

The Chronology of Second and Third Molar Mineralization in Korean Population and Application to Forensic Age Estimation

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Dental Age Estimation

Child

Developmental
Methods
(Teeth)

Adolescence

Developmental
Methods
(3rd Molar)
+
Anthropologic
age indicator
(Bone)

Adult

Invasive

- Histological Methods
- Biochemical Methods

Non-invasive

- Morphological Methods
- Radiologic Methods

Introduction

- Most variant teeth among human dentition
- Different development pattern between different populations
- Choi and Kim (1991) – different criteria
- Increasing accuracy with combination of 2nd molar and 3rd molar

Materials

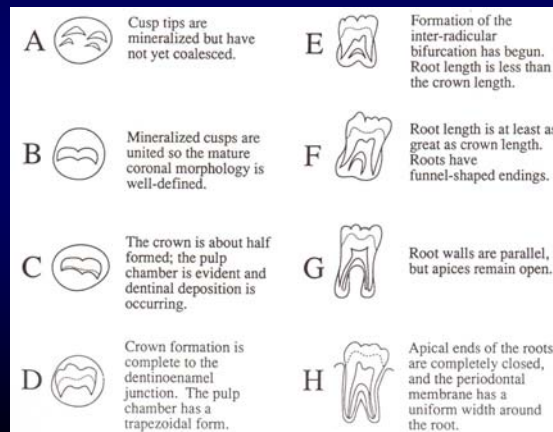
- 2087 Orthopantomograms

Age	Sex		Total
	Male	Female	
3	21	16	37
4	25	32	57
5	51	43	94



Methods

- Evaluation of the degree of mineralization using eight grade scheme presented by Demirjian



Statistical Analysis

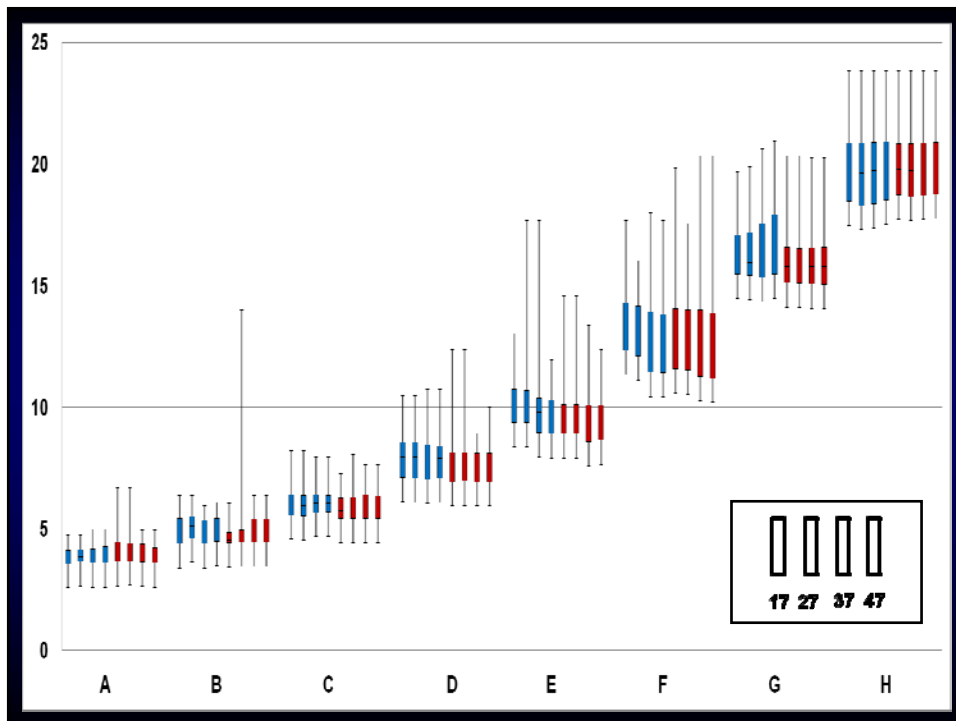
- Statistical data of mineralization grade of 2nd and 3rd molar (mean, standard deviations etc)
- Sex differences, Arch differences, Left-right symmetry – Chi-square test
- Interobserver reliability – Kappa statistics
- Relationship between age and mineralization degree – Multiple linear regression analysis

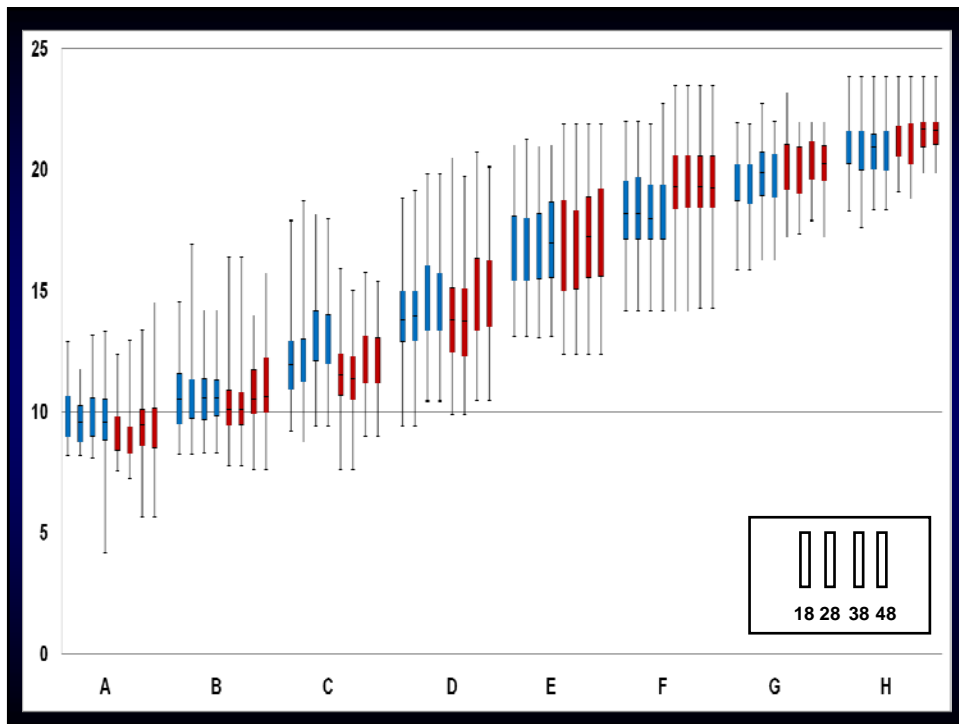
Results

* $p < 0.05$, ** $p < 0.01$

Tooth Stage	n	Male		Female			
		Mean	S.D.	Mean	S.D.		
17	A	20	3.85	0.39	21	4.12	0.78
	B	23	5.00	0.67	21	4.68	0.47
	C*	84	6.09	0.75	66	5.83	0.59
	D*	155	7.95	1.03	107	7.64	1.02
	E**	135	10.15	1.15	100	9.71	1.23
	F	149	13.23	1.50	172	12.95	1.73
	G	89	16.23	1.54	87	15.91	1.15
	H	358	19.63	1.61	460	19.58	1.49
27	A	24	3.90	0.38	20	4.14	0.79
	B	22	5.15	0.66	22	5.11	2.05
	C	80	6.05	0.73	67	5.85	0.63
	D*	160	7.95	1.05	105	7.65	1.02
	E**	128	10.16	1.32	99	9.71	1.24
	F	155	13.12	1.49	167	12.84	1.64
	G	85	16.31	1.66	85	15.88	1.27
	H	362	19.59	1.64	473	19.67	1.53
37	A	22	3.94	0.45	20	3.98	0.54
	B	26	4.90	0.62	27	4.88	0.62
	C	81	6.07	0.67	67	5.92	0.64
	D**	139	7.82	0.96	95	7.51	0.75
	E	112	9.74	1.24	85	9.45	1.15
	F	184	12.70	1.73	197	12.63	1.88
	G*	110	16.36	1.88	88	15.91	1.25
	H	340	19.65	1.63	466	19.71	1.49
47	A	26	3.98	0.46	20	3.92	0.50
	B	24	4.99	0.67	27	4.88	0.62
	C	84	6.07	0.67	68	5.92	0.64
	D**	132	7.84	0.92	97	7.55	0.80
	E	112	9.65	0.93	82	9.45	1.04
	F	186	12.66	1.70	191	12.56	1.84
	G**	123	16.58	1.89	95	15.90	1.23
	H	332	19.71	1.60	463	19.75	1.48

Tooth Stage	n	Male		Female			
		Mean	S.D.	Mean	S.D.		
18	A*	24	9.99	1.38	24	9.11	1.07
	B	56	10.75	1.64	39	10.32	1.42
	C	35	12.18	1.69	37	11.50	1.56
	D	65	13.93	1.78	80	13.79	2.05
	E	77	16.83	1.93	108	16.93	2.17
	F**	91	18.28	1.75	187	19.23	1.71
	G**	75	19.39	1.33	61	20.12	1.32
	H	67	20.87	1.19	28	21.09	1.05
28	A	20	9.55	0.99	20	9.07	1.42
	B	48	10.71	1.57	38	10.35	1.48
	C**	49	12.45	1.95	38	11.39	1.55
	D	59	14.11	1.80	89	13.73	2.00
	E	73	16.71	1.83	106	16.83	2.12
	F**	105	18.36	1.79	196	19.24	1.71
	G*	67	19.37	1.35	51	19.99	1.24
	H	60	20.75	1.27	28	21.10	1.12
38	A	50	9.88	1.06	45	9.49	1.48
	B	50	10.70	1.28	43	10.72	1.34
	C**	80	13.17	1.69	58	12.12	1.39
	D	64	14.75	2.01	100	14.91	2.05
	E	56	16.84	1.92	112	17.32	2.20
	F**	113	18.11	1.58	192	19.35	1.60
	G**	107	19.72	1.40	68	20.31	1.07
	H*	52	20.83	1.31	20	21.61	0.91
48	A	56	9.63	1.33	40	9.46	1.50
	B	46	10.65	1.22	46	11.02	1.70
	C**	81	13.05	1.61	60	11.96	1.35
	D	65	14.63	1.80	96	14.91	2.05
	E	52	17.11	1.89	111	17.33	2.23
	F**	113	18.15	1.66	202	19.33	1.63
	G**	107	19.60	1.39	73	20.22	1.17
	H*	61	20.86	1.32	21	21.60	0.89





Results

- Interobserver reliability – excellent (kappa value=0.905 ~ 0.948)
- Left-right symmetry – not observed ($p < 0.001$)
- Arch difference – not observed ($p < 0.001$)
- Relationship between age and mineralization degree – Strong positive relationship ($R^2 = 0.78 \sim 0.95$)



All Subjects	One variable				Two variables				Four variables
	Mx M2	Mx M3	Mn M2	Mn M3	Mx M2 + Mn M2	Mx M3 + Mn M3	Mx M2 + Mx M3	Mn M2 + Mn M3	Mx M2 & M3 + Mn M2 & M3
Intercept	19.68	20.94	19.69	21.05	19.79	21.24	20.93	21.05	21.22
Mx M2	A	-15.69			-8.42				
	B	-14.83			-7.97				
	C	-13.70			-7.59				
	D	-11.85			-6.73		-7.54		-4.02
	E	-9.71			-5.94		-6.43		-3.63
	F	-6.60			-3.77		-4.52		-2.51
	G	-3.61			-2.07		-2.59		-1.47
	H	0.00			0.00		0.00		0.00
Mx M3	A		-11.38				-5.60	-5.04	-2.62
	B		-10.36				-5.12	-4.54	-2.32
	C		-9.11				-4.94	-4.25	-2.39
	D		-7.08				-4.25	-3.23	-1.81
	E		-4.05				-2.36	-2.21	-1.29
	F		-2.02				-1.00	-1.66	-0.86
	G		-1.22				-0.75	-1.15	-0.68
	H		0.00				0.00	0.00	0.00
Mn M2	A			-15.73	-7.42				
	B			-14.80	-6.97				
	C			-13.69	-6.32				
	D			-12.00	-5.32			-9.22	-3.82
	E			-10.07	-4.14			-6.96	-2.78
	F			-7.03	-3.11			-5.29	-2.20
	G			-3.53	-1.77			-4.19	-1.33
	H			0.00	0.00			0.00	0.00
Mn M3	A				-11.35		-6.29	-6.15	-2.90
	B				-10.34		-5.61	-5.72	-2.64
	C				-8.32		-4.17	-4.37	-2.00
	D				-6.20		-3.05	-3.16	-1.38
	E				-3.89		-2.21	-2.49	-1.23
	F				-2.16		-1.25	-1.69	-1.01
	G				-1.10		-0.66	-1.05	-0.70
	H				0.00		0.00	0.00	0.00
R-square	0.94	0.81	0.93	0.82	0.95	0.84	0.89	0.89	0.91

Male	One variable				Two variables				Four variables
	Mx M2	Mx M3	Mn M2	Mn M3	Mx M2 +	Mx M3 +	Mx M2 +	Mn M2 +	Mx M2 & M3 +
					Mn M2	Mn M3	Mx M3	Mn M3	Mn M2 & M3
Intercept	19.63	20.87	19.65	20.83	19.78	21.02	20.87	20.83	21.02
Mx M2	A	-15.78			-9.06				
	B	-14.63			-8.30				
	C	-13.54			-7.97				
	D	-11.68			-7.09		-7.08		-3.93
	E	-9.48			-6.18		-5.79		-3.35
	F	-6.40			-3.95		-3.78		-2.34
	G	-3.40			-2.20		-2.13		-1.38
	H	0.00			0.00		0.00		0.00
Mx M3	A		-10.88			-4.76	-5.14		-2.71
	B		-10.12			-4.87	-4.88		-2.68
	C		-8.69			-5.22	-4.61		-3.34
	D		-6.94			-4.26	-3.74		-2.62
	E		-4.04			-2.47	-2.40		-1.81
	F		-2.60			-1.56	-2.01		-1.36
	G		-1.48			-0.97	-1.36		-0.98
	H		0.00			0.00	0.00		0.00
Mn M2	A			-15.71	-6.91				
	B			-14.75	-6.53				
	C			-13.59	-5.88				
	D			-11.84	-4.81			-5.84	-3.14
	E			-9.91	-3.73			-4.48	-2.17
	F			-6.95	-2.73			-3.52	-1.46
	G			-3.29	-1.60			-1.69	-0.87
	H			0.00	0.00			0.00	0.00
Mn M3	A				-10.95	-6.36		-6.56	-3.08
	B				-10.13	-5.56		-6.24	-2.75
	C				-7.67	-3.44		-4.45	-1.53
	D				-6.09	-2.77		-3.55	-1.07
	E				-4.00	-2.09		-2.84	-0.89
	F				-2.72	-1.34		-1.96	-0.77
	G				-1.12	-0.41		-1.05	-0.42
	H				0.00	0.00		0.00	0.00
R-square	0.94	0.83	0.93	0.84	0.95	0.86	0.90	0.88	0.91

Female	One variable				Two variables				Four variables
	Mx M2	Mx M3	Mn M2	Mn M3	Mx M2 +	Mx M3 +	Mx M2 +	Mn M2 +	Mx M2 & M3 +
					Mn M2	Mn M3	Mx M3	Mn M3	Mn M2 & M3
Intercept	19.72	21.10	19.71	21.61	19.79	21.84	21.09	21.61	21.82
Mx M2	A	-15.59			-7.86				
	B	-15.04			-7.86				
	C	-13.88			-7.31				
	D	-12.07			-6.42		-8.40		-8.54
	E	-10.00			-5.77		-6.95		-3.72
	F	-6.77			-3.56		-5.14		-2.44
	G	-3.80			-1.83		-2.94		-1.25
	H	0.00			0.00		0.00		0.00
Mx M3	A		-11.98			-5.80	-5.12		-2.44
	B		-10.77			-4.99	-4.52		-2.09
	C		-9.59			-4.39	-4.07		-1.64
	D		-7.30			-4.08	-2.89		-1.18
	E		-4.17			-2.14	-2.18		-0.87
	F		-1.86			-0.79	-1.64		-0.60
	G		-0.98			-0.57	-0.98		-0.52
	H		0.00			0.00	0.00		0.00
Mn M2	A			-15.73	-7.84				
	B			-14.83	-7.19				
	C			-13.80	-6.68			-9.56	
	D			-12.20	-5.86			-7.76	0.00
	E			-10.27	-4.52			-5.90	-3.36
	F			-7.09	-3.49			-4.53	-2.86
	G			-3.80	-2.03			-2.70	-1.78
	H			0.00	0.00			0.00	0.00
Mn M3	A				-12.12	-7.05		-6.37	-3.27
	B				-10.89	-6.52		-5.82	-3.25
	C				-9.49	-5.67		-5.05	-3.06
	D				-6.69	-3.84		-3.38	-2.19
	E				-4.29	-2.88		-2.77	-1.99
	F				-2.25	-1.65		-2.08	-1.71
	G				-1.30	-1.04		-1.29	-1.12
	H				0.00	0.00		0.00	0.00
R-square	0.94	0.81	0.94	0.82	0.95	0.84	0.90	0.90	0.92

All Subjects	One variable				Two variables				Four variables
	Mx M2	Mx M3	Mn M2	Mn M3	Mx M2 + Mn M2	Mx M3 + Mn M3	Mx M2 + Mx M3	Mn M2 + Mn M3	Mx M2 & M3 + Mn M2 & M3
Intercept	-2.49	7.12	-2.59	7.70	-2.84	6.88	-2.70	-1.67	-3.22
Mx M2	2.71				1.80		2.20		1.18
Mx M3		1.85				0.87	0.72		0.39
Mn M2			2.71		0.96			1.97	1.06
Mn M3				1.79		1.04		0.86	0.37
R-square	0.91	0.78	0.90	0.81	0.92	0.82	0.89	0.88	0.90

Male	One variable				Two variables				Four variables
	Mx M2	Mx M3	Mn M2	Mn M3	Mx M2 + Mn M2	Mx M3 + Mn M3	Mx M2 + Mx M3	Mn M2 + Mn M3	Mx M2 & M3 + Mn M2 & M3
Intercept	-2.27	7.65	-2.40	8.09	-2.61	7.38	-0.70	0.42	-0.76
Mx M2	2.68				1.87		1.86		1.04
Mx M3		1.70				0.80	0.79		0.50
Mn M2			2.68		0.86			1.60	0.76
Mn M3				1.65		0.96		0.95	0.38
R-square	0.92	0.81	0.90	0.83	0.92	0.85	0.89	0.88	0.90

Female	One variable				Two variables				Four variables
	Mx M2	Mx M3	Mn M2	Mn M3	Mx M2 + Mn M2	Mx M3 + Mn M3	Mx M2 + Mx M3	Mn M2 + Mn M3	Mx M2 & M3 + Mn M2 & M3
Intercept	-2.74	6.37	-2.79	7.09	-3.10	6.14	-4.44	-2.89	-4.84
Mx M2	2.74				1.71		2.46		1.26
Mx M3		2.04				0.93	0.69		0.31
Mn M2			2.74		1.08			2.14	1.24
Mn M3				1.97		1.18		0.87	0.43
R-square	0.91	0.78	0.90	0.80	0.92	0.82	0.90	0.89	0.91



**Forensic odontologic
age estimation
16.27 ~ 16.42**

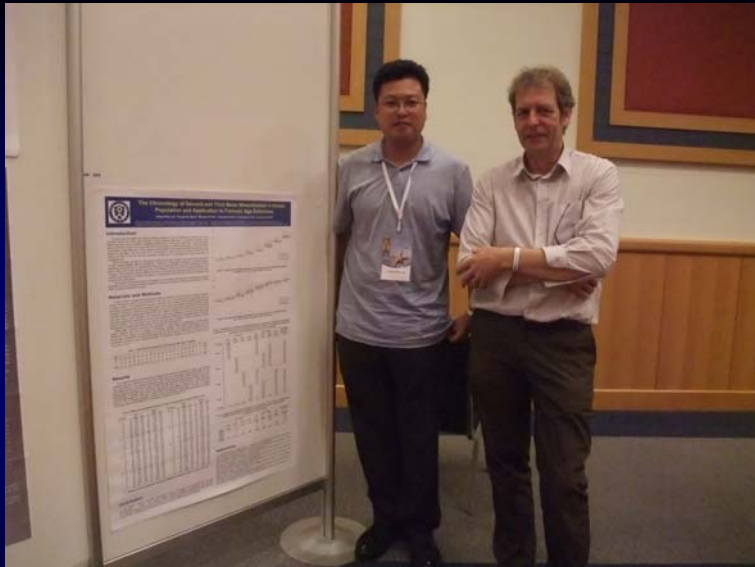
**Estimated age
Around 16**



**Forensic anthropologic
age estimation
16 ~ 22**

Conclusion

- Establishment of Korean populational data of mineralization of 2nd and 3rd molar
- Presentation of regression equation for application to forensic age estimation of Koreans



This research was presented in 4th meeting of Mediterranean Academy of Forensic Science (2009) as a poster presentation