Guha and Basu (1938), and Gupta et al. (1962), critically reviewed by Lukacs (1982).

1.1. Harappan subsistence and diet

An initial summary of changes in subsistence in the greater Indus Valley from Neolithic (Mehrgarh) to Bronze Age (Harappa) relied on a limited range of primary and secondary sources (Lukacs, 1992, p. 145). A fluorescence of research in archaeobotany and zooarchaeology has yielded significant advances in knowledge of Harappan subsistence in the past 25 years. Advances in understanding fluvial landscapes (Giosan et al., 2012), paleoecology (Madella and Fuller, 2006; Sarkar et al., 2016); and spatio-temporal pace of urbanization (Gangal et al., 2010) provide context for new evidence on floral and faunal components of Harappan diet. Improved methods include systematic sampling, advances in data collection and analysis, attention to climate-induced environmental change *vs.* culture-based food preference, and consideration of the acquisition and processing of faunal and botanical components of the diet (Fuller and Harvey, 2006; Fuller and Madella, 2001; Weber, 2003). Reconstructing Harappan diet from archaeological evidence of faunal and floral remains is complicated by inter-site differences in food preparation techniques, disposal of food refuse, and taphonomic factors influencing preservation (Meadow, 1991).

Overviews of Mature Harappan phase (2600–1900 BC) subsistence emphasize: a) the mix of intensive agriculture and pastoralism, b) the predominance of winter (*rabi*) crops (mainly barley and wheat) over summer (*kharif*) crops (various millets), and c) a focus on domestic bovids, primarily cattle, but also sheep and goat (Meadow, 1991; Possehl, 2002). Riverine fish including carp, two types of catfish, and four other fish species were caught in the slow-moving side channels, oxbows and meanders of the nearby Ravi River (Belcher, 1991, 2003). Importantly, four marine fish species (mackerel/tuna, catfish, grunters and jacks) comprise a very small but important component of the Harappan diet that came from trade in dried or salted fish (Belcher,