The Volume of the Sella Turcica in Adults

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正常人のトルコ鞍容積について

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関　　一　　郎

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トルコ鞍の大きさに関するX線学的計測研究は多数行われているがその容積に関する研究は極めて少く，本邦においては未だ報告をみていない．著者は，従来の諸計測法を再検討し，臨床医が容易に使用しうる実験式$V=^2/_3$（L×D×W）を考え，本式により正常成人（20～49才）（男 300例，女 200例） 500例を計測した．計測結果は

1. 男，761.8±5.4cumm.
2. 女，749.0±8.0cumm.
3. 男女平均，756.7±5.1cumm.
4. 臨床的正常範囲，400～1100cumm.
5. 特に有意の性差は認められない．
6. トルコ鞍の面積と巾とには，逆の相関がある．更に，トルコ鞍の容積研究の意義を簡単に論じ，又，屍体頭部12例のX線学的トルコ鞍容積と解剖学的下垂体容積の相関を研究した．

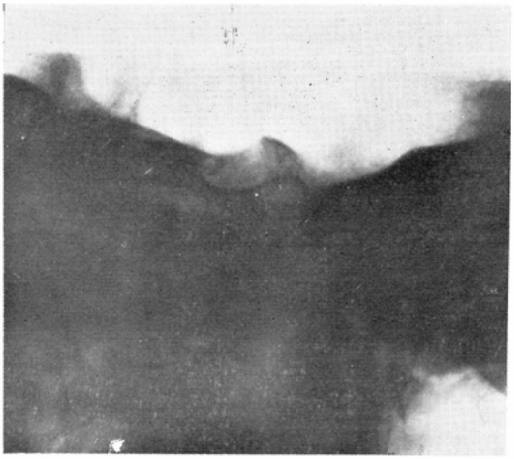
On the size of the sella turcica, numerous radiographical measurements have been undertaken by various workers, but with a few exceptions, They have been limited to linear dimensions or to the area of the lateral profile on the lateral view. In describing the size of the sella, information of only the length and depth or of the area could not give a reliable estimation of its size (10, 23, 26). There were, however, very few literature on the roentgen-volumetric studies on the sella turcica, until Di Chiro and Nelson (10) in 1962 reported a comprehensive series of cases in which normal values of the sellar volume in adults were given. As up to date there have been no literature reported on the radiographical volume of the sella turcica in Japan.

The auther reviewed the literature to examine the reported methods of sellar measurements and made an experimental formula which general clinicians, in their busy practice, might be easily applicable to estimate the sellar size without any special equipments and trained technics. With this formula, 500 sellar volumes were measured and calculated.

This paper is presented as the first comprehensive series of sellar volume measured from the skull radiographs in Japan.

Method of Measurement

The length and depth of the sella were determined from the lateral skull view (Fig. 1). In this series,



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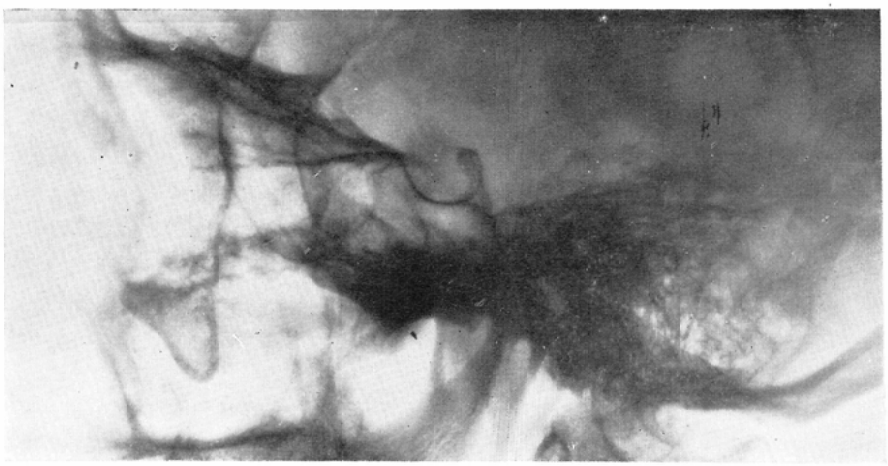


1 C

Fig. 1. Lateral Skull Views

(1A) Lateral radiograph of the cadaver with removed brain shows position of diaphragma sellae clearly.

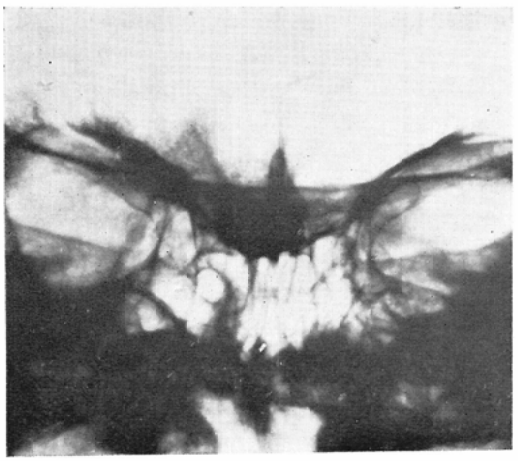
(1B) Sella after removal of pituitary gland and filling with opaque media. This shows position of diaphragma and discrepancy between sella and pituitary gland.

(1C) Lateral radiograph of normal adult

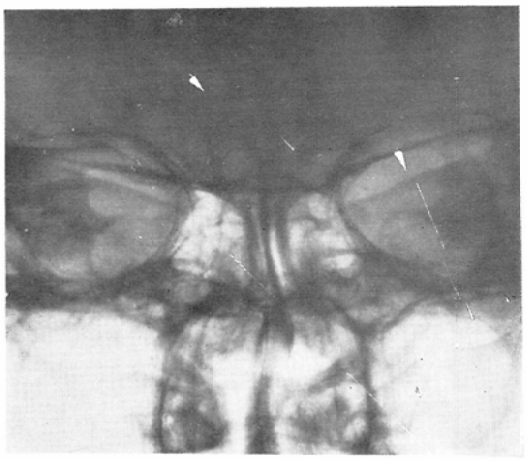
the diaphragma sellae was chosen as a standard line on the lateral view. The diaphragma usually originates from just below the tip of the tuberculum sellae to slightly below the top of the dorsum sellae and to the most anterior part of the posterior clinoid process, but the author has chosen for the sake of clarity to draw a line from the tip of the tuberculum to the top of the dorsum sellae.

The length of the sella was represented through the greatest anteroposterior diameter parallel to it. The depth was taken to be the greatest perpendicular distance from this line to the sellar floor.

The width was obtained by measuring the transverse dimension of the sellar floor on the straight postero-anterior view (Fig. 2) as well as on the postero-anterior view with a 15 deg. tilt to the feet (9, 10, 19, 26), though it was also able to be obtained from the dorsum sellae on the Chamberlain-Towne's



2 A



2 B

Fig. 2 Postero-anterior Views

(2A) Cadaver, filled with opaque media, shows the relationship between pituitary gland and sellar floor (width). Lateral border of pituitary gland corresponds with edge of floor.

(2B) Straight postero-anterior view of normal adult.

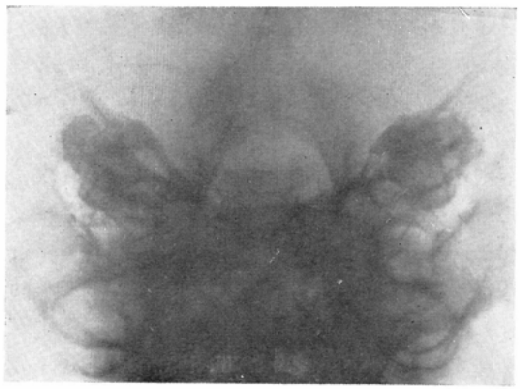


Fig. 3 Chamberlein-Towne's View

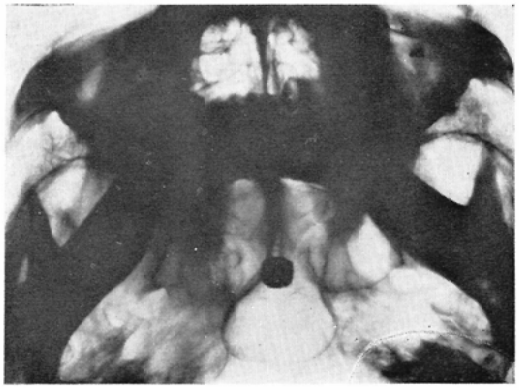


Fig. 4 Axial View

D.S. Diaphragma sellae L Length D Depth W Width

Fig. 5 Measuring Points

view (Fig. 3) or from the floor on the axial view (Fig. 4). The floor of the sella was recognized as a flat, slightly concave, or rarely convex, plateau on the postero-anterior view, so the width was given by the distance between the two highest points located on the edges of the plateau.

The area was measured from the area enclosed by the sellar profile below the diaphragma (Fig. 1).

The measuring points used in this series are shown in Fig. 5.

Experimental Formula

The author tried to calculate the volume with three linear components; the length, the depth and the width. If the shape of the sella turcica is regarded as the cylindrical, and if the lateral profile as a part of the ellipsoid (Fig. 6), the sellar volume is expressed as follows:

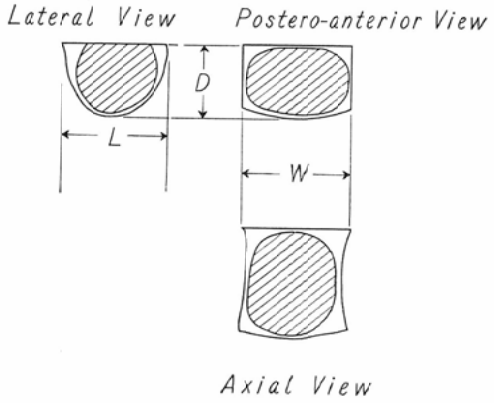
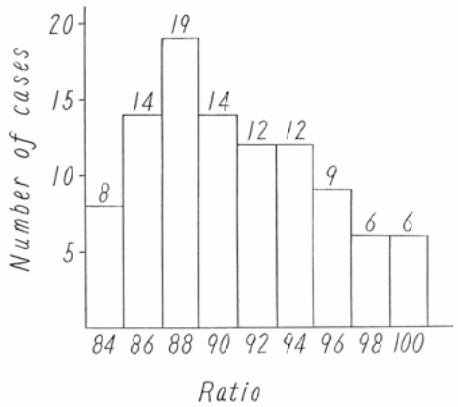


Fig. 6 Schema of Sella Turcica and Pituitary Gland (Portion of Oblique Lines)

$$\text{Volume} = \text{Area} \times W = \pi/4\ (L \times D) \times W \times C$$

Where L is the length in mm, D the depth, W the width, and C correction factors. Correction factors are consisted of two factors; the one is correction for $\pi/4$, the other is magnification correction.

In this procedure, the "corner" of the sella is necessarily excluded from the "true" area, and the calculated area may be inaccurate compared with that of a squared millimeter paper method (17) or of a planimeter method (21). In order to supplement this deficiency, area correction coefficient was used. Measuring 100 lateral radiographs, the area was calculated and compared with that of the squared millimeter paper method. The ratio of the calculated area to that of the squared millimeter method was ranged from 0.84 to 1.02, an average of 0.919 (Graph 1). In other words, the calculated area was expressed an average of 92 per cent of the "true" area. When the formula, therefore, was modified by the correction



Graph 1 Frequency distrtibution of a ratio of the area calulated to that of the squared millimeter method

factor 1.09, 95 per cent or more of all cases were within ± 10 per cent of the deviation to the "true" area and the average error became 4.2 per cent.

Next, the magnification correction required to give the "true" sella volume was calculated by comparison of similar triangles, knowing the focus-film and object-film distances as follows;

$$\text{Magnification correction factor} = \left(1 - \frac{Br/2 + 0.7}{100}\right)^2 \left(1 - \frac{NT + 0.7}{100}\right)$$

$$= 1 - \frac{Br + NT + 2.1}{100}$$

where Br is the maximum breadh of the skull on the straight posteroanterior view, and NT is the distance from the tuberculum sellae to a joint point where on the lateral view the nasion-tuberculum line joins a line, which is tangent to the skull and perpendicular to the nasion-tuberculum line. The grid-film distance was 0.7 cm. Resulting from measurements of each of 100 cases, of both sexes, the magnification correction factor was 0.75 in male, and 0.76 in female.

Therefore, the volume is able to be estimated with this formula by measuring three linear components.

$$\text{Volume} = {}^2/_3 \ (L \times D \times W)$$

Material and Method

The present study, to establish the normal range of the volume of the sella turcica in adults,was made on materials from Jikei University Hospital. The sella turcica of 500 "normal" adults were examined. Any case bearing a history of suspected intracranial lesion and other lesions which might cause sellar changes, and those unsuitable for measurements for the technical reasons were excluded from this series.

This group consisted of 300 males and 200 females, and their ages ranged from 20 to 49 years of age.

All cases were radiographed with a focus-film distance of 100 cm, and Lysholm grid was used.

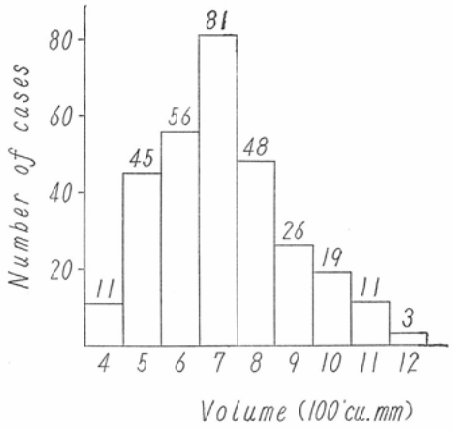
For the purpose of record and accuracy, every roentgenogram was copied on paper. Then, copied paper was measured five times and the average of these was taken as the measured value.

Results

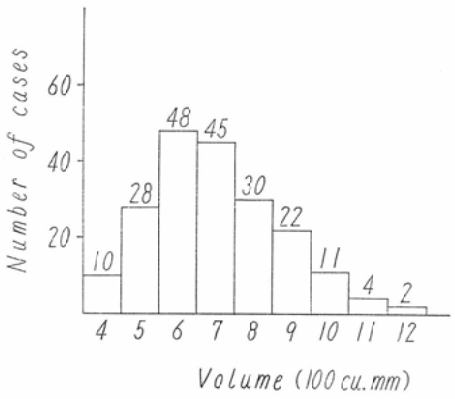
The results are shown in Table 1, and also diagrammatically in Graph 2, 3, 4.

Table 1 The volume of the sella turcica in 500 "normal" adults cu mm

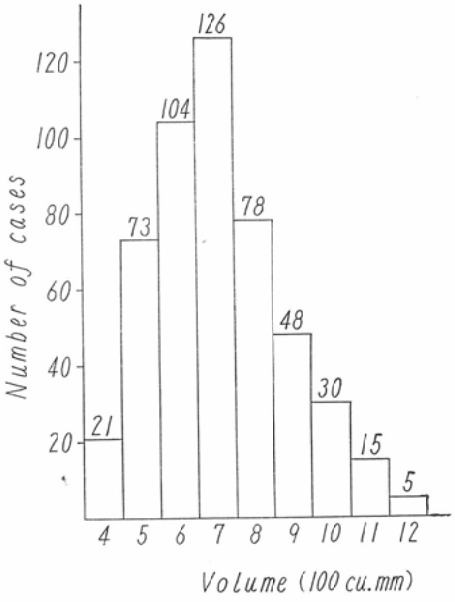
	Male	Female	Total
Volume cu. mm	300 cases	200 cases	500 cases
400～ 499	11	10	21
500～ 599	45	28	73
600～ 699	56	48	104
700～ 799	81	45	126
800～ 899	48	30	78
900～ 999	26	22	48
1000～1099	19	11	30
1100～1199	11	4	15
1200～1299	3	2	5
M	761.8±5.4	749.0±8.0	756.7±5.1
α	171.2	167.9	170.0
M±α	585.2～938.4	573.1～924.9	581.6～931.8
M±2 α	414.0～1109.6	405.2～1092.8	411.6～1101.8



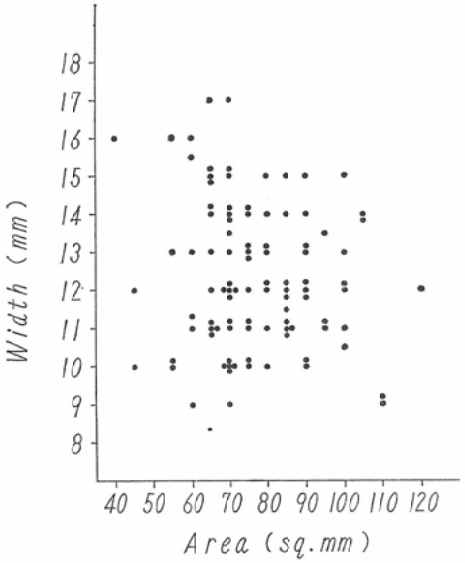
Graph 2 Frequency distribution of the volume of the sella in 300 "normal" adult males.



Graph 3 Frebuency distribution of the volume of the sella in 200 "normal" adult females.



Graph 4 Frequency distribution of the volume of the sella in 500 "normal" adults sexes combined.



Graph 5 Relationship between Width and Area in 100 male adults.

M is the mean volume, and α is the standard deviation. The values of M $\pm$ 2 α can be regarded as normal limits, and M $\pm$ α as middle sizes. The values between M $\pm$ α and M $\pm$ 2α is the borderline zones. The values outside of M $\pm$ 2 α are extreme random cases.

The mean value for adult males was 761.8 and for females 749.0 cu. mm, and there was no significant differentiation between the volumes of the both sexes. The values of 400 to 1100 cu. mm may be regarded for practical purposes as the limits of the normal sellar volume in adults.

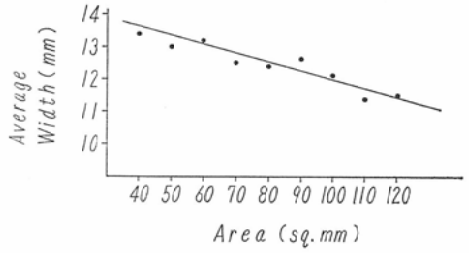
Table 2 Relationship between Area and Width in 500 "normal" adults

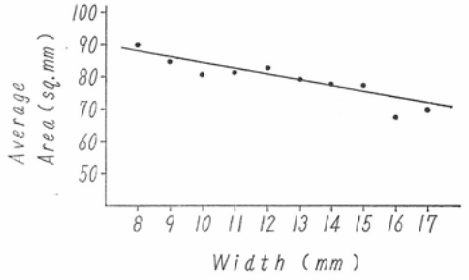
Area (sq. mm)	Width (mm) 8	9	10	11	12	13	14	15	16	17	Average	No.
40～ 49			1		2	2	1		1		13.4	7
50～ 59		1	7	3	3	4	4	1	5		13.0	28
60～ 69	1	5	8	21	5	17	18	13	6	1	13.2	95
70～ 79	1	8	20	14	32	24	14	6	1	1	12.5	121
80～ 89	3	12	15	20	25	16	18	7	2		12.4	118
90～ 99	2	5	7	17	16	17	11	4	2		12.6	81
100～ 109	3	3	6	4	6	5	4	3			12.1	34
110～ 119		3	3		3	1	1				11.4	11
120～ 129			1	3	1						11.5	5
Average	90.0	84.7	80.7	81.6	83.0	79.4	78.0	77.7	67.4	70.0	12.5／79.3	56
No.	10	37	68	82	93	86	71	34	17	2	50	500

Table 3 Relationship between Area and Width in 500 "normal" adults

Area (sq. mm)	No.	Width (mm) narrow 8—10	middle 11—14	wide 15—17
Small Area 40— 69	130	23 (17.7)	80 (61.5)	27 (20.8)
Middle Area 70— 99	320	73 (22.8)	224 (70.0)	23 (7.2)
Large Arer 100— 129	50	19 (38.0)	28 (56.0)	3 (6.0)

Figures in ( ) $= \frac{\text{No. of Width}}{\text{No. of Area}} \times 100$





Graph 6 Relationship between Area and Width in 500 normal adults

An interesting observation is the relationship between the lateral area and the width of the sella (Table 2, 3, and Graph 5, 6). There is no constant relation between them. The author considers, however, there is a tendency of somewhat inverse correlation between them. This observation indicates that sellar volume is a more accurate measure of sellar size than the others.

Discussion

A review of the pertinent literature reveals that the measurement of the sellar size was applied for clinical diagnostic examinations (2, 7, 9, 10, 13, 14, 17, 18, 19, 21, 26), as well as for developmental and constitutional investigations (1, 4, 5, 15, 18, 20, 26, 30, 32), and it is more of academic than clinical significance. This volumetric appraisal of the size is also aimed mainly to facilitate the description and the morphological differentiation of normal and abnormal sizes of the sella turcica.

It is evident that, for the academic investigations, the establishment of the normal value of the sellar volume becomes necessary and important.

In sellar measurements, the selection of bony landmarks is obviously of great importance and the largest confusion in measurements is, perhaps, arising from the choice of numerous end-points for the sellar dimensions.

The most important point in the volumetric study is the determination of the upper and lateral border of the sella turcica (9, 10). In this series, the diaphragma sellae (Fig. 1) has been chosen as a standard line and upper limit, and the edge of the sellar floor (Fig. 2) as the lateral border, resulting from several investigations used postmortem cadavers.

Details of this investigation are to be published later. The advantages of choosing the diaphragma as a standard line on the lateral view are as follows;

1. It is most proper and suitable to select the upper limit of the lateral radiograph to determine the sellar volume.

2. By the measurement of the length (parallel) and the depth (perpendicular), it is more objective and reproducible than the others.

The next problem is the determination of the lateral border of the sella turcica, in other words, the width of the sella. Many workers (3, 13, 14, 17, 25, 30) took the narrowest transverse diameter, "waist" of the dorsum sellae on the Chamberlain-Towne's view as the width of the sella (Fig. 3). This is, however, not really suitable for this purpose because of having several disadvantages as follows;

1. The X-ray used is oblique and the resulting picture distorted (9, 10, 23).

2. The shape and outline of the dorsum sellae are physically irregular (16, 28, 31).

3. The dorsum varies greatly in its coronal diameter (9).

4. It is not easy to take a proper radiograph (12).

5. Thr dorsum will not give information regarding the width of the sella in pathologic cases (9, 10, 31).

The length and the width is, also, able to be measured from the axial view (10, 16) (Fig. 4), but with a certain degree of difficulty.

The floor of the sella turcica is clearly seen and recognized on the postero-anterior view (9, 10, 19, 26, 33) of the skull in over 90 percent of the cases (10). The author agrees with this opinion and takes the floor for the width of the sella turcica.

Table 4 Radiographical calculation of the volume of the sella turcica in adults.

Author	year	No.	Method	M cu. mm	Range cu. mm	F.F.D
Meldolesi and Pansadoro [25]	1937	34	Area × dorsum	985	561—1410	?
Di Chiro and Nelson [10]	1962	173	$^1/_2$ (L×H×W)	594	233—1092	36 in
Oon [26]	1963	250	Area × floor	1291	700—1960	28 in
Seki	1964	500	$^2/_3$ (L×D×W)	757	411—1102	100 cm

Meldolesi and Pansadoro (25) were perhaps the earliest workers to calculate the volume of the sella from radiographs (Table 4). Since then, several authors tried to estimate the radiographical volume of the sella, and, in 1960, Di Chiro (9) proposed a method for estimation of the volume of the sella turcica based upon the formula for an ellipsoid, $V=^1/_2$ (L×H×W). Where L is the length, H the height, and W the width. While this method has the advantage of simplicity in routine clinical radiology, it is, in my opinion, inadequate as a precise measure of the sellar volume, because the shape of the sella is rather cylindrical than ellipsoid as shown in Fig. 5.

For clinical purpose, especially in borderline cases, the measurement is more reliable than the subjective estimation by mere inspection. And, it is also very valuable and illustrative, when one wants to compare the same sella in different periods by observing its growth, progress of pituitary pathology, or in describing the degree of deviation from the normal zone (2).

Measurements of the area are more efficient than those of mere diameters (5, 23), and measurements of the volume are, in my opinion, more accurate and reliable than those of the area. But, the diagnostic practical significance of sellar size and its measuremtnt should not be over- and/or underestimated (18). As for the each medical sign, the sellar volume also had various limitations in clinical usage. There is a certain degree of parallelism between the sella turcica and the pituitary gland (5, 6, 10), and the estimation of the sellar volume may be assumed to reflect the volume and perhaps the activity of the pituitary gland (32). However, the parallelism is not constant due to following reasons.

1. The intrasellar content is not only the pituitary gland, but also its covering, connective tissue, perihypohyseal venous plexus and subarachnoidal cysts (11, 27, 29).
2. A part of the pituitary gland is extrasellar (10).
3. The sella may enlarge without enlargement of the pituilary gland.
4. The pituitary gland, on the contrary, may enlarge without causing enlargement of the sella (33).
5. In addition to these, the volume of the pituitary gland is not necessarily proportionate to its activity.

It has been estimated (8, 22) that the pituitary gland occupies 50–85 per cent of the cavume sellae. The author's data reveals that the pituitary gland is found to fill an average of 73.2 per cent of calculated sellar volume with a range from 41.6 to 93.3 per cent (Table 5, 6 and Graph 7).

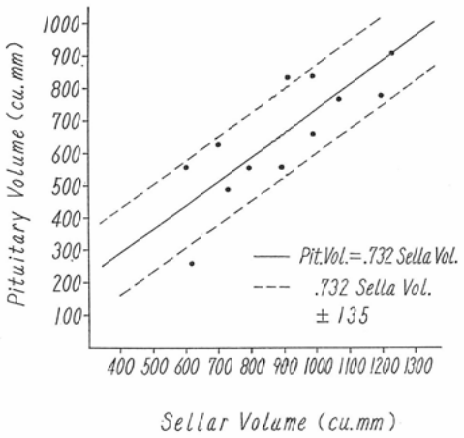
It is, therefore, worth emphasizing that marked disparity between the pituitary and the sella are the exception rather than the rule (6, 10).

Summery

1. This paper is presented as the first comprehnsive series of the volume of the sella turcica made

Table 5 Relationship between pituitary volume and radiographic sellar volume in cadavers (cu. mm)

Case	Sex	Sella	Pituitary	Pituitary/Sella×100
1	♀	947	840	88.7
2	♂	616	256	41.6
3	♀	792	557	70.3
4	♂	988	663	67.1
5	♀	988	840	85.0
6	♀	891	567	63.6
7	♂	1197	780	65.2
8	♂	1232	910	73.9
9	♀	698	630	90.3
10	♂	600	560	93.3
11	♂	1073	770	71.8
12	♀	726	490	67.5
		Sella	Pituitary	Pituitary/Sella×100
♂		951.0 (600—1232)	656.5 (256— 910)	68.8 (41.6～93.3)
♀		840.3 (697— 988)	654.0 (490— 840)	77.6 (63.6～90.3)
Total		895.6 (600—1232)	655.2 (256— 910)	73.2 (41.6～93.3)



from radiographs in Japan.

2. An experimental formula; V=2/3 (L×D×W) where L is the length, D the depth, and W the width, was proposed, and total of 500 "normal" adults (300 males, 200 females), ages ranging from 20 to 49 years, were examined and calcualted by using my own proposed formula.

3. Results were as follows;

(1) Male: M is 761.8±5.4 cu. mm, α 171.2 cu. mm.

(2) Female: M is 749.0±8.0 cu. mm, α 167.9 cu. mm.

(3) Sexes combined: M is 756.7±5.1 cu. mm, α 170.0 cu mm.

(4) The values of 400 to 1100 cu. mm may be regarded for the practical purpose as the limits

of the normal sellar volume in adults.

(5) There were no significant differences of the volume between both sexes.

(6) There was no constant relation, but a tendency of inverse correlation between the area and the width of the sella turcica.

4. Methods of the sellar measurement were reviewed and the importance of the choice of landmarks was emphasized.

5. The significance of the sellar volumetric study was briefly discussed.

6. Relationship between the volume of the sella and that of the pituitary gland was also examined in 12 cases of the cadavers.

7. The author is of the opinion that the sellar volume is a more accurate measure than two linear components or the lateral area.

Acknowledgement

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