Some Asymmetries in the Weight, Area and Linear Dimensions of the Mandible of Rats

by

Sumiko KIMURA and Tadashi KITAGAWA**

Introduction

The existence of the right-left asymmetry in the human mandible has been observed by Hrdlička (1940), Keen (1945), Rogers (1958), Lundström (1961) and Dvořák (1969). On the other hand, such observations as in human have not been reported except for a few experimental studies of mandibular asymmetry in the animals[8,17,21]. For that reason it seems not necessarily clear that on what dimension and to what extent mandibular asymmetry exists in lower mammals even if they have asymmetric mandibles.

Therefore, in the present study, the authors investigated that whether mandibular asymmetry exists or not in the animals who have quite different masticatory apparatus and function from in human.

Material and method

The mandibles of 54 laboratory rats consisting of male and female of the same number (body weight 200 to 260 gr.) were used. These specimens studied were the same as those used in the previous paper[12].

Measurements were made in sixteen dimensions on both sides and they are listed in Table 1. On each measurement, first of all, weight of each bone was measured to the nearest mg by a single-pan balance (Shimadzu Mfg. Co.) sensitive to 0.01 mg.

Secondly for measuring the dimensions of a area, a length and a height all the mandibles were radiographed from the buccal side by a conventional technique [Sakura graphic arts film, F.F.D. 45 cm, 120 sec., 5 mA, 18 or 37_kV_P, the former is for mandible frame and the latter is for alveolar part], and also they were taken pictures for measuring the dimensions of the thickness of the body and the length of the masseter muscle. Soft X-ray photograph was enlarged 10 times in size, the thickness of the body 4.6 and the length of the masseter muscle (the masseteric ridge to the posterior end of the angular process) 3.8 times respectively. Therefore all the values in each dimension shown in the results are enlarged ones.

On each measurement, all the dimensions were determined by projection methods as illustrated in Fig. 1.

In determining the area of incisor, molar, ramus and whole of them, these part of mandible were traced out on the enlarged picture and the weight of them

*木村澄子, 北川正: *Dept. of Anatomy, Nihon University School of Dentistry, Tokyo. This study was presented at the Eighty-four Annual Meeting of Japanese Association of Anatomists in 1979.*

were measured to a nearest mg after cutting out, then, the weight was converted to area dimension using the calibrated area of paper.

All the dimensions of length were measured as a distance along the basis line (tangential line of the inferior margin of the mandible, horizontal arrow in Fig. 1A) and those of height were measured as vertical distance (Fig. 1A).

As shown in Fig. 1B the buccolingual thickness of the body includes not only alveolar thickness but also masseteric ridge.

All the linear dimensions were measured with slide vernier caliper to nearest 1/20 mm.

Result

In the mandibles of both males and females, the mean values of each of 16 dimensions used in this study are larger on the dominant side (heavier side between right and left). The mean values and S.D. of the dominant and non-dominant sides are shown in Table 1 (males) and Table 2 (females). The differences between the mean values on the dominant side and those on the non-dominant side are statistically significant in all the 16 dimensions studied ($p < 0.01$ or $p < 0.001$, paired t test).

On the right and left sides the mean values and S.D. of measurements in each 16 dimensions are listed in Table 3 (males) and Table 4 (females). The differences between the means on the right side and those on the left side were very small, and in only a few dimensions significant differences were observed. Among them, a

Table 1. Means and standard deviations of each measurement on the dominant and non-dominant sides in the mandible of male rats.

n=27	Dominant side		Non-dominant side		T test
	Mean	S.D.	Mean	S.D.	
Weight (mg.)	162.92	7.37	160.43	7.80	***
Area (sq. mm.)					
Incisor	2465.18	102.55	2418.85	98.55	***
Molar	5481.45	205.10	5298.04	212.99	***
Ramus	7282.34	341.23	7113.49	335.90	***
Total	15144.88	477.83	14904.97	483.54	***
Length (mm.)					
Angular proc.	245.74	3.68	244.23	3.78	***
Condylod proc.	243.99	3.83	242.85	3.70	***
Coronoid proc.	193.58	4.29	191.80	4.32	***
Incisor	183.86	2.93	182.62	2.97	***
Molar	85.74	1.55	84.97	1.69	***
Masseter	64.34	1.32	63.90	1.32	***
Height (mm.)					
Angular proc.	28.32	2.16	26.74	1.88	***
Condylod proc.	99.62	2.77	98.05	2.81	***
Coronoid proc.	114.58	2.89	112.23	2.92	***
Body	64.51	1.61	62.74	1.37	***
Thickness (mm.)					
Body	16.56	0.36	16.29	0.39	**

The symbol *** denotes significance at 0.1% level and ** at 1% level respectively.

Fig. 1. A line drawing of the rat mandible. A; a buccal view on the left side. Horizontal arrow indicates a tangential line of the inferior margin of the mandible. The colored part shows the area of incisor, molar and ramus respectively. B; a caudal view of the alveolar part showing the buccolingual thickness of the body.

Table 2. Means and standard deviations of each measurement on the dominant and non-dominant sides in the mandible of female rats.

n=27	Dominant side		Non-dominant side		T test
	Mean	S.D.	Mean	S.D.	
Weight (mg.)	191.28	14.52	188.28	14.24	***
Area (sq. mm.)					
Incisor	2605.40	104.93	2539.48	116.34	***
Molar	5661.91	206.72	5536.82	195.02	***
Ramus	7826.77	466.80	7701.86	470.41	***
Total	16028.25	652.87	15843.89	644.79	***
Length (mm.)					
Angular proc.	253.54	4.79	251.79	4.52	***
Condylod proc.	247.64	4.60	246.24	4.54	***
Coronoid proc.	198.01	4.82	196.84	4.83	***
Incisor	188.97	3.07	187.31	3.12	***
Molar	86.29	1.63	85.41	1.75	***
Masseter	66.64	1.40	66.06	1.44	***
Height (mm.)					
Angular proc.	29.61	1.83	28.31	1.96	***
Condylod proc.	104.07	2.79	102.61	2.82	***
Coronoid proc.	118.71	3.54	117.20	3.82	***
Body	66.41	1.82	65.33	1.84	***
Thickness (mm.)					
Body	16.54	0.43	16.33	0.41	**

The symbol *** denotes significance at 0.1% level and ** at 1% level respectively.

Table 3. Means and standard deviations of each measurement on the right and left sides in the mandible of male rats.

n=27	Right		Left		T test
	Mean	S.D.	Mean	S.D.	
Weight (mg.)	161.89	7.49	161.47	7.89	—
Area (sq. mm.)					
Incisor	2435.69	100.27	2448.34	105.88	—
Molar	5390.89	217.18	5379.09	236.40	—
Ramus	7156.01	328.01	7239.82	364.44	*
Total	14982.59	480.88	15067.26	507.04	—
Length (mm.)					
Angular proc.	244.73	3.75	245.25	3.85	—
Condylod proc.	243.01	3.69	243.83	3.89	*
Coronoid proc.	192.28	4.41	193.10	4.36	—
Incisor	183.36	3.05	183.12	2.99	—
Molar	85.35	1.71	85.35	1.63	—
Masseter	64.01	1.35	64.22	1.32	*
Height (mm.)					
Angular proc.	27.15	1.92	27.91	2.35	*
Condylod proc.	99.01	2.96	98.66	2.83	—
Coronoid proc.	113.29	3.01	113.51	3.26	—
Body	63.44	1.64	63.82	1.82	—
Thickness (mm.)					
Body	16.37	0.44	16.48	0.35	—

The symbol * denotes significance at 5% level.

Table 4. Means and standard deviations of each measurement on the right and left sides in the mandible of female rats.

n=27	Right		Left		T test
	Mean	S.D.	Mean	S.D.	
Weight (mg.)	190.33	15.21	189.18	13.64	—
Area (sq. mm.)					
Incisor	2568.59	128.04	2576.29	101.79	—
Molar	5596.56	229.17	5602.07	190.64	—
Ramus	7759.04	472.32	7769.60	473.46	—
Total	15924.18	677.42	15947.96	632.80	—
Length (mm.)					
Angular proc.	252.44	4.89	252.88	4.59	—
Condylod proc.	246.68	4.66	247.20	4.58	—
Coronoid proc.	197.29	5.00	197.56	4.71	—
Incisor	188.09	3.18	188.19	3.23	—
Molar	85.83	1.69	85.87	1.80	—
Masseter	66.21	1.53	66.49	1.35	—
Height (mm.)					
Angular proc.	28.48	2.13	29.44	1.75	***
Condylod proc.	103.59	2.90	103.09	2.88	—
Coronoid proc.	117.98	3.94	117.93	3.56	—
Body	65.75	2.08	65.99	1.73	—
Thickness (mm.)					
Body	16.39	0.45	16.48	0.42	—

The symbol *** denotes significance at 0.1% level.

Table 5. The incidences of right and left side dominance of the mandible.

n=54	Right		Left		Equal	
	%	n	%	n	%	n
Weight	40.7	(22)	24.1	(13)	35.2	(19)
Area						
Incisor	35.2	(19)	38.9	(21)	25.9	(14)
Molar	38.9	(21)	40.7	(22)	20.4	(11)
Ramus	33.3	(18)	46.3	(25)	20.4	(11)
Total	20.4	(11)	37.0	(20)	42.6	(23)
Length						
Angular proc.	7.4	(4)	14.8	(8)	77.8	(42)
Condylod proc.	0	(0)	9.3	(5)	90.7	(49)
Coronoid proc.	11.1	(6)	16.7	(9)	72.2	(39)
Incisor	16.7	(9)	11.1	(6)	72.2	(39)
Molar	20.4	(11)	22.2	(12)	57.4	(31)
Masseter	5.6	(3)	24.1	(13)	70.4	(38)
Height						
Angular proc.	18.5	(10)	64.8	(35)**	16.7	(9)
Condylod proc.	40.7	(22)	22.2	(12)	37.0	(20)
Coronoid proc.	27.8	(15)	31.5	(17)	40.7	(22)
Body	31.5	(17)	42.6	(23)	25.9	(14)
Thickness						
Body	13.0	(7)	46.3	(25)	40.7	(22)

The symbol ** denotes significant difference at 1% level.

height of the angular process is significantly large on the left side in both male ($p < 0.05$) and female ($p < 0.001$). And a significant left side dominancies were observed in the area of the ramus, the length of the condyloid process and the masseter muscle in only the case of male ($p < 0.05$).

In Table 5 are shown the frequencies of occurrence of right- and left-side dominance in each dimension of the mandible. We adopted an equal category in which the difference between the value of right and left side was smaller than 1% of the value of the greater side. Significant difference was observed in only one dimension, i.e., the height of the angular process was greater on the left side in 35 out of 54 instances (materials) and exhibited a significant left-side dominance ($p < 0.01$, χ^2 test).

Discussion

The present investigation revealed that there was a significant difference between the one side of rat mandible (dominant side) and the other (non-dominant side) in all the sixteen dimensions tested (Table 1 and Table 2). This implies that a slight side difference of the mandible exists not only in human[2,9,10,14,18] but also in rat, though they have quite different mandibles in both form and function each other. However, on the mean values of right and left side of rat mandibles, significant side difference could be observed in only a few dimensions, that is, the height of angular process (in both male and female), the length of the masseter and the condyloid process and the area of ramus (only in male) showed significant left side dominance. Among them, the height of the angular process showed most notable right-left asymmetry and one-side dominance. And also such phenomenon has been already observed by authors in corresponding part of rabbit mandible[13]. And this result in animals is similar to that in human mandible[18].

The lateral surface of the angular process gives attachment to the masseter muscle and the internal surface to the internal pterygoid muscle and the reflexor part of the masseter. Therefore, it was suggested that the phenomenon of asymmetry found in the angular process was caused by the side difference of the roughening or hyperostosis of bony area where these masticatory muscles attach to.

The following reports may support the existence of a little asymmetry of mandible. In mammals such as rodents, the transverse width of the upper and lower jaws is the same (isognath) or the lower is wider[7] and two halves of mandible are loosely connected by movable mandibular syndesmosis[24]. As to masticatory movement of rat it has been observed by means of X-ray cinematography that rat often chews on one side of the jaw and switches to the other after a short period of a number of chewing cycles. In addition bilateral chewing appears to occur in association with mastication of some kinds of foods[5]. Moreover, it is inferred that not only crushing movement but also lateral movements with rotary component between the upper and lower jaws might exist in mastication of the rodents according to the results of the investigation of the form of the condyle and glenoid fossa and wear facets on the teeth[16,20].

These movements, such as bilateral, unilateral, propalinal and a slight lateral

ones in mastication of rats might cause some asymmetries and many symmetries in the form of rat mandible.

Summary

Mandibles of 54 rats consisting of males and females of the same number (weighing around 200 to 260 gr.) were measured in 16 dimensions (weight, area and linear dimensions).

In area and linear dimensions we used projective measurements with a certain constant enlargement of soft X-ray photographs and pictures of both right and left mandibles which were taken under the same conditions.

Therefore we compared the mandible on the right and left sides in each measurement, for the presence or absence of asymmetry and one-sided dominance.

As a result, mainly the following two findings were obtained.

1) The mean values of the dominant and non-dominant sides in each dimension showed significant difference ($p < 0.01$ or < 0.001).

2) Significant difference between the mean values of the right and left sides was not necessarily found in all dimensions but found in only a few dimensions, i.e., the height of angular process was significantly greater on the left side in both male ($p < 0.05$) and female ($p < 0.001$), and the area of the ramus and the length of the condyloid process and the length of the masseter muscle (the masseteric ridge to the posterior end of the angular process) showed significant difference ($p < 0.05$) in only male, they were all greater on the left side.

From these observation it was suggested that the phenomenon of asymmetry and one-sided dominance found in the height of the angular process and in some other dimensions was caused by the difference of the roughening or hyperostosis of bony area where masticatory muscles were given attachment.

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