International Journal of Healthcare Sciences ISSN 2348-5728 (Online)
Vol. 6, Issue 1, pp: (194-198), Month: April - September 2018, Available at: www.researchpublish.com

Dimensional Changes of Diaphragma Sellae Opening In Transsphenoidal Pituitary Adenoma Surgery

Ahmed Abdelmaksoud* (MD, PhD)[1], Peng Fu* (MD, PhD)[1], Osamah Alwalid (MBBS, M Med)[2], Ahmed Elazab (MD, PhD)[3,4], Ahmed Zalloom (MBBS)[1], Wei Xiang (MD, PhD), Xiaobing Jiang (MD, PhD)[1], Hongyang Zhao [1] (MD, PhD)

[1]Department of Neurosurgery, Wuhan Union Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, China.
[2]Department of Radiology, Wuhan Union Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, China.
[3]School of Biomedical Engineering, Health Science Center, Shenzhen University, Shenzhen, China
[4]Computer Science Department, Misr Higher Institute for Commerce and Computers, Mansoura, Egypt.

Ahmed Abdelmaksoud* and Peng Fu* contributed equally to this work.

Correspondance to: Prof. Hongyang Zhao (PhD, MD), Professor and Chairman of Neurosurgery department, Wuhan Union Hospital, Tongji Medical College, China.
Corresponding author's **email**: ahmedhamednseg@hotmail.com
Address: No. 1277, Ave Jiefang, Wuhan City, Hubei Province, China. Code: 430022
Tel.: +86 2785780458

Abstract: **Diaphragma sellae is a dural fold which extends over the pituitary fossa. It includes a defective area in its center, the diaphragmal opening, which transmits the pituitary stalk. In cases of pituitary adenoma, macroadenoma of large size tends to elevate the diaphragma sellae and may perforate it.**

Objectives: To study the dimensional changes of the diaphragma sellae opening between the diaphragmal opening dimensions and to correlate that dimensional change with volumetric data changes before and after the operation.

Materials and Methods: 72 cases were retrospectively enrolled in this study. The imaging data before and after the operation was revised. MITK, an open source software from MINT MEDICAL, was used to process the imaging data of these cases.

Results: There is a highly significant statistical relationship between the diaphragma sellae width and the pituitary adenoma total volume before the operation. The same occurred with the tumor volume above the level of the diaphragma sellae opening. On the other hand, there was a statistically non-significant correlation between the residual tumor volume and the width of the diaphragmal opening.

Conclusion: According to our results, presence of residual adenoma is not necessarily to be above the diaphragma sellae. The statistically non-significant correlation is due to the parasellar extension, which was the main cause of residual tumor presence in our specimen.

Keywords: **Diaphragmal opening, Pituitary adenoma, Transsphenoidal surgery.**

I. INTRODUCTION

Diaphragma Sellae is an extension of dura mater that cover the bony sella turcica(1). IT spreads over the pituitary gland completely, apart from a central defect which is called the diaphragma sellae opening. This opening is central in position and transmits the pituitary stalk which connects the hypothalamus with the pituitary gland. Diaphragmal opening also can sometimes transmit arachnoid folds filled with CSF in cases of empty sella syndrome(1,2).

Pituitary adenoma is a tumor which arises from the pituitary gland and can be classified into microadenomas (<10 mm in diameter) and macroadenomas (>10 mm in diameter). Macroadenomas tend to extend upwards towards the diaphragma sellae, raising it upwards(3) and may cause diaphragmal opening width to be increased. Also pituitary adenoma tends to extend inferiorly causing invasion of the sellar floor towards the sphenoid sinus, or laterally towards the cavernous sinus(2,4). There has been many systems proposed for classification of pituitary adenoma growth and invasiveness, but the most accepted worldwide is the Wilson's system(5) modified from Hardy(6,7) which is illustrated in Table 1.

Table 1: Wilson's classification of pituitary adenoma growth:

Extension:
Suprasellar extension: 0: None. A: extended to the suprasellar cistern. B: The anterior recess of the third ventricle is compressed. C: The third ventricle floor shows gross displacement. **Parasellar extension:** D: Intradural extension. E: Into the cavernous sinus/extradural extension.
Invasion:
Floor of the sella is intact: I: Sella is normal or focally expanded, the tumor is less than 10 mm. II: Sella is enlarged and the tumor is 10 mm or more. **Sphenoid sinus extension:** III: Localized perforation of the sellar floor. IV: Diffuse destruction of the sellar floor. **Distant spread:** CSF or blood borne

II. MATERIALS AND METHODS

We enrolled 72 cases of pituitary macroadenoma in this study, operated in our center. Patient database were revised and their clinical and imaging data, in the form of magnetic resonance images (MRI) before and after the operation, were enrolled in the study. We used MITK (Fig.1), a free open source software from MINT medical, to get the volumetric data of the adenoma, as well as to measure the diaphragmal opening width. These measurements were done on both the preoperative and postoperative MRIs. We also classified the tumor morphological extension and invasion according to Wilson's system.

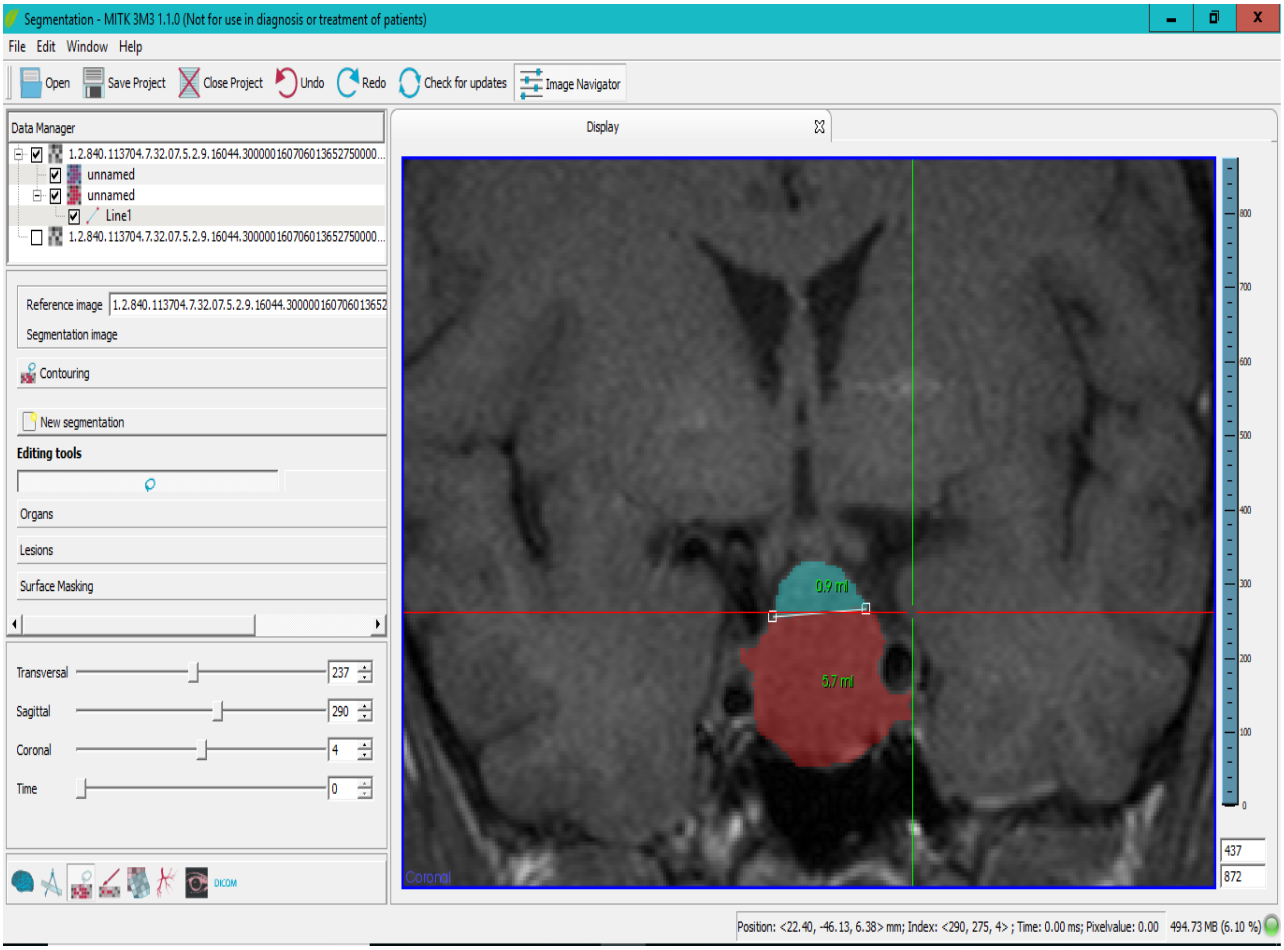

Fig.1: MITK software for measuring the intrasellar volume (red) the supradiaphradiaphragmatic volume (blue), the total tumor volume (sum of both intrasellar and supradiaphragmatic portions) and the width of the diaphragma sella opening (white line).

Statistical Analysis: We carried out the statistical analysis using SPSS version 22 for Windows. Categorical variables were expressed as frequency and percentage; while continuous data were expressed as mean (SD) or median (IQR). Parametric and nonparametric tests of association were used when appropriate. A P value of less than 0.05 was considered statistically significant.

III. RESULTS

72 cases were enrolled in our study, 33 females (45.8%) and 39 males (54.2%). Functioning adenomas represented 30 cases (41.6%) while non-functioning adenomas represented 42 cases (57.4%). Functioning adenomas represented 25% of cases (18 cases) while non-functioning adenomas represented 75% (54 cases). Residual tumor was present in 12 cases (16.6%), 6 of them had a parasellar residual (8.3%) and 6 had suprasellar extension (8.3%).

Correlating the pre tumor volumetric data of the tumor with the diaphragma sellae width, we found a very highly significant statistical relationship between the total tumor volume and the diaphragma opening width. The same thing occurred with the supradiaphragmatic volume, which had a highly significant statistical relationship with diaphragmal opening width.

Regarding the study of postoperative MRI, we found that the presence of residual tumor had a significant relationship ($P < 0.05$) with the extension classification of Wilson's system, while showed no correlation with the invasion classification of it. Correlating the diaphragma opening width with the presence of residual tumor, we found that there is no correlation between both of them. Tables 2 and 3 show a summary of statistical results.

Table 2: Correlation between the volumetric data of the adenoma before the operation and the diaphragmatic opening width

Variable		Diaphragmatic Opening Widht (mm) before
Total Tumor Volume (mm3)		
1-	Correlation Coefficient (r)	0.688
2-	P-value	<0.001
Supradiaphragmatic Volume (mm3)		
1-	Correlation Coefficient (r)	0.666
2-	P-value	<0.001

Table 3: Correlation between the residual volume and the diaphragma opening width in the postoperative MRI

Variable		Diaphragmatic Opening Widht (mm) After
Residual Volume		
1-	Correlation Coefficient (r)	0.286
2-	P-value	0.091

IV. DISCUSSION

Diaphragma sellae opening is one of the points which was not heavily discussed in the literature. Although most of the studies done about this point were studying its anatomical variations on cadaveric dissection(2), very few studies were done focusing on the changes of the diaphragmal opening with transsphenoidal adenoma resection.

MITK software is one of the free open-source software that provides a highly accurate method to measure volumes and dimensions of pituitary adenomas(8,9). It provides a tool called “the segmentation tool” which can effectively select the tumor tissue from normal tissue, and then can calculate the volume of the highlighted sections. This gave us an accurate evaluation over the ordinary methods with manually calculating the tumor volumes which could have many errors, especially because the measurements here are very small.

Pituitary adenoma is mosly non-invasive(4) but some of them tend to have extension to either the suprasellar or the parasellar portions. Invasion of the cavernous sinus can be a great challenge to neurosurgeons and in many cases, a surgeon has to leave a residual tumor in the cavernous sinus rather than taking the risk of its injury(10). Injury of the cavernous sinus contents can lead to serious consequences like intractable bleeding or cranial nerve injurt(4,10). That is one of the common causes to see residual tumor in the postoperative MRI.

When we started our research, we expected that there would be a high correlation between the width of the diaphragma sellae opening and the size of the tumor, either before or after the operation. This is because the main factor causing diaphragmal opening width to increase is the enlarging size of the adenoma, causing it to stretch leading to increased dimensions of diaphragmal opening(3,11). This was true regarding the preoperative images, but was not true regarding postoperative ones. We explain that by the presence of residual tumor in the parasellar areas around the cavernous sinus. Tumor in parasellar area can’t cause diaphragma sellae opening to get wider. Half of the cases which showed residual presence are in the cavernous sinus.

Many studies were done to predict why some pituitary adenomas are invasive and why some of them showed suprasellar extension while others show parasellar extension(2). Some studies suggest a role of cellular Ki-67, MIB-1, matrix metalloproteinase-9 and cathepsin B(12), others suggest a relationship between the type of the adenoma and the invasiveness suggesting that the growth hormone secreting adenoma has a higher incidence of invasiveness(13). Yokohama et al(14) suggested that the cause of that invasion is a defect in the medial wall of the sellae which causes its invasion by the adenoma. However, there is a great debate regarding the explanation of adenoma growth direction till now(2), which needs further work to be done for explaining it.

V. CONCLUSION

Diaphragma sellae opening dimensions is dependent mainly upon the pituitary adenoma size before the operation, but this is not the same with postoperative residual tumor presence. This dimensional non-correlation with the residual tumors is mostly due to the presence of residual tumor in the parasellar area. The role of diaphragma sellae in directing the adenoma growth is a rich topic and numerous hypotheses tried to explain it, but this needs further work to explain it conclusively.

REFERENCES

[1] Rhoton AL. The sellar region. Neurosurgery. 2002;51(4 SUPPL.):335–74.

[2] Campero A, Martins C, Yasuda A, Rhoton AJ. Microsurgical anatomy of the diaphragma sellae and its role in directing the pattern of growth of pituitary adenomas. Neurosurgery [Internet]. 2008;62(3):717–23. Available from: https://www.ncbi.nlm.nih.gov/pubmed/18425018

[3] Guinto Balanzar G, Abdo M, Mercado M, Guinto P, Nishimura E, Arechiga N. Diaphragma sellae: A surgical reference for transsphenoidal resection of pituitary macroadenomas. World Neurosurg [Internet]. 2011;75(2):286–93. Available from: http://dx.doi.org/10.1016/j.wneu.2010.08.002

[4] Greenberg M. Pituitary adenoma. In: Handbook of Neurosurgery. 7th ed. New York: Thieme Medical; 2010. p. 633–5.

[5] Wilson C. Neurosurgical management of large and invasive pituitary tumors. In: Tindall G, Collins W, editors. Clinical management of pituitary disorders. New York: Raven Press; 1979. p. 335–42.

[6] Hardy J. Transsphenoidal surgery of intracranial neoplasm. In: Thompson RA, Green R, editors. Adv neurol. New York: Raven Press; 1976. p. 261–74.

[7] Hardy J. Transsphenoidal surgery of hypersecreting pituitary tumors. In: Kohler PO, Ross GT, editors. Diagnosis and treatment of pituitary tumors. New York: Excerpta Medica/American Elsevier.; 1973. p. 179–94.

[8] Nolden M, Zelzer S, Seitel A, Wald D, Müller M, Franz AM, et al. The medical imaging interaction toolkit: Challenges and advances: 10 years of open-source development. Int J Comput Assist Radiol Surg. 2013;8(4):607–20.

[9] Stein D, Fritzsche KH, Nolden M, Meinzer HP, Wolf I. The extensible open-source rigid and affine image registration module of the Medical Imaging Interaction Toolkit (MITK). Comput Methods Programs Biomed [Internet]. 2010;100(1):79–86. Available from: http://dx.doi.org/10.1016/j.cmpb.2010.02.008

[10] Hendricks B, Cohen-Gadol A. Pituitary Macroadenoma. In: Neurosurgical Atlas [Internet]. Neurosurgical Atlas, Inc.; 2016. Available from: www.neurosurgicalatlas.com/volumes/brain-tumors/pituitary-and-parasellar-tumors/endoscopic-and-microscope-guided-adenoma-resection/pituitary-macroadenoma

[11] Wei L, Xi Z, Lin S, Zhao Q, Jing J, Wang S. MRI research of diaphragma sellae in patients with pituitary adenoma. Int J Clin Exp Med [Internet]. 2015;8(8):12842–9. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26550199

[12] Iuchi T, Saeki N, Osato K, Yamaura A. Proliferation, vascular endothelial growth factor expression and cavernous sinus invasion in growth hormone secreting pituitary adenomas. Acta Neurochir. 2000;142:1345–1351.

[13] Lundin P, Nyman R, Burman P, Lundberg PO MC. MRI of pituitary macroadenomas with reference to hormonal activity. Neuroradiology. 1992;34:43–51.

[14] Yokoyama S, Hirano H, Moroki K, Goto M, Imamura S, Karatsu J. Are nonfunctioning pituitary adenomas extending into the cavernous sinus aggressive and/or invasive? Neurosurgery. 2001;49:857–863.