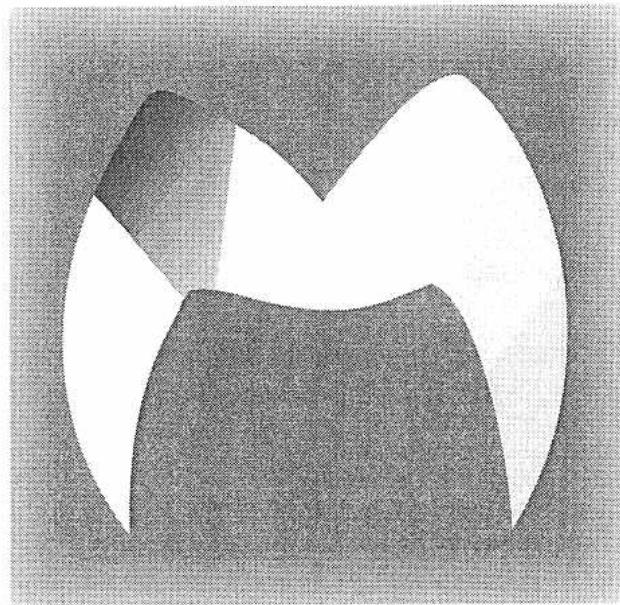


Human Dental Development, Morphology, and Pathology

A Tribute to Albert A. Dahlberg



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Frontispiece: photography by Bob Godman.
Mrs. Thelma Dahlberg writes that this photograph, ". . . was taken by the tax assessor on one of his annual visits. Which, I believe, is further proof that Al liked everyone, and everyone liked him." (Personal correspondence June 11, 1996).

Chapter 7

Are Mahars Autochthonous Inhabitants of Maharashtra?: A Study of Dental Morphology and Population History in South Asia.

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ABSTRACT

The Mahars, a low caste Hindu group many of whom have converted to Buddhism, claim to be the indigenous inhabitants of Maharashtra. This claim of biological antiquity is investigated by examining the frequencies of 17 dental traits among three contemporary social groups of Maharashtra (Marathas, Mahars, Gonds) and one prehistoric sample. In the first comparison, these groups were compared with a prehistoric sample from Maharashtra (Inamgaon), and with two 'outgroups': living Papago Indians and American whites. While Papago Indians and American whites strongly separated from one another and from all Maharashtrians, patterns of affinity among Maharashtran samples remained unclear.

In the second comparison, dental morphology data from nine additional prehistoric samples from central and south Asia were considered. The low-status Mahars tend to be most divergent from Inamgaon and their role in the population history of Maharashtra remains unconfirmed. However, the results of this study suggest that dental morphology variation is not substantially affected by progressive gracilization of the tooth crown corresponding with the technocultural transition to agricultural production and the adoption of sophisticated food preparation techniques.

Key Words: biological affinities, dental morphology, India, caste, tribe.

INTRODUCTION

The purposes of this research are three-fold. The first is to test patterns of phenetic association among contemporary Maharashtrians in light of current claims by Mahars, a low status caste group, that they represent the autochthonous inhabitants of Maharashtra. The second is to test the efficacy of dental morphology variation for consistent depiction of patterns of human variation at different levels of magnitude of biological separation. The third is to contrast data derived from contemporary populations with that obtained from prehistoric samples to address issues surrounding the peopling and intergroup interaction in south Asia. A comprehensive review of the issues regarding Mahar ethnic identity, including ethnographic documentation and a critical summary of their oral and literary claims to be an indigenous population of Maharashtra state are provided elsewhere (Lukacs, in press).

METHODS

Frequencies of dental traits were calculated for each grade of expression by sex in each of the three contemporary Maharashtran groups according to the individual count method of Scott (1973, 1977, 1980; Turner and Scott, 1980). This technique not only accounts for the fluctuating asymmetric effects of environmental factors (Van Valen, 1962a,b; Staley and Green, 1971; Sciulli et al., 1979), but also maximizes sample sizes in dental series derived from archaeological contexts, such as Inamgaon, where remains are often fragmentary. Frequencies of dental trait expression by grade, sex and series among the contemporary Maharashtran groups is presented in Lukacs and Hemphill (in prep.).

While variation in dental trait morphology was scored along a continuum of expression in each sample, trait expression was dichotomized into presence/absence only for comparative purposes. In most cases, any degree of trait development was considered a positive expression. The only exceptions to this rule involved incisor shoveling and hypocone development. When assessments of incisor

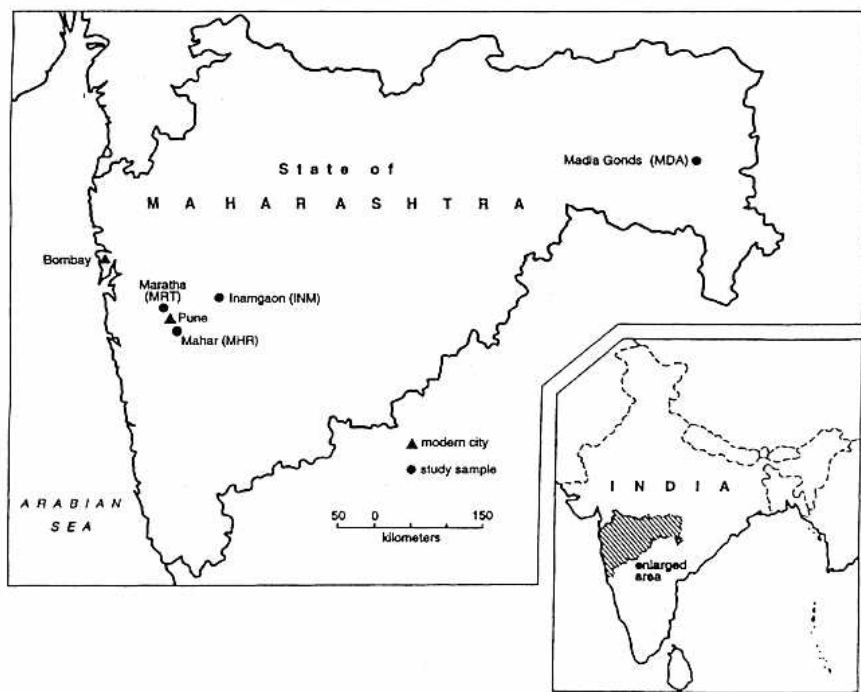


Figure 1. Dental morphology sample map (Maharashtran samples).

shoveling were compared between the first and second author, we found some disagreement in the recognition of extremely minor expressions of this trait. To eliminate this difference in inter-observer assessment, trace expressions (grade 1) as well as complete absence (grade 0) were considered absent for comparative purposes in this study. In accordance with our previous examinations of dental morphology variation (Hemphill et al., 1991; Hemphill and Lukacs, 1993; Lukacs and Hemphill, 1991, 1992) only full expressions (grade 4) hypocone development were considered positive manifestations of this trait.

Frequencies of dental morphology traits among contemporary Maharashtrians were contrasted with other samples in two stages of comparison. In the first comparison the three Maharashtran samples were compared with the prehistoric sample from Inamgaon (Fig. 1), and against samples of contemporary Papago Indians and American whites. In the second comparison these groups were contrasted with frequencies obtained from nine prehistoric skeletal series from central and south Asia (Fig. 2). In this latter comparison, the two samples from Mehrgarh, the sample from Harappa, and the four samples from central Asia all predate the sample from Inamgaon. Timargarha is contemporaneous, while Sarai Khola, post-dates the Inamgaon sample. Sources and sample sizes for all dental series are provided in Table 1.

Table 1. Sample Sizes and Sources.

Sample	Abb.	Date	N _{max} ¹	Source
Mahars	MHR	Living	195	Lukacs and Hemphill (in prep.)
Madia Gonds	MDA	Living	169	Lukacs and Hemphill (in prep.)
Marathas	MRT	Living	198	Lukacs and Hemphill (in prep.)
Inamgaon	INM	1600-700 B.C.	41	Lukacs (1987)
Papago	PAP	Living	178	Scott (1973)
American whites	AMW	Living	77	Scott (1973)
Neolithic Mehrgarh	NeoMRG	6000 B.C.	49	Lukacs (1988)
Chalcolithic Mehrgarh	ChlMRG	4500 B.C.	25	Lukacs and Hemphill (1991)
Harappa	HAR	2300-1700 B.C.	33	Lukacs (1992)
Sarai Khola	SKH	200-100 B.C.	15	Lukacs (1983)
Timargarha	TMG	1400-850 B.C.	25	Lukacs (1983)
Djarkutan	DJR	2100-1950 B.C.	39	Hemphill and Christensen (in prep.)
Sapalli Tepe	SAP	2300-2150 B.C.	43	Hemphill and Christensen (in prep.)
Kuzali	KUZ	1950-1800 B.C.	24	Hemphill and Christensen (in prep.)
Molali	MOL	1800-1650 B.C.	41	Hemphill and Christensen (in prep.)

1. N_{max} represents the greatest number of individuals scored for a non-metric trait.

Although 57 tooth-trait combinations were scored among contemporary Maharashtrians, only 17 tooth-trait combinations were scored in common with the prehistoric series from Inamgaon. Contingency chi-square analysis was used to determine how many of these tooth-trait combinations differ significantly across all samples in both comparisons. Once the number of significant differences was determined, these data were subjected to further analysis. These additional analyses included three different multivariate techniques.

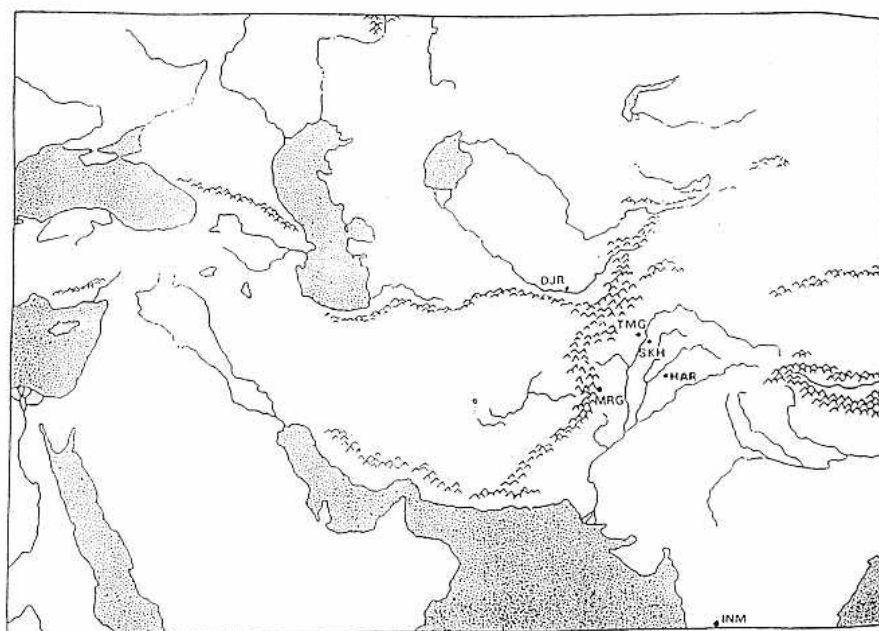


Figure 2. Dental morphology sample map (central & south Asia).

Prior to multivariate analysis, trait frequencies obtained through presence/absence dichotomization were arcsine transformed to stabilize sample variance according to the method of Green and Suchey (1976). In the first method, arcsine transformed trait frequencies were used as input for cluster analysis. Dendrograms were constructed in euclidian space with Ward's (1963) minimum variance technique. In the second method, arcsine transformed trait frequencies were utilized in a mean measure of divergence analysis. Differences in individual trait frequencies were summarized by means of the formula recommended by Green and Suchey (1976). The variance and standard deviation of this mean measure of divergence (MMD) value were calculated according to the method of Sjøvold (1973). Standardized distances were calculated by dividing the MMD value of a specific inter-sample comparison by its standard deviation. Such standardized distances, functionally equivalent to z-scores, are more appropriate for evaluating relative separations in cases where sample sizes differ between populations (Sofaer *et al.* 1986). Standardized MMD values were used as input for multidimensional scaling with Guttman's coefficient of alienation (Guttman 1968). Following standard procedure, all negative standardized MMD values were set at zero prior to submission to multidimensional scaling. Two and three-dimensional ordinations were constructed to provide visual assessment of the relative distances between each sample in euclidian space.

The third multivariate technique used to examine patterns of affinity was principal components analysis. Arcsine transformed trait frequencies were standardized to have a zero

Table 2. Frequencies of Dental Morphology Traits - Comparison One

Dental Trait	Tooth	Abb.	Inamgaon			Mahars			Madia Gonds			Marathas			Papago			American Whites		
			P	N	Freq.	P	N	Freq.	P	N	Freq.	P	N	Freq.	P	N	Freq.	P	N	Freq.
Shoveling	UI1	ShovI1	22	24	0.917	77	186	0.414	80	163	0.491	81	198	0.409	168	171	0.982	12	46	0.261
Shoveling	UI2	ShovI2	13	19	0.684	22	181	0.122	23	161	0.143	24	194	0.124	150	168	0.893	5	52	0.096
Med. Lingual Ridge	UI1	MlrI1	14	25	0.560	106	177	0.599	60	153	0.392	95	194	0.490	72	133	0.541	40	60	0.667
Med. Lingual Ridge	UI2	MlrI2	1	20	0.050	41	174	0.236	21	149	0.141	42	190	0.221	68	144	0.472	43	65	0.662
Hypocone Size	UM1	HypoM1	27	41	0.659	163	195	0.836	155	169	0.917	170	197	0.863	170	178	0.955	77	77	1.000
Hypocone Size	UM2	HypoM2	0	20	0.000	10	164	0.061	10	153	0.065	4	179	0.022	28	147	0.190	35	35	0.467
Carabelli's Trait	UM1	CaraM1	13	40	0.325	140	187	0.749	86	165	0.521	122	198	0.616	115	160	0.719	55	74	0.743
Metaconule	UM1	MtclM1	6	41	0.146	43	191	0.225	36	156	0.231	56	193	0.290	28	126	0.222	3	44	0.068
Metaconule	UM2	MtclM2	3	20	0.150	33	153	0.216	34	138	0.246	32	169	0.189	3	79	0.038	3	46	0.065
Entoconulid	LM1	C6M1	4	37	0.108	13	191	0.068	12	158	0.076	17	194	0.088	71	135	0.526	3	47	0.064
Entoconulid	LM2	C6M2	0	24	0.000	3	174	0.017	5	152	0.033	5	191	0.026	17	129	0.132	0	70	0.000
Metaconulid	LM1	C7M1	2	36	0.056	25	191	0.131	27	165	0.164	15	198	0.076	53	158	0.335	18	67	0.269
Metaconulid	LM2	C7M2	1	25	0.040	3	177	0.017	7	158	0.044	1	197	0.005	22	128	0.172	9	61	0.148
Cusp Number	LM1	CspnM1	32	39	0.821	170	192	0.885	149	161	0.925	166	195	0.851	175	175	1.000	57	60	0.950
Cusp Number	LM2	CspnM2	4	24	0.167	30	178	0.169	32	158	0.203	28	192	0.146	98	140	0.700	4	67	0.060
Y-Groove Pattern	LM1	YgrvM1	32	35	0.914	115	127	0.906	112	115	0.974	117	128	0.914	83	90	0.922	7	9	0.778
Y-Groove Pattern	LM2	YgrvM2	7	24	0.292	30	161	0.186	31	133	0.233	51	181	0.282	16	95	0.168	5	13	0.385

Table 3. Contingency Chi-Square Analysis - Comparison One.

Trait	X ²	p	df
ShovI1	179.067	0.000	5
ShovI2	371.329	0.000	5
MlrI1	20.716	0.001	5
MlrI2	95.140	0.000	5
HypoM1	47.895	0.000	5
HypoM2	122.737	0.000	5
CaraM1	45.428	0.000	5
MtclM1	12.171	0.033	5
MtclM2	20.688	0.001	5
C6M1	168.472	0.000	5
C6M2	35.252	0.000	5
C7M1	52.738	0.000	5
C7M2	55.904	0.000	5
CspnM1	213.801	0.000	5
CspnM2	208.205	0.000	5
YgrvM1	7.723	0.172	5
YgrvM2	8.765	0.119	5

mean and unit variance prior to principal components analysis. Principal components were derived from the covariance matrix. Principal components with eigenvalues greater than one were retained. Factor score coefficients (eigenvector coefficients) for each variable were multiplied by the standardized arcsine transformed frequency for each sample. These values were summed for each sample according to the first three principal components and ordinated into two and three dimensions to illustrate the relative position of each sample in multicomponent space.

RESULTS

First Comparison. In the first comparison, dichotomized dental morphology trait frequencies among Mahars, Marathas and Madia Gonds were pooled by sex and compared with a sample obtained from the prehistoric Maharashtra site of Inamgaon and contemporary samples of Papago Indians and American whites (Table 2). Contingency chi-square analysis (Table 3) indicates that 15 of 17 tooth-trait combinations scored in common differ significantly across all six samples. The only tooth-trait combinations not significant were frequencies of the Y-groove on LM1 and LM2.

Cluster analysis of arcsine transformed trait frequencies (Fig. 3) identifies the Papago as the most divergent of the six samples considered. American whites, while less divergent than the Papago, are also depicted as strongly separated from both contemporary and prehistoric Indian samples from Maharashtra. Cluster analysis indicates that closest affinities among the Maharashtra samples occurs between the two caste groups; that is, the low-status Mahars and the high-status Marathas. The single contemporary tribal group included in this analysis, the Madia Gonds, joins the two caste groups at a further remove. Inamgaon, the prehistoric sample, represents the most divergent of the Maharashtra samples.

Results of mean measure of divergence analysis are presented in Table 4. The top value in each cell is the MMD value. The bottom (bolded) value is the standardized MMD value. Two dimensional ordination of multidimensionally scaled standardized

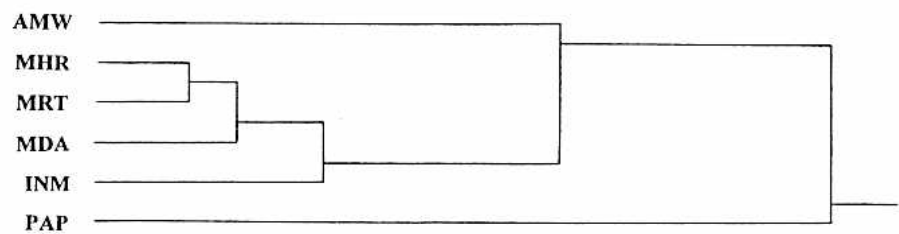


Figure 3. Cluster analysis of arcsine transformed trait frequencies - comparison one.

MMD values is presented in Figure 4. This ordination supports both the strong separation of the Papago sample from all other groups, as well as the less marked separation of American whites from all Maharashtra samples identified by cluster analysis. However, patterns of affinity among Maharashtra samples illustrated in Fig. 4 appear to stand in contrast to those identified in Fig. 3. This two dimensional ordination of standardized MMD values suggests that the Maratha occupy a central phenetic position, possessing nearly equal affinities to all other Maharashtra samples- both prehistoric and contemporary. The Mahars, on the other hand, appear to be most similar to the high-status Marathas, and more distant from both the prehistoric sample from Inamgaon and the tribal sample of Madia Gonds. Perhaps the most intriguing feature of Fig. 4 is the close proximity between Inamgaon and the Madia Gonds. Rather than suggesting that all contemporary Maharashtra samples share closer affinities to one another than to the prehistoric sample (as indicated by cluster analysis), the pattern of phenetic distances illustrated in Fig. 4 suggest that the Madia Gonds represent the best candidate for the descendants of the prehistoric occupants of Inamgaon.

Addition of the third dimension to the ordination of multidimensionally scaled standardized MMD values (Fig. 5) helps refine this association between the Madia Gonds and the prehistoric sample from Inamgaon. It is clear that when the third dimension is taken into account that it is the Madia Gonds, rather than Inamgaon, which represents the most divergent Indian sample. In fact, the tribal Madia Gonds and the low-status Mahars represent the opposite extremes of variation among our Maharashtran samples. Thus, the Mahars appear to be strongly separated from both the Madia Gonds and the sample from Inamgaon. The Marathas, on the other hand, appear to possess nearly equal similarities to the low-status Mahars on the one hand, and to the prehistoric sample from Inamgaon on the other. Inamgaon, while strongly separated from the low status Mahars shares nearly equal affinities to the tribal Madia Gonds as to the high-status Mahars. As illustrated by both cluster analysis (Fig. 3) and by two-dimensional ordination of multidimensionally scaled MMD values (Fig. 4), the Papago and the sample of American whites are strongly separated from all Maharashtran samples and from one another.

Principal components analysis yields three components with eigenvalues greater than one. Together, these three components combine to account for 93.0% of the total variance (Table 5). The first component accounts for 49.3% of the total variance and appears to draw a fundamental distinction between samples marked by relatively complex teeth and those groups which feature teeth that exhibit a more gracile morphology. This distinction is due to the fact that

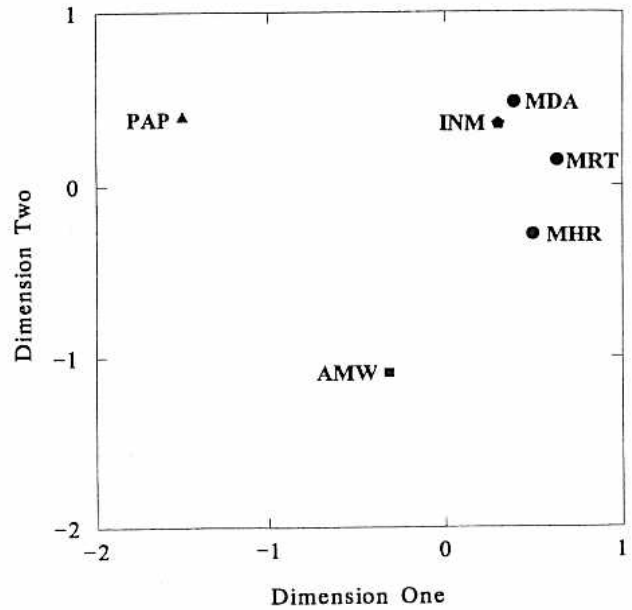


Figure 4. Two-dimensional ordination of multidimensionally scaled standardized MMD value - comparison one.

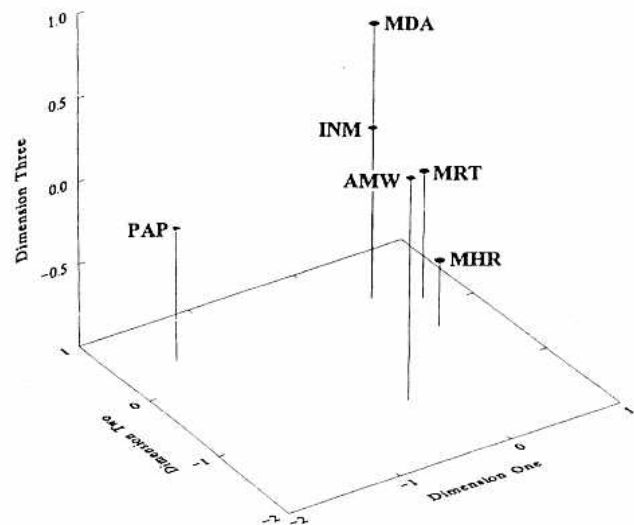


Figure 5. Three-dimensional ordination of multidimensionally scaled standardized MMD values - comparison one.

Table 4. Mean Measure of Divergence Analysis - Comparison One.

	INM	MHR	MDA	MRT	PAP
MHR	0.0278 1.8692				
MDA	0.0085 0.5624	0.0191 4.5097			
MRT	0.0051 0.3483	0.0016 0.4192	0.0053 1.2910		
PAP	0.4149 26.7595	0.3888 83.8550	0.3683 74.8038	0.4087 90.4480	
AMW	0.1896 8.2756	0.1085 7.9445	0.1616 11.6298	0.1323 9.7494	0.4620 32.2701

the first component receives strong positive loadings for shoveling and median lingual ridge development on the maxillary incisors, full development of the hypocone on the maxillary molars, Carabelli's trait, as well as for retention of the hypoconulid and the presence of accessory cusps on the mandibular molars. The first component receives low loadings for presence of the metaconule on the maxillary molars and retention of the Y-groove on the mandibular molars. Consequently, high scorers along this component will feature dentitions marked by frequent shoveling and median lingual ridge development on the maxillary incisors, maxillary molars which exhibit frequent retention of the full hypocone and Carabelli's trait (UM1) coupled with absence of the metaconule, and by mandibular molars which although often lacking the Y-groove, feature frequent retention of the hypoconulid and presence of both the entoconulid and metaconulid. By contrast, low scorers along the first component feature dentitions marked by low levels of incisor shoveling and medial lingual ridge development, maxillary molars that frequently exhibit reduced hypocones, lack Carabelli's trait, but which are marked by relatively frequent occurrence of the metaconule. Low scorers also feature mandibular molars that frequently exhibit a Y-groove, but which frequently display loss of the hypoconulid and an absence of accessory cusps (entoconulid, metaconulid).

The second principal component accounts for 33.9% of the total variance. This component receives relatively high loadings for incisor shoveling, the metaconule (especially on UM1), the Y-groove on LM1, retention of the hypoconulid on LM2, and presence of the entoconulid on LM1 and LM2. Conversely, this component receives low loadings for median lingual ridge development on the maxillary incisors, retention of the full hypocone and Carabelli's trait (UM1) on the maxillary molars, and presence of the Y-groove on LM2.

Table 5. Principal Component Loadings - Comparison One.
Component

Variable	One	Two	Three
ShovI1	0.712	0.699	-0.073
ShovI2	0.796	0.530	-0.287
MlrI1	0.304	-0.705	-0.279
MlrI2	0.791	-0.571	0.175
HypoM1	0.687	-0.253	0.636
HypoM2	0.644	-0.748	0.070
CaraM1	0.595	-0.244	0.629
MtclM1	-0.228	0.805	0.411
MtclM2	-0.863	0.267	0.366
YgrvM1	-0.291	0.932	0.111
YgrvM2	-0.192	-0.857	-0.214
CspnM1	0.909	0.035	0.328
CspnM2	0.735	0.654	-0.172
C6M1	0.815	0.507	-0.259
C6M2	0.758	0.640	-0.096
C7M1	0.964	-0.120	0.127
C7M2	0.906	-0.251	-0.264
Eigenvalue	8.375	5.769	1.663
Percent of Variance	49.265	33.934	9.781
Total Variance		92.980	

Therefore, high scorers on the second component will feature dentitions marked by maxillary incisors which display shoveling but no median lingual ridge development, presence of the metaconule on UM1, presence of the Y-groove on LM1 coupled with absence of this groove on LM2, by LM2s which frequently retain the hypoconulid, and by mandibular molars that exhibit relatively high frequencies of the entoconulid. Low scorers along the second component will feature dentitions marked by maxillary incisors which feature median lingual ridge development but lack shoveling, by maxillary molars which have full development of the

hypocone and Carabelli's trait (UM1) but lack the metaconule, and by mandibular molars which couple relatively low frequencies of the Y-groove on LM1 with rather high frequencies of this groove on LM2.

The third principal component accounts for 9.8% of the total variance. The third component receives relatively high loadings for full hypocone development on UM1, Carabelli's trait, presence of the metaconule on UM1 and UM2, and retention of the hypoconulid on LM1. Conversely, the third component receives relatively low loadings for shoveling on UI2, median lingual ridge development on UI1, retention of the Y-groove and hypoconulid on LM2, and the presence of all accessory cusps on the mandibular molars (except for C7 on LM1). Consequently, high scorers along component three will possess dentitions that tend to feature low levels of incisor shoveling, low levels of medial lingual ridge development on UI1, frequent full retention of the hypocone on UM1, frequent presence of Carabelli's trait and the metaconule, and by mandibular first molars marked by Y-grooves and retention of the hypoconulid coupled with an absence of these features on LM2 as well as by a general absence of accessory cusps among all mandibular molars. Low scorers along component three will feature dentitions marked by high levels of shoveling, frequent medial lingual ridge development on UI1, and by mandibular molars that often display Y-grooves and retention of the hypoconulid on LM2 relative to LM1 and by frequent occurrence of accessory cusps.

Ordination of group scores for the first two principal components provides a fourth variation on the patterning of phenetic affinities among Maharashtrians (Fig. 6). Similar to two-dimensional ordination of multidimensionally scaled standardized MMD values (Fig. 4), ordination of the first two principal components suggests that the high-status Marathas possess equal affinities to all other samples from Maharashtra. Nevertheless, the positioning of Inamgaon and the Madia Gonds is fundamentally different from that depicted in Fig. 4. Rather than suggesting that these latter two samples share the closest of affinities among Maharashtrians, this ordination suggests that, in fact, they are the most divergent. Inamgaon appears to share closest affinities to the high-status Marathas, and slightly more distant affinities to the low-status Mahars. As in all other plots, this ordination of the first two principal components identifies the Papago and American whites as strongly divergent from all Maharashtran samples as well as from one another.

Addition of the third component (Fig. 7) helps clarify the pattern of affinities among Maharashtran groups. In agreement with the results from cluster analysis (Fig. 3), this ordination identifies the prehistoric sample from Inamgaon as strongly divergent from all contemporary Maharashtrians. Among these latter groups, affinities appear to be somewhat closer between the two castes (Mahars, Marathas) than between either of these groups and the tribal Madia Gonds. In marked contrast to the results obtained from three-dimensional ordination of multidimensionally scaled MMD values (Fig. 5), this ordination indicates that Inamgaon and the Madia Gonds represent the most divergent Maharashtran samples, rather than the most closely affiliated. Again, as in all other analysis, ordination of the first three

principal components provides a strong separation between the Papago and American whites from all prehistoric and contemporary Maharashtrians, and from one another.

Second Comparison. Given the rather confusing and inconclusive results obtained from a contrast between the three contemporary Maharashtran samples, the prehistoric sample from Inamgaon, and contemporary samples of Papago Indians and American whites, a second comparison was undertaken. In this second comparison sex-pooled dichotomized dental morphology trait frequencies from nine prehistoric samples from south and central Asia were added to the samples considered in the first comparison. Trait frequencies by site for these 10 additional samples are provided in Table 6. Contingency chi-square analysis (Table 7) indicates that 16 of 17 tooth-trait combinations scored in common differ significantly across all 15 samples. As in comparison one, inter-group frequencies of the Y-groove on LM2 did not differ significantly in this larger data set, but inclusion of these additional samples does result in significant inter-sample variation in the frequency of this trait on LM1.

Cluster analysis of arcsine transformed trait frequencies separates samples into two clades, with all central Asian samples in one clade and all other samples in the other (Fig. 8). Among central Asians, closest phenetic affinities occur between Sapalli, the earliest sample, and Molali, the latest sample. Djarkutan joins these two samples at a further remove, while Kuzali represents the most peripheral of the central Asian groups. Cluster analysis indicates that closest affinities among members of the second

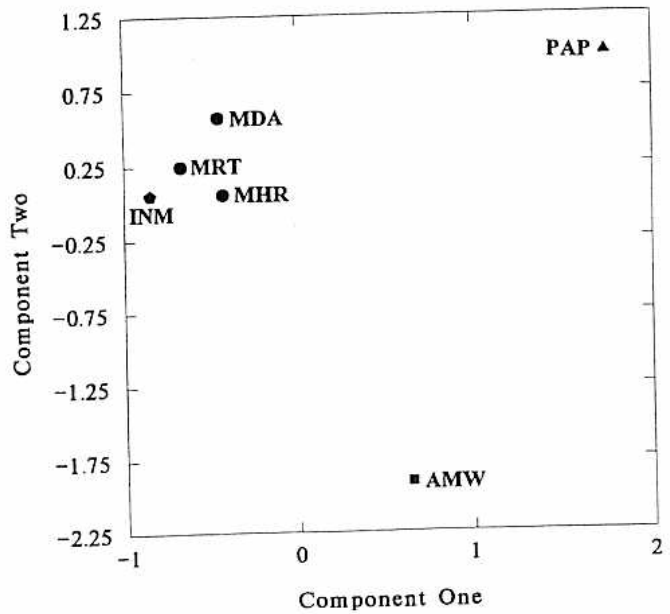


Figure 6. Two-dimensional ordination of group principal component scores - comparison one.

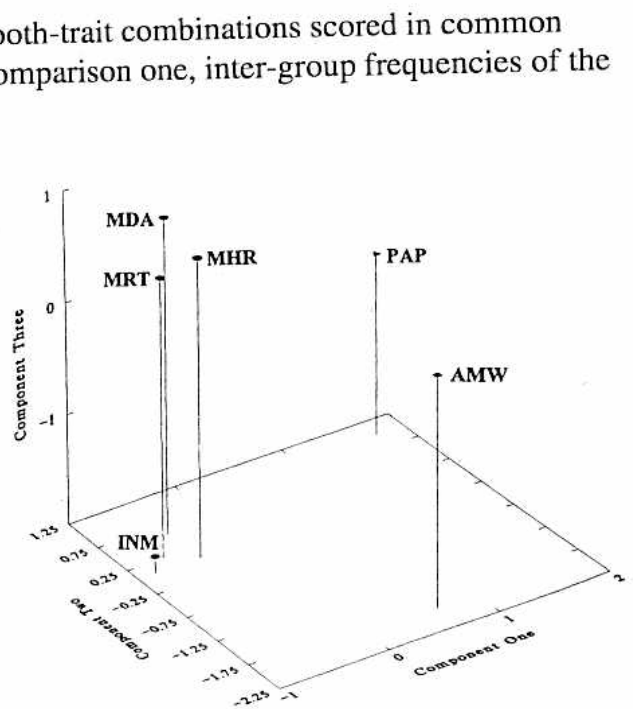


Figure 7. Three dimensional ordination of group principal component scores - comparison one.

clade occur among contemporary Maharashtrians, with the two caste groups (Mahars, Marathas) exhibiting slightly closer affinities to one another than to the tribal group (Madia Gonds). Harappans join these contemporary Maharashtrians at a distant remove. The two samples from Mehrgarh (NeoMRG, ChlMRG) are identified as possessing closest affinities to one another, but it is clear from this array that the degree of affinity between these two samples is not close. American whites are identified as possessing closer affinities to contemporary Maharashtrians, Harappans, and the two samples from Mehrgarh than possessed by the two post-Harappan Civilization samples from northern Pakistan (TMG, SKH) and by Inamgaon, the prehistoric sample from Maharashtra. The Papago represent a distant outlier to all non-central Asian groups.

Results of mean measure of divergence analysis from comparison two are presented in Table 8. Two dimensional ordination of multidimensionally scaled MMD values is presented in Figure 9. This ordination clearly identifies the Papago as the phenetically most distant sample. Contemporary Maharashtrians are all positioned in the upper right corner of this ordination and appear to share closest phenetic affinities with the neolithic sample from Mehrgarh and with Inamgaon. Of the contemporary Maharashtran samples, high-status Marathas are most similar to the prehistoric sample from Inamgaon, while low-status Mahars are identified as the most distant. Tribal Madia Gonds exhibit slightly closer affinities to low-status Mahars than to the high-status Marathas. In direct contrast to results obtained from cluster analysis, two-dimensional ordination of multidimensionally scaled standardized MMD values does not indicate that the neolithic and chalcolithic inhabitants of Mehrgarh share closest similarities with one another. Rather, the neolithic occupants of Mehrgarh are phenetically more similar to the samples from Inamgaon, Harappa, Timargarha and even contemporary Maharashtrians, than to the later chalcolithic inhabitants of this site. Chalcolithic Mehrgarh occupies a position in this ordination rather distant from all other samples, showing some distant affinities to Harappans and American whites. The position of American whites is intermediate between south Asians on the one hand and central Asians on the other. All central Asian samples group together at the bottom right of this ordination. Reflecting the results obtained by Hemphill *et al.* (this volume), closest affinities between south Asians and central Asians occurs between the latest members of these respective series (south Asia: Sarai Khola, central Asia: Kuzali, Molali).

Three-dimensional ordination of multidimensionally scaled standardized MMD scores is presented in Figure 10. This ordination confirms the basic pattern of affinities identified in Fig. 9, but helps clarify others. Once again, the Papago are clearly identified as the most divergent sample included in this analysis. The third dimension also clarifies the phenetic position of American whites. American whites are explicitly identified as possessing greater affinities to south and central Asians than possessed by the Papago, but it is also obvious from Fig. 10 that American whites represent a distant outlier to these groups, with only slightly closer affinities to central Asians than to south Asians.

Table 6. Frequencies of Dental Morphology Traits - Comparison Two.

Dental Trait	Tooth	Abb.	Sarai Khola			Timargarha			Neolithic Mehrgarh			Chalcolithic Mehrgarh			Harappa		
			P	N	Freq.	P	N	Freq.	P	N	Freq.	P	N	Freq.	P	N	Freq.
Shoveling	UI1	ShovI1	3	9	0.333	7	7	0.143	25	28	0.893	21	25	0.840	8	15	0.533
Shoveling	UI2	ShovI2	2	9	0.222	2	7	0.286	31	37	0.838	21	24	0.875	10	16	0.625
Med. Lingual Ridge	UI1	MlrI1	2	9	0.222	3	8	0.375	15	26	0.577	14	25	0.560	8	12	0.667
Med. Lingual Ridge	UI2	MlrI2	0	9	0.000	0	7	0.000	2	29	0.069	7	24	0.292	6	13	0.462
Hypocone Size	UM1	HypoM1	11	14	0.786	17	22	0.773	35	42	0.833	22	22	1.000	16	16	1.000
Hypocone Size	UM2	HypoM2	2	13	0.154	0	13	0.000	2	41	0.049	10	18	0.556	2	18	0.111
Carabelli's Trait	UM1	CaraM1	2	9	0.222	9	18	0.500	7	27	0.259	11	18	0.611	4	9	0.444
Metaconule	UM1	MtclM1	3	9	0.333	4	19	0.211	7	28	0.250	5	19	0.263	6	13	0.462
Metaconule	UM2	MtclM2	2	14	0.143	0	13	0.000	10	25	0.400	6	18	0.333	4	16	0.250
Entoconulid	LM1	C6M1	1	14	0.071	0	22	0.000	3	37	0.081	5	23	0.217	1	20	0.050
Entoconulid	LM2	C6M2	0	15	0.000	1	18	0.056	0	44	0.000	1	23	0.043	0	28	0.000
Metaconulid	LM1	C7M1	1	15	0.067	2	24	0.083	4	40	0.100	3	25	0.120	1	22	0.045
Metaconulid	LM2	C7M2	0	15	0.000	2	20	0.100	0	43	0.000	0	24	0.000	0	28	0.000
Cusp Number	LM1	CspnM1	9	15	0.600	19	25	0.760	39	43	0.907	20	23	0.870	17	20	0.850
Cusp Number	LM2	CspnM2	1	15	0.067	3	17	0.176	3	49	0.061	2	24	0.083	0	33	0.000
Y-Groove Pattern	LM1	YgrvM1	5	7	0.714	12	17	0.706	23	25	0.920	15	21	0.714	15	17	0.882
Y-Groove Pattern	LM2	YgrvM2	5	14	0.357	3	18	0.167	12	37	0.324	6	22	0.273	3	31	0.097

Table 6. Continued.

Dental Trait	Tooth	Abb.	Sapalli Tepe			Djarkutan			Kuzali			Molali		
			P	N	Freq.	P	N	Freq.	P	N	Freq.	P	N	Freq.
Shoveling	UI1	ShovI1	2	19	0.105	3	16	0.188	1	13	0.077	4	25	0.160
Shoveling	UI2	ShovI2	10	17	0.588	8	22	0.364	6	14	0.429	14	27	0.519
Med. Lingual Ridge	UI1	MlrI1	4	17	0.235	3	17	0.176	2	13	0.154	9	23	0.391
Med. Lingual Ridge	UI2	MlrI2	5	17	0.294	4	22	0.182	6	14	0.429	8	25	0.320
Hypocone Size	UM1	HypoM1	36	36	1.000	30	30	1.000	23	23	1.000	41	41	1.000
Hypocone Size	UM2	HypoM2	23	32	0.719	21	32	0.656	11	22	0.500	23	37	0.622
Carabelli's Trait	UM1	CaraM1	8	25	0.320	3	21	0.143	2	20	0.100	13	36	0.361
Metaconule	UM1	MicIM1	3	37	0.081	1	29	0.034	2	21	0.095	3	39	0.077
Metaconule	UM2	MicIM2	2	34	0.059	0	32	0.000	1	24	0.042	3	37	0.081
Entoconulid	LM1	C6M1	3	25	0.120	1	20	0.050	0	14	0.000	3	33	0.091
Entoconulid	LM2	C6M2	0	40	0.000	0	36	0.000	0	15	0.000	0	35	0.000
Metaconulid	LM1	C7M1	1	38	0.026	1	32	0.031	0	18	0.000	2	39	0.051
Metaconulid	LM2	C7M2	0	43	0.000	1	39	0.026	0	18	0.000	1	36	0.028
Cusp Number	LM1	CspnM1	22	28	0.786	20	21	0.952	10	15	0.667	29	33	0.879
Cusp Number	LM2	CspnM2	2	41	0.049	2	36	0.056	1	14	0.071	2	35	0.057
Y-Groove Pattern	LM1	YgrvM1	19	24	0.792	20	22	0.909	10	14	0.714	25	34	0.735
Y-Groove Pattern	LM2	YgrvM2	7	38	0.184	11	35	0.314	5	15	0.333	5	33	0.152

Addition of the third dimension also helps clarify patterns of phenetic affinity between contemporary Maharashtrans and the prehistoric sample from Inamgaon. Inamgaon occupies a position along the third dimension intermediate between the high-status Marathas and the tribal Madia Gonds. By contrast, the low-status Mahars are strongly separated, not only from Inamgaon, but also from both Madia Gonds and Marathas on this third dimension. For all three dimensions, Inamgaon lies mid-way between the phenetic positions occupied by the much earlier occupants of neolithic Mehrgarh (6000 B.C.) and contemporary Marathas. Madia Gonds, on the other hand, occupy a position intermediate between neolithic Mehrgarh and Inamgaon, but along a completely different vector from that shared by Inamgaon and the Marathas.

The third dimension of Fig. 10 not only helps clarify patterns of affinity between Inamgaon and contemporary Maharashtrans, but also serves to illustrate the relationship between this prehistoric Maharashtran sample with prehistoric samples from the Indus Valley. It is evident from Fig. 10 that not only does Inamgaon occupy an intermediate position between neolithic Mehrgarh and contemporary Maharashtrans (perhaps best illustrated by the high-status Marathas and less so by the Madia Gonds and Mahars), but this prehistoric Maharashtran sample also occupies an intermediate position between neolithic Mehrgarh and the three contemporary Maharashtran samples on the one hand, and all other south Asian samples on the other. This intermediate position is especially evident between Inamgaon and the sample from Timargarha, and less well marked with Sarai Khola and chalcolithic Mehrgarh. Addition of the third dimension emphasizes the differences between neolithic Mehrgarh and chalcolithic Mehrgarh, but also serves to distantly associate this latter sample with Harappa. Harappa is depicted as possessing very close phenetic affinities with Timargarha. Once again, this ordination also indicates that while south Asians and central Asians feature marked differences between them, closest associations occur between Kuzali and the latest of the prehistoric samples from the Indus Valley, Sarai Khola.

Principal components analysis yields six components with eigenvalues greater than one. If we consider only the first three components, these three components combine to account for 67.2% of the total variance (Table 9). The first component accounts for 35.3% of the total variance and appears to draw a fundamental distinction between samples marked by relatively complex teeth- either maxillary incisors, mandibular molars, or both, and those groups which possess teeth with a more gracile morphology. This distinction is due to the fact that the first component receives strong positive loadings for incisor shoveling and median lingual ridge development, for Carabelli's trait, as well as for retention of the hypoconulid and the presence of accessory cusps on the mandibular molars. Conversely, the first component receives low loadings for retention of a full hypocone and presence of the metaconule on the maxillary molars and for retention of the Y-groove on LM2. Consequently, high scorers along this component will feature dentitions marked by frequent shoveling and median lingual ridge development on the maxillary incisors, Carabelli's trait, frequent loss of full expression of the hypocone, especially on UM2, and by the presence of accessory cusps (entoconulid,

Table 7. Contingency Chi-Square Analysis - Comparison Two.

Trait	X ²	p	df
ShovI1	253.880	0.000	14
ShovI2	379.526	0.000	14
MlrI1	46.840	0.000	14
MlrI2	115.001	0.000	14
HypoM1	80.499	0.000	14
HypoM2	302.298	0.000	14
CaraM1	123.581	0.000	14
MtclM1	35.395	0.001	14
MtclM2	53.314	0.000	14
C6M1	198.166	0.000	14
C6M2	54.693	0.000	14
C7M1	82.663	0.000	14
C7M2	81.077	0.000	14
CspnM1	220.599	0.000	14
CspnM2	298.217	0.000	14
YgrvM1	41.969	0.000	14
YgrvM2	19.448	0.149	14

metaconulid) on mandibular first and second molars. By contrast, low scorers along the first component feature dentitions marked by low levels of incisor shoveling and medial lingual ridge development, maxillary molars that frequently exhibit retention of the full hypocone but which lack Carabelli's trait, frequent retention of the Y-groove on LM2, and by mandibular molars that feature few accessory cusps.

The second principal component accounts for 20.3% of the total variance and appears to draw distinctions among samples almost exclusively on the basis of features present among maxillary teeth. This component serves to separate those samples whose dentitions are marked by relatively robust maxillary lateral incisors relative to central incisors (for both shoveling and medial lingual ridge development) and by maxillary molars that frequently retain a full hypocone but lack the presence of the metaconule, from those samples whose dentitions exhibit relatively robust maxillary central incisors for lateral incisors, and by maxillary molars that exhibit frequent reduction of the hypocone. The second component receives relatively high