Dental Anthropological Study of the Non-metric Traits of the Palauans

Hiroaki Ichikawa, and Masanobu Matsuno

Department of Anatomy and Physical Anthropology, Nihon University School of Dentistry at Matsudo, Matsudo, Chiba 271-8587, Japan

Correspondence to :

Hiroaki Ichikawa

E-mail : h_ichikawa@w8.dion.ne.jp

Abstract

The frequency of the dental non-metric traits of school students in Koror, Palau was investigated. The parameters were recorded based on 22 crown traits classified by the Arizona State University Dental Anthropology System. In Palauans, the frequencies of shoveling and double shovel were not so high as in northeast Asians, but relatively high frequencies were found in tuberculum dentale in the maxillary second incisor and Cusp 5 in the maxillary first molar. Carabelli's trait and deflecting wrinkle were not found so frequently as in the Philippines and Bali populations. The frequency, 70.6%, of the 4-cusp type of the mandibular second molar was highest in the Asian populations cited in this study. The principal coordinate plot for these 17 sets of scores, based on Smith's MMDs and standard deviations showed that data from Sundadont and Sinodont populations were differently positioned on the first axis. The Palauans belonged to Sundadont group and located in an extreme position on the right of the first axis and in relatively lower position in the second axis, which represented the unique combination of dental characters of Palauans.

Keywords :

dental trait, Palauans, non-metric, dental anthropology

Introduction

Republic of Palau is an island country in the western part of Micronesia (Fig.1). Four major movements of human dispersals into Micronesia from surrounding islands since 3,600 years B.P. are proposed based on archaeological evidence (1). Various trials to trace the route of migration of peoples and to confirm the archaeological evidence have been made from the physical anthropological point of view. Skeletal analysis revealed that inhabitants in Micronesia were of mixed ancestry, while there is a discernible Melanesian contribution to some of the modern populations in Micronesia (2).

Palau was settled from further west, such as the Philippines or the island Indonesia on the lingual evidence (1), probably around 2,000 years ago. Palauan (also spelled Belauan) is the language spoken in Palau. It is a member of the Austronesian family of languages, and is considered to be one of two languages in Micronesia (the other being Chamorro) belonging to the Western Malayo-Polynesian group, all others considered to be mem-

bers of either the Micronesian or Polynesian outlier subgroups of Eastern Malayo-Polynesian group (3).

The population of Palau is 20,303 at present, in which 70% are indigeneous people, but 30% are

Fig. 1. The location of dental survey in Republic of Palau.

people having Philippines or Japanese origin. Palau has been independent from USA since 1994. The capital locates in Melekeok, and its island area is 458 km².

Turner (4) found that Micronesians, including pre-historic Guamanians, were dentally most similar to Borneo peoples, followed closely by samples from Fiji-Rotuma, Marquesas, Hawaii, and Java-Sumatra. Several dental studies on the descriptions of dental crown and root traits in Micronesia have been reported (5, 6, 7, 8, 9). These studies revealed the characteristics of dental traits of some populations in Micronesia, but more details of dental traits in Palau have not been reported, yet.

The purposes of this study were to describe the frequencies of dental non-metric characters in Palauans and to compare the results with other populations in Asia.

Materials and Methods

Dental plaster casts of the permanent dentition of 47 male and 47 female school students of Koror, the former capital of Republic of Palau, which were taken by Nihon University Dental Survey Team in 1996. Ages of the students were from 15 to 19 years old and dental traits were well preserved in this age range without severe attrition. Students having only indigenous parents and grand-parents were selected for examination. The parameters recorded in this study were 22 crown traits classified by the Arizona State University Dental Anthropology System (10). These are listed in Table 1 to Table 22, where the grades or scores for each trait are also shown. The data from males and females were pooled, because there were no significant differences (at the 5% level) between the sexes in the frequencies of all 22 traits observed in this study.

Scoring of the traits involved a four-point scale of none (–), trace (±), present (+) and strong (++), except for the following cases: interruption groove and winging in the upper incisor (6-point and 5-point scales respectively), odontome in the premolars (2-point scale i.e. present or absent), lingual cusp variation in the lower molars and hypocone reduction in

the upper molars (4 levels based on a combination of cusp numbers and their size), Carabelli's trait in the upper molars (5-point scale), and distal trigonid crest in the lower molars and cusp number in the lower molar (2-point scales).

In the comparison of frequencies in Palauans with those of 30 other East Asian populations, the number of crown parameters was reduced to 17, and the number of levels in the various scales was reduced to two, with all points above 1 (2-4, 2-5, 2-6) combined into one score (11). Thus the frequencies for each parameter were expressed simply as present or absent.

Using the frequencies of the 17 traits, Smith's Mean Measure of Divergence (MMD), together with the Freeman-Tukey method for inverse sine transformation, was used to determine inter-population distances, (12, 13, 14). Affinity between Palauans and other Asian populations was expressed on two dimensions of the principal coordinate analysis based on Smith's MMD.

The statistical test, i.e., the MMD, the principal coordinate analysis, and the Chi-square test for sex differences, were all carried out on a personal computer using the JMP statistical package (SAS Institute Inc. ver. 6.0.0).

Table 1. Teeth and frequencies of shoveling in the Palau (sexes pooled).

Expression	UI1		UI2	
	N	%	N	%
– : None	18	19.15	27	30.00
± : Trace	46	48.94	39	43.33
+ : Present	29	30.85	24	26.67
++ : Strong	1	1.06	0	0.00
Total	94		90	

Table 2. Teeth and frequencies of double-shoveling in the Palau (sexes pooled).

Expression	UI1		UI2	
	N	%	N	%
– : None	55	58.51	55	59.78
± : Trace	34	36.17	35	38.04
+ : Present	5	5.32	2	2.17
++ : Strong	0	0.00	0	0.00
Total	94		92	

Table 3. Teeth and frequencies of tuberculum dental in the Palau (sexes pooled).

Expression	UI1		UI2		UC	
	N	%	N	%	N	%
– : None	26	27.96	56	61.54	19	21.35
± : Trace	33	35.48	13	14.29	34	38.20
+ : Present	31	33.33	18	19.78	32	35.96
++ : Strong	3	3.23	4	4.40	4	4.49
Total	93		91		89	

Table 4. Teeth and frequencies of spinal process in the Palau (sexes pooled).

Expression	UI1		UI2	
	N	%	N	%
– : None	50	54.95	83	93.26
± : Trace	24	26.37	3	3.37
+ : Present	16	17.58	2	2.25
++ : Strong	1	1.10	1	1.12
Total	91		89	

Table 5. Teeth and frequencies of interruption groove in the Palau (sexes pooled).

Expression	UI1		UI2	
	N	%	N	%
– : None	93	100	81	90.00
MB: Mesiolingual border	0	0.00	2	2.22
DB: Distlingual border	0	0.00	5	5.56
MD: Mesio and distlingual border	0	0.00	0	0.00
MA: Mesial area	0	0.00	2	2.22
DA: Distal area	0	0.00	0	0.00
Total	93		90	

Table 6. Teeth and frequencies of winging in the Palau (sexes pooled).

Expression	UI1	
	N	%
C+ : Present (counter winging)	9	9.57
C± : Trace (counter winging)	19	20.21
– : None	52	55.32
± : Trace	6	6.38
+ : Present	8	8.51
Total	94	

Table 7. Teeth and frequencies of canine mesial ridge in the Palau (sexes pooled).

Expression	UC	
	N	%
– : None	78	88.64
± : Trace	7	7.95
+ : Present	3	3.41
++ : Strong	0	0.00
Total	88	

Table 8. Teeth and frequencies of canine distal accessory ridge in the Palau (sexes pooled).

Expression	UC	
	N	%
– : None	46	53.49
± : Trace	25	29.07
+ : Present	14	16.28
++ : Strong	1	1.16
Total	86	

Table 9. Teeth and frequencies of accessory marginal tubercle in the Palau (sexes pooled).

Expression	UP1		UP2	
	N	%	N	%
– : None	74	79.57	75	81.52
± : Trace	12	12.90	12	13.04
+ : Present	6	6.45	5	5.43
++ : Strong	1	1.08	0	0.00
Total	93		92	

Table 10. Teeth and frequencies of odontomes in the Palau (sexes pooled).

Expression	UP1		UP2		LP1		LP2	
	N	%	N	%	N	%	N	%
– : None	90	100	86	100	93	100	92	100
+ : Present	0	0.00	0	0.00	0	0.00	0	0.00
Total	90		86		93		92	

Table 11. Teeth and frequencies of lingual cusp variation in the Palau (sexes pooled).

Expression	LP1		LP2	
	N	%	N	%
0 : None	3	3.37	0	0.00
1 : One lingual cusp	68	76.40	29	31.52
2 : Two lingual cusp	15	16.85	61	66.30
3 : Three lingual cusp	3	3.37	2	2.17
Total	89		92	

Table 12. Teeth and frequencies of hypocone reduction in the Palau (sexes pooled).

Expression	UM1		UM2	
	N	%	N	%
4+ : Large cusp	81	95.29	1	1.35
4- : Small cusp	3	3.53	50	67.57
3+ : Faint cusp	1	1.18	19	25.68
3- : None or faint ridge	0	0.00	4	5.41
Total	85		74	

Table 13. Teeth and frequencies of metacone reduction in the Palau (sexes pooled).

Expression	UM1		UM2	
	N	%	N	%
- : None	65	77.38	8	11.11
± : Trace	19	22.62	40	55.56
+ : Present	0	0.00	23	31.94
++ : Strong	0	0.00	1	1.39
Total	84		72	

Table 14. Teeth and frequencies of cusp 5 in the Palau (sexes pooled).

Expression	UM1		UM2	
	N	%	N	%
- : None	39	50.00	46	68.66
± : Trace	17	21.79	11	16.42
+ : Present	20	25.64	9	13.43
++ : Strong	2	2.56	1	1.49
Total	78		67	

Table 15. Teeth and frequencies of Carabelli's trait in the Palau (sexes pooled).

Expression	UM1		UM2	
	N	%	N	%
- : None	42	46.67	72	91.14
± : Line	19	21.11	4	5.06
± : Trace	15	16.67	2	2.53
+ : Tubercle	12	13.33	1	1.27
++ : Cusp	2	2.22	0	0.00
Total	90		79	

Table 16. Teeth and frequencies of protostylid in the Palau (sexes pooled).

Expression	LM1		LM2	
	N	%	N	%
- : None	65	79.27	78	91.76
± : Trace	15	18.29	6	7.06
+ : Tubercle	2	2.44	1	1.18
++ : Cusp	0	0.00	0	0.00
Total	82		85	

Table 17. Teeth and frequencies of deflecting wrinkle in the Palau (sexes pooled).

Expression	LM1		LM2	
	N	%	N	%
- : None	35	49.30	82	100
± : Trace	23	32.39	0	0.00
+ : Present	12	16.90	0	0.00
++ : Strong	1	1.41	0	0.00
Total	71		82	

Table 18. Teeth and frequencies of distal trigonid crest in the Palau (sexes pooled).

Expression	LM1		LM2	
	N	%	N	%
- : Abscent	73	100	78	100
+ : Present	0	0.00	0	0.00
Total	73		78	

Table 19. Teeth and frequencies of cusp 6 in the Palau (sexes pooled).

Expression	LM1		LM2	
	N	%	N	%
- : None	67	78.82	71	85.54
± : C5>C6	14	16.47	4	4.82
+ : C5=C6	4	4.71	6	7.23
++ : C5<C6	0	0.00	2	2.41
Total	85		83	

Table 20. Teeth and frequencies of cusp 7 in the Palau (sexes pooled).

Expression	LM1		LM2	
	N	%	N	%
- : None	89	98.89	87	100
± : Faint cusp	0	0.00	0	0.00
+ : Small cusp	1	1.11	0	0.00
++ : Large cusp	0	0.00	0	0.00
Total	90		87	

Table 21. Teeth and frequencies of groove pattern in the Palau (sexes pooled).

Expression	LM1		LM2	
	N	%	N	%
Y pattern	56	87.50	2	2.94
+ pattern	6	9.38	47	69.12
X pattern	2	3.13	19	27.94
Total	64		68	

Table 22. Teeth and frequencies of cusp number in the Palau (sexes pooled).

Expression	LM1		LM2	
	N	%	N	%
4 : 4 cusp	4	6.25	48	70.59
5 : 5 cusp	60	93.75	20	29.41
Total	64		68	

Results

The frequencies of the 22 non-metric traits of the upper and lower dentition in Palauans are shown in different grades of expression in Table 1 to Table 22. They are expressed by the individual count and percentage. Total sample numbers are different from trait to trait because of differences in the number of observable cases. Table 23 shows the dichotomized frequencies of the 17 analyzed traits in Palauans to compare with those of other Asian populations cited from anthropological or dental science journals.

In Palauans, the frequencies of shoveling and double shovel are not so high as in northeast Asians, but relatively high frequencies were found in tuberculum dentale in the maxillary second incisor and Cusp 5 in the maxillary first molar. Carabelli's trait and deflecting wrinkle were not found so frequently as in the Philippines and Bali populations. The frequency,

70.59%, of the 4-cusp type of the mandibular second molar was highest in the Asian populations cited in this study.

Table 24 shows the dichotomized frequencies of the 17 traits in 30 populations of East Asia, and also in the Palauans. Frequencies for the populations other than the Palauans were taken from already published studies (11, 15-26). The traits which showed a relatively low frequency in the Palauans compared with other Asian populations were shoveling and double shoveling of the upper central incisor, the Carabelli's trait in the upper first molar, and deflecting wrinkle, distal trigonid crest, cusp 6, cusp 7, and Y-groove pattern in the lower first molar. On the other hand, traits with a relatively high frequency were tuberculum dentale in upper second incisor, mesial ridge in upper canine, cusp 5 in upper first molar and Cusp number in lower second molar.

The principal coordinate plot for these 17 sets of scores, based on Smith's MMDs and standard deviations, is shown in Fig. 2. Data from Sundadont and Sinodont populations were differently positioned on the first axis. The Palauans belonged to Sundadont group and located in an extreme position on the right of the first axis and in relatively lower position in the second axis.

Table 23. Dichotomized frequency of 17 selected traits in the Palau

Trait	Tooth	Expression dichotomy*	Frequency in Palau (%)
Shoveling	UI1	(++ , +)/(+ + ~ -)	31.91
Double-shoveling	UI1	(++ , +)/(+ + ~ -)	5.32
Tuberculum dentale	UI2	(+ + ~ ±)/(+ + ~ -)	38.46
Mesial ridge	UC	(+ + ~ ±)/(+ + ~ -)	11.36
Distal accessory ridge	UC	(+ + ~ ±)/(+ + ~ -)	46.51
Lingual cusp variation	LP2	(3, 2)/(3 ~ 0)	68.48
Odontomes	U-L, P1-2	(+)/(+ , -)	0.00
Hypocone	UM2	(4 + ~ 3+)/(4 + ~ 3 -)	94.59
Cusp 5	UM1	(+ + ~ ±)/(+ + ~ -)	50.00
Carabelli's trait	UM1	(++ , +)/(+ + ~ -)	15.56
Protostylid	LM1	(+ + ~ ±)/(+ + ~ -)	20.73
Deflecting wrinkle	LM1	(+ +)/(+ + ~ -)	1.41
Distal trigonid crest	LM1	(+)/(+ , -)	0.00
Cusp 6	LM1	(+ + ~ ±)/(+ + ~ -)	21.18
Cusp 7	LM1	(+ + ~ ±)/(+ + ~ -)	1.11
Y groove pattern	LM2	(Y)/(Y , + , X)	2.94
Cusp number	LM2	(4)/(5, 4)	70.59

* : (Present range of grades)/(total range of grades)

Table 24. Numbers of samples and dental trait frequencies (Total N, Present %) in East Asian population samples.

	UI1		UI1	UI2	UC		UC	LP2	U, LP1, 2		UM2					
Palau	94	31.91	94	5.32	91	38.46	88	11.36	86	46.51	92	68.48	93	0.00	74	94.59
Pumi	76	63.16	84	10.71	83	7.23	80	7.50	72	22.22	86	67.44	88	1.14	78	88.46
Naxi	92	64.13	97	13.40	97	14.43	90	11.11	85	55.29	96	46.88	97	1.03	85	78.82
Hani	80	55.00	86	15.12	86	9.30	76	7.89	66	51.52	86	51.16	87	1.15	88	84.09
Dai	89	33.71	93	45.16	98	39.80	90	0.00	92	53.26	96	67.71	96	1.04	95	84.21
Dafur	172	51.20	172	32.00	168	16.70	166	11.20	172	65.70	173	81.50	167	1.10	156	78.30
Hui	162	58.00	155	46.50	165	10.30	167	10.20	164	50.00	166	83.70	168	2.40	150	92.00
Chaoxian	167	68.90	165	50.30	167	14.40	166	11.40	163	52.10	165	80.00	167	0.50	156	85.20
Man	208	61.60	200	42.50	205	4.40	211	8.10	212	53.80	210	93.30	211	0.50	201	88.50
Han	145	56.60	143	23.10	136	14.70	147	4.80	147	67.30	147	83.00	139	0.70	129	89.20
Bali	172	25.00	169	12.40	171	7.60	173	1.70	168	64.80	172	73.30	172	0.60	169	94.10
Bunun	95	76.84	90	42.22	93	24.73	86	6.98	88	69.32	93	80.65	94	1.06	71	88.73
Ami	146	70.55	141	33.33	139	16.55	135	5.93	134	61.19	144	85.42	145	2.76	129	83.72
Yami	192	70.31	191	23.04	189	15.87	155	10.32	157	68.79	153	88.89	155	1.29	106	80.19
NE Siberia	44	61.36	24	25.00	61	32.79	90	0.00	22	54.55	66	40.91	54	0.00	138	76.09
Amur	16	68.75	18	44.44	27	11.11	27	11.11	13	53.85	39	71.79	40	5.00	52	82.69
N China-Mongolia	200	84.00	213	30.05	246	19.11	255	2.35	125	66.40	276	81.16	231	3.90	406	90.39
Recent Japan	276	65.94	267	19.48	304	15.46	365	3.01	240	57.92	341	65.98	462	4.98	482	86.51
Jomon	117	25.64	138	1.45	201	23.88	136	2.21	49	69.39	294	63.61	260	0.38	206	82.04
Hong Kong P	307	63.84	299	28.43	298	19.13	305	2.95	249	54.62	319	66.46	314	7.64	299	90.30
S China P	35	74.29	33	24.24	44	11.36	55	3.64	26	80.77	72	77.78	94	0.00	93	86.02
Prehistoric Taiwan	22	59.09	21	0.00	14	14.29	10	0.00	7	42.86	24	79.17	17	0.00	27	85.19
Philippines	54	42.59	29	17.24	58	22.41	76	2.63	39	61.54	89	66.29	116	2.59	148	83.78
Early Mainland (SeA)	99	32.32	100	10.00	113	27.43	120	2.50	44	56.82	157	76.43	83	1.20	189	93.12
Recent SE Asia	13	46.15	14	28.57	17	23.53	39	2.56	17	41.18	52	61.54	63	3.17	102	87.25
Recent Thailand P	127	37.01	111	9.01	128	19.53	143	7.69	80	47.50	147	63.95	189	4.23	196	89.80
Burma	15	13.33	13	0.00	26	11.54	33	6.06	16	62.50	25	44.00	57	1.75	95	94.74
Nepal	10	20.00	11	9.09	9	22.22	17	0.00	9	66.67	13	61.54	38	2.63	58	86.21
Recent Indomalaysia	49	24.49	36	11.11	57	28.07	82	6.10	39	71.79	112	78.57	147	0.68	215	91.16
Early Malay Archipelago	71	29.58	67	28.36	84	32.14	103	9.71	63	50.79	105	85.71	120	4.17	156	89.10
East Malay Archipelago	12	8.33	3	0.00	13	23.08	16	6.25	9	88.89	21	71.43	25	0.00	29	86.21

Cusp 5	Carabelli's trait			Protostylid		DW	DTC	Cusp 6		Cusp 7	YGP		Cusp number				
	UM1	UM1	LM1	LM1	LM1			LM1	LM2		LM2						
78	50.00	90	15.56	82	20.73	71	1.41	73	0.00	85	21.18	90	1.11	68	2.94	68	70.59
75	24.00	85	22.35	76	30.26	64	1.56	66	4.55	57	21.05	77	1.30	71	4.23	72	50.00
87	12.64	89	5.62	77	23.38	68	1.47	65	0.00	64	23.44	81	1.23	80	5.00	76	34.21
86	17.44	90	15.56	86	32.56	67	1.49	56	12.50	76	7.89	88	3.41	79	3.80	79	53.16
93	29.03	93	16.13	88	39.77	82	1.22	68	1.47	86	30.23	90	4.44	90	4.44	90	48.89
159	17.00	163	35.60	153	60.80	158	21.50	152	7.20	150	54.00	157	10.20	160	3.80	155	32.90
166	23.50	157	45.80	161	31.70	159	32.70	158	5.10	159	34.00	160	8.10	153	4.60	147	29.90
153	26.80	157	49.60	151	27.20	152	6.60	155	0.00	153	39.90	156	6.40	161	2.50	160	34.40
212	25.50	212	33.90	210	32.40	209	28.20	209	6.20	209	34.00	208	5.80	209	2.90	207	35.80
130	20.00	135	16.20	125	19.20	107	30.80	115	7.80	115	40.90	115	5.20	115	0.90	112	27.70
168	29.20	169	59.10	162	4.90	146	13.00	154	1.90	157	20.40	162	8.00	51	0.00	155	40.60
90	35.56	94	46.81	76	27.63	70	31.43	74	6.76	76	47.37	79	8.86	84	5.95	85	27.06
138	26.09	146	42.47	144	25.69	122	31.15	131	10.69	137	34.31	142	11.97	146	4.79	144	40.28
192	41.15	197	37.06	191	18.85	188	26.06	188	9.04	190	45.79	188	5.32	144	7.64	141	21.99
63	3.17	109	18.35	87	21.84	43	39.53	83	7.23	46	50.00	96	5.21	89	20.22	86	3.49
42	21.43	60	26.67	53	7.55	38	39.47	49	20.41	44	50.00	55	7.27	56	12.50	52	11.54
295	28.14	374	30.48	332	30.12	89	29.21	158	5.70	211	37.44	341	9.38	338	6.51	258	17.05
390	19.74	458	31.22	353	21.25	262	14.89	334	17.96	314	42.68	382	6.54	352	13.07	345	13.62
146	31.51	181	8.29	233	13.30	162	4.94	292	6.85	214	46.73	285	5.26	290	32.07	244	28.69
276	21.74	301	37.54	274	21.90	215	9.77	227	5.29	267	33.71	295	8.81	228	7.46	296	24.32
62	16.13	99	25.25	85	24.71	39	17.95	63	7.94	60	40.00	85	10.59	80	12.50	77	19.48
9	22.22	15	33.33	29	6.90	9	44.44	16	25.00	15	46.67	33	6.06	19	10.53	21	19.05
132	27.27	146	36.99	122	18.85	74	18.92	93	9.68	98	38.78	129	6.20	123	13.01	122	27.87
132	37.12	140	37.14	171	27.49	76	31.58	96	6.25	136	36.76	217	9.68	187	17.11	163	38.65
74	13.51	93	41.94	74	18.92	36	19.44	65	10.77	61	27.87	84	7.14	83	15.66	79	31.65
143	28.67	179	40.22	166	28.31	80	18.75	128	10.16	120	28.33	178	6.18	176	19.32	163	25.77
72	33.33	93	30.11	30	13.33	14	0.00	19	5.26	21	52.38	35	8.57	33	6.06	28	21.43
50	32.00	50	26.00	33	15.15	14	7.14	21	4.76	21	42.86	34	5.88	30	23.33	28	53.57
177	36.16	207	46.38	124	21.77	66	10.61	81	11.11	97	36.08	137	13.14	142	18.31	134	29.85
90	24.44	100	23.00	124	12.90	66	10.61	116	6.03	99	45.45	131	4.58	139	19.42	130	24.62
22	45.45	28	50.00	23	8.70	17	0.00	20	10.00	18	38.89	25	4.00	25	20.00	24	45.83

Fig. 2. Two dimensional expression of multidimensional scaling applied to Smith's MMD based on 17 crown traits in 31 Asian populations. Proportion of variation explained by axis 1 and 2 is 36.7% and 20.2%, respectively.

Discussion

There are two major dental and morphological variations among Mongoloid populations, which are called Sinodonty and Sundadonty (4). These are categorical definitions of the combined dental characteristics of the Northeast and Southeast Asian populations, respectively. In addition, Sunda-Pacific and Sahul-Pacific type of the dentition has been also proposed to represent the dentition of Polynesians and Micronesians in Sunda-Pacific, and Melanesians in Sahul-Pacific (10).

Thirty East Asian populations compared with Palauans in this study were 16 Sinodont and 14 Sundadont populations (6, 7, 8, 15-22). The Northeast and Southeast Asian populations corresponded to Sinodont and Sundadont in Turner's classification were separated out in negative and positive directions on the first principal coordinate of the principal coordinate analysis, as can be seen in Fig. 2. A multiple regression analysis demonstrated that the

first principal coordinate correlated positively with LM2 cusp number and negatively with UI1 shoveling, UI1 double-shoveling and LM1 deflecting wrinkle. The second principal coordinate correlated positively with LM2 groove pattern and negatively with LM2 cusp number (data not shown).

As in the Turner's classification, dental characters in Micronesians and Polynesians are similar. For example, Hanihara (27) presented close affinity between Micronesians including Ponape, Guam and Tinian, and Polynesians based on the nine discrete crown traits. He also presented a clustering of Oceanic populations including Micronesians based on mesiodistal diameter of the tooth from skeletal materials, and discussed that Ponape in Central Micronesia was clustered in the group of Polynesians, but Guam and Tinian were independently clustered together separated from Polynesians, although sample size was small (28).

Sakurada (1999) also studied 6 non-metric traits of two Micronesians, and compared their frequencies with other Pacific peoples (29). His study revealed that Micronesians dental traits were similar to those in Polynesians, but different from Melanesians. However, the traits observed were not sufficient and the populations compared were limited to Pacific peoples in his study. In our data, although other Pacific peoples were not included, many of Asians were included. The isolated position of Palau among many Asians suggests that dental traits of Palauans are consisted of specific combination of the frequency. It was suggested that other Pacific peoples may occupy the positions around Palau if they are analyzed in the future.

In the study of tooth size of Pacific populations based on mesiodistal and buccolingual diameter, Palauans were grouped with Samoans and modern Philippines (30). This result was thought to be reasonable from the view point of migration history of Palauans (1). However, it was difficult to find the relationship between Palau and Philippine from our data.

Although no data are available for the comparison of 22 traits of the dentition in Pacific peoples, the

position of Palauans in Fig. 2 in this study might represent the specific dental traits of the Pacific people. The position of Palauans was in the Sundadont group, but far from Philippines and other Southeast populations. More data of Pacific peoples are needed to detect affinities with other Asian populations.

Conclusion

In Palauans, the frequencies of shoveling and double shovel are not so high as in northeast Asians, but relatively high frequencies were found in tuberculum dentale in the maxillary second incisor and Cusp 5 in the maxillary first molar. Carabelli's trait and deflecting wrinkle were not found so frequently as in the Chinese or Taiwanese populations. The frequency, 70.59%, of the 4-cusp type of the mandibular second molar was highest in the Asian populations cited in this study.

The principal coordinate plot for these 17 sets of scores, based on Smith's MMDs and standard deviations showed that data from Sundadont and Sinodont populations were differently positioned on the first axis. The Palauans belonged to Sundadont group and located in an extreme position on the right of the first axis and in relatively lower position in the second axis, which represented the unique combination of dental characters of Palauans.

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