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Sella turcica morphology in skeletal mandibular protrusion

***Shuichi Makino[1], Chikako Hosoyama[2], Hidetoshi Morikuni[2], Kenichiro Yasui[2], Yuji Nakayama[2], Aki Nishiura[2] and Naoyuki Matsumoto[2]**

[1]Graduate School of Dentistry (Department of Orthodontics), [2]Department of Orthodontics, Osaka Dental University, 8-1 Kuzuhahanazono-cho, Hirakata-shi, Osaka 573-1121, Japan
**E-mail: makino-s@cc.osaka-dent.ac.jp*

We investigated the relationship between sella turcica size and maxillofacial morphology in skeletal Class III malocclusion among Japanese adults.The subjects were 115 patients visiting the Osaka Dental University Hospital between May 2014 and March 2019 with ∠ANB＜1.0º, negative overjet, and an absence of congenital abnormalities in the skeletal Class III malocclusion group. Individuals with 1.0º ≤ ∠ANB ≤ 4.0º were included as controls (n＝122). Lateral cephalometric analysis was performed to measure the overbite depth indicator (ODI), the maximum anteroposterior width (W) of the sella turcica, depth (De) of the sella turcica, and diameter (Di) of the sella turcica; and interclinoid distance (I), among other parameters.

In the skeletal Class III malocclusion group, Di and I were significantly smaller among the males, and De was significantly larger among females. In males, a positive correlation was observed between De and ODI. In females, a positive correlation was observed between W and Pog to NB, De and ∠ANB, ∠Occlusal pl to SN, and ∠GoGn to SN. These findings indicate the possibility of predicting maxillofacial growth based on sella turcica morphology, which could help improve orthodontic treatment. (J Osaka Dent Univ 2023; 57: 99-106)

Key words: Sella turcica; Sella turcica morphology; Maxillofacial growth; Malocclusion; Japanese

INTRODUCTION

The sella turcica is located in the sphenoid bone and used as a reference point for cephalometric analysis. The pituitary gland is present inside the sella turcica, and diseases of the pituitary gland may affect the shape and size of the sella turcica. The morphology of the sella turcica, and growth and development of the maxillofacial skull have been well studied,[1, 2] and their association with skeletal malocclusion has been noted.[3-8] Alkofide reported a relationship between sella turcica size and skeletal malocclusion among Saudi subjects.[3] Filipovic *et al.* reported this relationship among Serbian subjects.[4] However, there are few reports on the relationship between sella turcica morphology and skeletal malocclusion in Japanese subjects. In this study, we used standardized lateral cephalometric radiographs to investigate the relationship between the sella turcica size and maxillofacial morphology in skeletal Class III malocclusion in Japanese adults.

MATERIALS AND METHODS

Subjects and materials

Among the adult patients who visited the orthodontic clinic at Osaka Dental University Hospital between May 2014 and March 2019, a total of 115 patients, 37 males and 68 females were selected as the skeletal Class III malocclusion group (“skeletal 3 group”) based on the following criteria: ∠ANB ＜1.0º, negative overjet, and an absence of any

congenital abnormality. In addition we referred to the analysis of Iizuka *et al.*[9] and defined individuals with 1.0º ≤ ∠ANB ≤ 4.0º as the control ("skeletal 1 group"), which had a total of 122 participants, 66 males and 56 females.

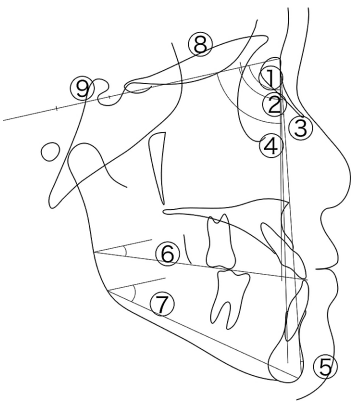

Fig. 1 Measurements on the lateral cephalogram (Steiner). ① ∠SNA (angle), ② ∠SNB (angle), ③ ∠ANB: ①-② (angle), ④ ∠SND (angle), ⑤ Pog to NB (mm), ⑥∠Occlusal to SN (angle), ⑦ ∠GoGn to SN (angle), ⑧ SL (mm), ⑨ SE (mm).

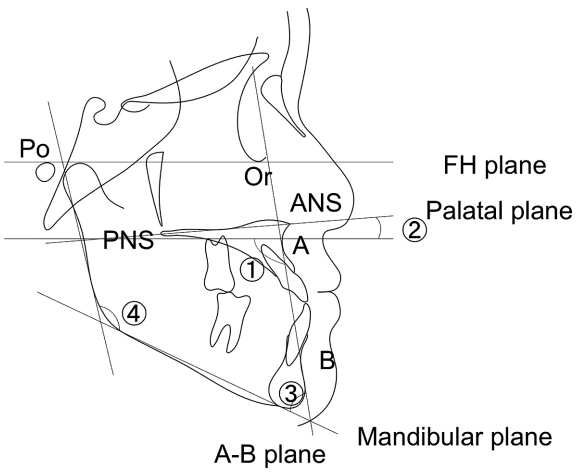

Fig. 2 Measurements on the lateral cephalogram. APDI: ①+②, ODI: ②+③, Kix index: APDI/ODI, ④ Gonial angle (angle).

Lateral cephalometric analysis

We used cephalometric radiographs of the participants to assess the nine measurement items used in the Steiner analysis (Fig. 1); and to assess the Gonial angle used in Downs analysis[10]; and anteroposterior dysplasia indicator (APDI), overbite depth indicator (ODI), and Kix index as proposed by Kim[11, 12] (Fig. 2). Next, to evaluate the sella turcica morphology, we measured the maximum anteroposterior width (W), depth (De), and the diameter (Di) of the sella turcica according to the method by Jones *et al.*[13] To evaluate the bridging of the sella turcica, we measured the interclinoid distance (I) (Fig. 3). Additionally, based on the study by Uesato *et al.* on 50 Japanese and Japanese-American patients,[14] we categorized the skeletal 3 group participants with ∠GoGn to SN ≥ 34.5º as the high angle group and those with ∠GoGn to SN＜34.5º as the normal angle group (Table 1).

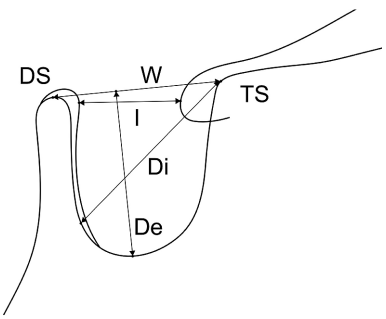

Fig. 3 Dimensions of the sella turcica. Width (W): Superior aspect of the dorsum sella (DS) to the superior aspect of the tuberculum sella (TS), Depth (De): Greatest distance perpendicular from line W to the base of the pituitary fossa, Diameter (Di) of the sella, and Interclinoid (I): The shortest distances between the clinoid processes.

Table 1 Subjects in this study

Subjects	Skeletal 3	Skeletal 1	High angle skeletal 3	Normal angle skeletal 3
Number	105 (37 M, 68 F)	122 (66 M, 56 F)	62 (16 M, 46 F)	43 (21 M, 22 F)
Range of ages	14 y 9 m-28 y 10 m	20 y 3 m-29 y 9 m	14 y 9 m-28 y 10 m	15 y 4 m-28 y 9 m
Mean age	19 y 4 m	23 y 10 m	18 y 11 m	19 y 8 m

Statistical processing

Student's *t*-test was conducted for each measurement value, and the difference was considered significant for $p<0.05$. Next, we conducted correlation tests relating to Pearson's correlation coefficient *r* to calculate the risk ratio *p.* A correlation was considered for $p<0.05$ and $r>0.20$ or $r<-0.20$.

This study was conducted with the approval of the Osaka Dental University ethics committee (Approval No.111114).

RESULTS

The findings of the male and female participants were compared. A comparison of the sella turcica morphology between the skeletal 3 and skeletal 1 groups revealed that Di and I were significantly smaller among males of the skeletal 3 group, and De was significantly larger among females of that group (Table 2). Next, we investigated the relationship between the sella turcica morphology and maxillofacial skeleton in the skeletal 3 group. In males, a positive correlation was observed between De and ODI. In females, a positive correlation was observed between W and Pog to NB, De and ∠ANB, ∠Occlusal plane to SN, and ∠GoGn to SN negative correlation was observed between De and ∠SNA, ∠SNB, ∠SND, SL and APDI (Table 3). In the skeletal 1 group, we investigated the relationship between the sella turcica morphology and maxillofacial skeleton. Among males, a positive correlation was observed between not only W and ∠ANB, but also between W and SE. A positive correlation was also observed between I and ∠ANB. On the other hand, a negative correlation was observed between Di and the Kix index. Among females, no correlations was observed for any item (Table 4). Although comparison of sella turcica morphology in the high angle group and normal angle group showed no significant differences among

Table 2 Comparison of sella turcica linear dimensions for skeletal 3 patients and skeletal 1 patients

Parameter	Skeletal 3		Skeletal 1		*p*-value (skeletal 3 and skeletal 1)	
Gender	Male (n=37)	Female (n=68)	Male (n=66)	Female (n=56)	Male	Female
Width (mm)	9.4±3.1	9.1±2.0	10.0±2.6	8.9±2.8	$p=0.071$	$p=0.862$
Depth (mm)	8.1±2.1	8.6±1.3	7.8±1.5	8.1±1.2	$p=0.947$	$*p=0.020$
Diameter (mm)	10.7±2.5	11.7±1.4	11.7±1.7	11.8±1.3	$*p=0.001$	$p=0.697$
Interclinoid distance (mm)	4.3±2.1	3.9±1.9	5.5±2.5	4.0±2.1	$*p=0.004$	$p=0.759$

Mean±SD, $*p<0.05$.

Table 3-1 Correlation with measurements for sella turcica linear dimensions and pre-exiting measurement values in skeletal 3 male patients

Measurement	W		De		Di		I	
∠SNA	$p=0.319$	$r=0.168$	$p=0.598$	$r=-0.090$	$p=0.686$	$r=0.069$	$p=0.084$	$r=0.288$
∠SNB	$p=0.413$	$r=0.139$	$p=0.425$	$r=-0.135$	$p=0.974$	$r=0.005$	$p=0.082$	$r=0.290$
∠ANB	$p=0.855$	$r=0.031$	$p=0.584$	$r=0.093$	$p=0.533$	$r=0.106$	$p=0.826$	$r=-0.038$
∠SND	$p=0.402$	$r=0.142$	$p=0.351$	$r=-0.158$	$p=0.979$	$r=-0.005$	$p=0.120$	$r=0.260$
Pog to NB	$p=0.594$	$r=0.090$	$p=0.136$	$r=-0.250$	$p=0.453$	$r=-0.127$	$p=0.464$	$r=-0.124$
Occlusal plane to SN	$p=0.887$	$r=-0.024$	$p=0.523$	$r=0.108$	$p=0.999$	$r=0.000$	$p=0.732$	$r=-0.058$
Go-Gn to SN	$p=0.927$	$r=0.016$	$p=0.834$	$r=0.036$	$p=0.768$	$r=0.050$	$p=0.758$	$r=-0.052$
SL	$p=0.652$	$r=0.077$	$p=0.542$	$r=-0.103$	$p=0.749$	$r=-0.054$	$p=0.086$	$r=0.286$
SE	$p=0.299$	$r=-0.175$	$p=0.970$	$r=-0.006$	$p=0.431$	$r=-0.133$	$p=0.052$	$r=-0.321$
Gonial angle	$p=0.964$	$r=-0.008$	$p=0.317$	$r=-0.169$	$p=0.681$	$r=-0.070$	$p=0.598$	$r=0.090$
APDI	$p=0.219$	$r=0.207$	$p=0.873$	$r=-0.027$	$p=0.852$	$r=0.032$	$p=0.102$	$r=0.273$
ODI	$p=0.840$	$r=0.034$	$*p=0.041$	$r=0.338$	$p=0.235$	$r=0.200$	$p=0.535$	$r=-0.105$
Kix index	$p=0.950$	$r=0.011$	$p=0.072$	$r=-0.300$	$p=0.313$	$r=-0.171$	$p=0.274$	$r=0.185$

Table 3-2 Correlation with measurements for sella turcica linear dimensions and pre-exiting measurement values in skeletal 3 female patients

Measurement	W		De		Di		I	
∠SNA	$p=0.514$	$r=0.080$	$*p=0.009$	$r=-0.314$	$*p=0.008$	$r=-0.317$	$p=0.769$	$r=-0.036$
∠SNB	$p=0.266$	$r=0.137$	$*p=0.000$	$r=-0.417$	$*p=0.025$	$r=-0.271$	$p=0.954$	$r=-0.007$
∠ANB	$p=0.283$	$r=-0.132$	$*p=0.040$	$r=0.249$	$p=0.445$	$r=-0.094$	$p=0.575$	$r=-0.069$
∠SND	$p=0.182$	$r=0.164$	$*p=0.000$	$r=-0.437$	$*p=0.021$	$r=-0.281$	$p=0.976$	$r=-0.004$
Pog to NB	$*p=0.014$	$r=0.297$	$p=0.132$	$r=-0.184$	$p=0.502$	$r=-0.083$	$p=0.916$	$r=0.013$
Occlusal pl. to SN	$p=0.619$	$r=-0.061$	$*p=0.001$	$r=0.399$	$p=0.112$	$r=0.194$	$p=0.057$	$r=0.232$
Go-Gn to SN	$p=0.077$	$r=-0.216$	$*p=0.004$	$r=0.342$	$p=0.062$	$r=0.227$	$p=0.408$	$r=0.102$
SL	$p=0.245$	$r=0.143$	$*p=0.010$	$r=-0.310$	$p=0.060$	$r=-0.229$	$p=0.796$	$r=-0.032$
SE	$p=0.512$	$r=0.081$	$p=0.420$	$r=0.099$	$p=0.663$	$r=0.054$	$p=0.532$	$r=0.077$
Gonial angle	$p=0.140$	$r=-0.181$	$p=0.095$	$r=0.204$	$p=0.789$	$r=-0.033$	$p=0.396$	$r=0.105$
APDI	$p=0.079$	$r=0.214$	$*p=0.004$	$r=-0.349$	$p=0.805$	$r=-0.031$	$p=0.392$	$r=0.106$
ODI	$p=0.350$	$r=0.115$	$p=0.778$	$r=0.035$	$p=0.737$	$r=-0.042$	$p=0.697$	$r=-0.048$
Kix Index	$p=0.951$	$r=0.008$	$p=0.201$	$r=-0.157$	$p=0.763$	$r=0.037$	$p=0.553$	$r=0.073$

Table 4-1 Correlation with measurements for sella turcica linear dimensions and pre-exiting measurement values in skeletal 1 male patients

Measurement	W		De		Di		I	
∠SNA	$p=0.903$	$r=-0.015$	$p=0.412$	$r=-0.103$	$p=0.189$	$r=-0.164$	$p=0.598$	$r=-0.066$
∠SNB	$p=0.407$	$r=-0.104$	$p=0.489$	$r=-0.087$	$p=0.081$	$r=-0.216$	$p=0.315$	$r=-0.126$
∠ANB	$*p=0.003$	$r=0.362$	$p=0.528$	$r=-0.079$	$p=0.114$	$r=0.196$	$*p=0.048$	$r=0.244$
∠SND	$p=0.267$	$r=-0.139$	$p=0.480$	$r=-0.088$	$p=0.103$	$r=-0.203$	$p=0.214$	$r=-0.155$
Pog to NB	$p=0.706$	$r=-0.047$	$p=0.347$	$r=0.118$	$p=0.175$	$r=0.169$	$p=0.337$	$r=-0.120$
Occlusal pl. to SN	$p=0.079$	$r=0.218$	$p=0.498$	$r=0.085$	$p=0.156$	$r=0.177$	$p=0.259$	$r=0.141$
Go-Gn to SN	$p=0.433$	$r=0.098$	$p=0.548$	$r=-0.075$	$p=0.909$	$r=-0.014$	$p=0.565$	$r=0.072$
SL	$p=0.176$	$r=-0.169$	$p=0.716$	$r=-0.046$	$p=0.263$	$r=-0.140$	$p=0.120$	$r=-0.193$
SE	$*p=0.009$	$r=0.318$	$p=0.240$	$r=0.147$	$p=0.067$	$r=0.227$	$p=0.176$	$r=0.168$
Gonial angle	$p=0.802$	$r=-0.031$	$p=0.141$	$r=-0.183$	$p=0.496$	$r=-0.085$	$p=0.935$	$r=-0.010$
APDI	$p=0.700$	$r=-0.048$	$p=0.366$	$r=0.113$	$p=0.359$	$r=-0.115$	$p=0.405$	$r=-0.104$
ODI	$p=0.369$	$r=0.112$	$p=0.414$	$r=0.102$	$p=0.076$	$r=0.220$	$p=0.152$	$r=0.178$
Kix Index	$p=0.625$	$r=-0.061$	$p=0.626$	$r=-0.061$	$*p=0.021$	$r=-0.284$	$p=0.268$	$r=-0.138$

Table 4-2 Correlation with measurements for sella turcica linear dimensions and pre-exiting measurement values in skeletal 1 female patients

Measurement	W		De		Di		I	
∠SNA	$p=0.348$	$r=0.128$	$p=0.520$	$r=-0.088$	$p=0.483$	$r=-0.096$	$p=0.596$	$r=0.072$
∠SNB	$p=0.463$	$r=0.100$	$p=0.427$	$r=-0.108$	$p=0.473$	$r=-0.098$	$p=0.521$	$r=0.088$
∠ANB	$p=0.689$	$r=0.055$	$p=0.399$	$r=0.115$	$p=0.723$	$r=0.049$	$p=0.544$	$r=-0.083$
∠SND	$p=0.523$	$r=0.087$	$p=0.362$	$r=-0.124$	$p=0.445$	$r=-0.104$	$p=0.396$	$r=0.116$
Pog to NB	$p=0.732$	$r=-0.047$	$p=0.229$	$r=-0.163$	$p=0.327$	$r=-0.133$	$p=0.352$	$r=0.127$
Occlusal pl. to SN	$p=0.268$	$r=-0.151$	$p=0.879$	$r=-0.021$	$p=0.383$	$r=0.119$	$p=0.074$	$r=-0.241$
Go-Gn to SN	$p=0.482$	$r=-0.096$	$p=0.732$	$r=0.047$	$p=0.123$	$r=0.209$	$p=0.236$	$r=-0.161$
SL	$p=0.397$	$r=0.115$	$p=0.886$	$r=-0.020$	$p=0.349$	$r=-0.128$	$p=0.108$	$r=0.217$
SE	$p=0.723$	$r=-0.048$	$p=0.866$	$r=-0.023$	$p=0.304$	$r=0.140$	$p=0.609$	$r=0.070$
Gonial angle	$p=0.900$	$r=0.017$	$p=0.656$	$r=-0.061$	$p=0.174$	$r=0.184$	$p=0.502$	$r=-0.092$
APDI	$p=0.967$	$r=0.006$	$p=0.114$	$r=-0.214$	$p=0.926$	$r=-0.013$	$p=0.727$	$r=0.048$
ODI	$p=0.893$	$r=0.018$	$p=0.750$	$r=-0.044$	$p=0.303$	$r=-0.140$	$p=0.535$	$r=0.085$
Kix Index	$p=0.728$	$r=-0.048$	$p=0.501$	$r=-0.092$	$p=0.265$	$r=0.152$	$p=0.728$	$r=-0.048$

Tabele 5 Comparison of sella turcica linear dimensions for normal angle and high angle

	Normal angle				High angle				p-value			
									Skeletal 1		Skeletal 3	
	Skeletal 1		Skeletal 3		Skeletal 1		Skeletal 3		Normal angle and High angle		Normal angle and High angle	
Parameter (mm)	M (n=56)	F (n=56)	M (n=16)	F (n=68)	M (n=19)	F (n=56)	M (n=16)	F (n=68)	M	F	M	F
Width	10.1±2.3	9.5±2.7	9.3±3.4	9.0±2.3	9.2±2.3	8.7±2.8	9.5±2.4	9.1±1.7	$p=0.58$	$p=0.26$	$p=0.43$	$p=0.25$
Depth	7.9±1.8	7.7±1.1	7.8±2.3	8.1±1.1	7.6±1.8	8.6±1.1	8.4±1.9	8.9±1.3	$p=0.18$	$*p=0.00$	$p=0.68$	$*p=0.04$
Diameter	11.7±1.7	11.4±1.5	10.5±2.6	11.6±1.5	11.6±1.7	12.1±1.2	11.0±2.1	11.8±1.3	$p=0.13$	$p=0.84$	$p=0.47$	$p=0.34$
Interclinoid distance	5.5±2.8	4.4±2.5	4.5±2.4	3.6±1.7	6.0±2.8	3.7±1.4	4.0±1.7	4.1±1.9	$p=0.89$	$p=0.12$	$p=0.68$	$p=0.32$

Table 6 Literature data and our data of sella turcica linear dimensions in skeletal 1 patients and skeletal 3 patients

Authors	Publication (yr)	Country	Age (yrs)	Skeletal 1				Skeletal 3			
				n	Width	Depth	Diameter	n	Width	Depth	Diameter
Alkofide *et al.*	2007	Saudi Arabia	10-26	60	10.70±2.03	8.90±1.27	13.90±1.85	60	11.40±2.86	9.10±1.36	14.60±2.08
Meyer-Marcotty *et al.*	2009	Germany	older than 17 years	150	10.89±1.62	8.16±1.15	12.99±1.55	250	11.19±1.65	8.39±1.30	13.05±1.63
Yassir *et al.*	2010	Iraq	17-25	50	9.67±1.77	8.42±1.21	12.00±1.20	30	9.73±1.48	8.59±1.12	12.50±1.42
Filipovic *et al.*	2011	Serbia	18-22	30	9.18±1.74	8.48±1.28	10.95±1.04	30	10.10±1.70	9.20±1.26	11.28±1.29
Shah *et al.*	2011	Pakistan	17-25	60	10.70±2.24	9.73±1.69	13.50±1.99	60	12.00±2.24	9.90±1.87	14.50±2.22
Sathyanarayana *et al.*	2013	India	older than 15	60	8.90±1.78	7.30±1.23	10.90±1.41	60	9.70±1.47	7.30±1.09	11.50±0.98
Valizadeh *et al.*	2015	Iran	14-26	29	10.43±1.48	8.83±1.21	13.02±1.57	30	9.52±2.23	8.45±1.39	12.12±1.90
Shrestha *et al.*	2018	Nepal	18-30	40	7.97±1.52	6.40±0.92	9.30±1.02	40	9.16±2.42	6.74±1.54	10.35±1.64
Sobuti *et al.*	2018	Iran	14-26	35	8.14±1.77	6.43±0.98	10.09±1.22	35	7.23±1.75	6.66±0.07	9.80±1.30
Afzal *et al.*	2019	Pakistan	13-19	30	6.10±1.80	7.60±1.50	9.60±1.60	30	5.90±2.30	7.80±1.30	9.70±1.30
Present study (Male)	**2022**	**Japan**	**18-30**	**66**	**10.00±2.60**	**7.80 1.50**	**11.70±1.70**	**37**	**9.40±3.10**	**8.10±2.10**	**10.70±2.50**
Present study (Female)	**2022**	**Japan**	**18-30**	**56**	**8.90±2.80**	**8.10 1.20**	**11.80±1.30**	**68**	**9.1±2.00**	**8.6±1.30**	**11.70±1.40**

(mm)

males, the high angle group showed significantly higher values for De among females (Table 5).

DISCUSSION

Size of sella turcica

In this study, we measured the maximum W, De and Di of the sella turcica to evaluate its size according to the method described by Jones *et al.*[13] The size of the sella turcia observed in the present study was smaller than that reported by Alkofide *et al.*[3] among Saudi subjects and Meyer-Marcotty *et al.*[15] among German subjects, and by Shah *et al.*[16] among Pakistani subjects. In contrast, the size of the sella turcica observed in the present study was larger than that reported by Sobuti[17] among Iranian subjects and by Afzal[18] among Pakistani subjects (Table 6). These findings indicate differences in the size of the sella turcica among ethnic groups.

Regarding the relationship between the size of the sella turcica and skeletal malocclusion, Meyer-Marcotty *et al.,*[15] Shah *et al.,*[16] Sobuti *et al.,*[17] Afzal *et al.*[18] and Yassir *et al.*[19] reported no significant differences in the W, De or Di of the sella turcica among individuals with skeletal Class I, II and Ⅲ malocclusion. However, Alkofide[3] compared individuals with skeletal Class II and III malocclusion and identified a significant relationship between the type of malocclusion and the sella turcica diameter. Moslemzadeh *et al.*[7] also reported a significant difference in W between individuals with skeletal II and III malocclusion. Sathyanarayana *et al.*[5] studied Indian subjects with skeletal I, II and II malocclusion and reported a significant difference in both W and Di among all of the groups. Filipovic *et al.*.[4] compared Serbian individuals with skeletal II and III malocclusion and reported significant differences in W and De. When comparing the skeletal 1 and skeletal 3 groups in this study, we found a significant difference in W and I between the two groups among males and a significant difference in De between the two groups among females, which is consistent with previous reports. Regarding the relationship between the size of the sella turcica and maxillofacial skelelton in this study, a correlation was observed between W and APDI in the skeletal 3 group. A large APDI value indicated a Class III malocclusion tendency, whereas a small APDI value indicated a Class II tendency. Sathyanarayana and Moslemzadeh *et al.*[5, 7] reported a correlation between W and the skeletal 3 group. And the results of this study showed that there was a similar correlation among Japanese subjects. There was a positive correlation of De with ∠Occl to SN, and ∠GoGn to SN and a negative correlation of De with∠SND. ∠GoGn to SN indicates the inclination of the mandibular marginal plane and is also involved in the length of the facial height. Afzal *et al.*[18] also reported a similar relationship between the depth of the sella turcica and facial height. Additionally, a negative correlation was observed between De and ∠SNA, ∠SNB, Po to NB (mm), APDI, and the Kix index. These results indicate that a greater sella turcica depth results in less forward growth of both the maxilla and mandible. Our finding of a negative correlation between De and APDI differs from that of Filipovic,[4] who reported that the depth of the sella turcica was significantly greater in the skeletal 3 group than in the skeletal 1 group. Based on the results of our study, which indicated that the facial height increases with depth, it is thought that ∠ANB and APDI were low because of clockwise rotation of the mandible. Considering the syndromes impacting the maxillofacial morphology of individuals with skeletal Class III malocclusion, acromegaly, which is a syndrome characterized by the skeletal pattern found in Class III malocclusion, is a disease characterized by slowly progressive anomalies of body mass, primarily due to overproduction of the growth hormone (GH) and insulin-like growth factor 1 (IGF 1) associated with pituitary adenoma. In a study, cephalometric analysis of patients who were diagnosed with acromegaly and their twin brothers who were not diagnosed with it, showed that the former had a larger maximum anteroposterior width, depth and diameter of the sella turcica, a significantly smaller ∠ANB and ∠GoGn to SN, and a significantly larger Gonial angle in the skeletal system. These differences arose from mandibular prominence due to bony proliferation at the condyles.[20] Down syndrome is also characterized

by the skeletal pattern of Class III malocclusion.[21] And patients with this syndrome have been found to have a larger depth and diameter of the sella turcica than those of non-syndromic patients.[22] Additionally, regarding skeletal type, characteristics of skeletal Class III malocclusion have been observed with an increased ratio of the lower face to the front face height, Gonial angle, and ∠GoGn to SN.[23] The characteristics of these syndromes also suggests that the depth of the sella turcica is related to the morphology of the mandible.

Morphology of the sella turcica

In this study, we also measured I to determine the morphology of the sella turcica. The incidence of bridging of the sella turcica in patients without craniofacial abnormalities is 7.3-9.9%.[13, 24-26] Direct observation of autopsied tissues has revealed an incidence of 1.75-7%.[27-29] A strong correlation between the craniofacial skeletal pattern and bridging of the sella turcica has been observed previously, and the proportion of bridging has been reported to be higher in skeletal Class III malocclusion than in skeletal Class I or II malocclusion.[6, 15, 17, 30] In the present study as well, the skeletal 3 group showed a significantly smaller value for I than the skeletal 1 group, indicating a strong calcification tendency. Further, a positive correlation was observed with the ∠Occl to SN value, suggesting that the occlusal plane tended to be steeper as the calcification tendency of the sella turcica increased.

Becktoer *et al.*[24] used lateral cephalometric radiographs of 177 people who underwent surgical corrective treatment in order to investigate morphological abnormalities, such as flatness or depression of the sella turcica floor, angle of the sella turcica tubercle contour, and shape of the anterior and posterior clinoid processes. Their results showed that 8.6% of patients exhibited bridging of the sella turcica. Jones *et al.*.[13] investigated 150 patients who underwent surgical corrective treatment and reported bridging of the sella turcica in 16.7% of them. Kader *et al.*[30] reported that 10.71% of patients with surgical corrective treatment and 7.14% of skeletal Class III malocclusion patients with orthodontic treatment had bridging of the sella turcica, with a greater frequency of bridging among patients who underwent surgical correction. In addition, Axelsson *et al.*[31] comprehensively investigated the morphology of the sella turcica of 72 Norwegian subjects aged 6-21 years and classified it into six main sella types: normal sella turcica, oblique anterior wall, double-contoured sella, sella turcica bridge, notching of the posterior wall of the sella, and pyramidal shape of the dorsum sellae. However, Alkofide *et al.*[3] reported that these morphological types were observed in both healthy subjects, as well as those with pathologies. Nevertheless, these morphological types were based on qualitative assessments, which made it difficult to classify some patients into specific categories.[32] Differences in data from anatomical studies and lateral cephalometric radiographs have been attributed to the overlapping of the sella turcica and the anterior clinoid process in radiographs, and it is thought that only three-dimensional imaging, such as computed tomography and digital volume tomography, can provide more accurate information about the sella turcica. However, routine use of these imaging techniques in orthodontic patients is not recommended from an ethical perspective owing to the high radiation exposure associated with tomography.

CONCLUSIONS

Among the parameters indicating the size of the sella turcica, a correlation was found between De and ∠GoGn to SN in the skeletal Class 3 group. Controlling vertical growth from an early age by implanting a temporary anchorage devices (TAD) and preventing a future increase in the ∠GoGn to SN value might be effective. The purpose of orthodontic treatment during growth would become more specific and clear if the facial height after growth could be predicted based on sella turcica morphology, potentially reducing the mental, physical, and economic burden on the patient. The findings of this study indicate the possibility of predicting maxillofacial growth based on the morphology of the sella turcica in Japanese.

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