Original Article

Intraoperative Squash Cytology of Central Nervous System and Spinal Cord Lesions with Histological Correlation

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ABSTRACT

Aims: Squash Cytology is now a well established and universally accepted technique in diagnosing a wide range of Central Nervous System (CNS) lesions and is presently being employed for both therapeutic and prognostic reasons. This study was conducted with an aim to correlate squash smears with histopathology and to compare statistical data employing sensitivity, specificity and diagnostic accuracy of squash cytology.

Methods: The present study was a retrospective study comprising 369 lesions of central nervous system and spinal cord that were retrieved from archives. All the cases for which Intraoperative squash cytology and subsequent histopathology was available were included in the study. Cytology smears were stained with May- Grunwald- Geimsa (MGG), Hematoxylin & Eosin (H&E) and Pap stain. Histopathology smears were made from formalin fixed tissue sent separately and stained with H&E.

Results: Of 369 cases, 86.4% were neoplastic and 13.6% nonneoplastic on histopathology. Amongst neoplasms, Astrocytic tumors constituted 24.7% of cases followed by Meningiomas comprising 17.8%. Amongst the benign lesions Tuberculoma was seen most frequently (3.25%). Overall diagnosticAccuracy of squash was 95.25%. On statistical analysis Sensitivity, Specificity, Positive Predictive value (PPV) and Negative Predictive Value (NPV) of squash cytology were 94.3%, 95.6%, 95.3% and 95.1% respectively. On applying student T test, for statistical correlation between squash cytology and histopathology p value was 0.363347 ($p>0.05$) hence errors in diagnosis by squash were insignificant.

Conclusion: Intraoperative squash cytology is fairly accurate, reliable and cost effective method for rapid diagnosis of CNS lesions.

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Introduction

Lesion within the central nervous system are diverse entities ranging from inflammatory conditions to neoplasms and remain one of the most challenging domains of neuropathologists. The accurate assessment of the diseased tissue is fundamental to the diagnosis and management of central nervous system lesion. [1]

With the advent of neuroimaging techniques like computed tomography (CT) and magnetic resonance imaging (MRI), the diagnosis of very small, slow growing and minimally symptomatic lesion can be easily discovered. Diagnosis of these lesions based only on clinical and radiological findings is difficult and many a time incomplete with regards to infiltration. Accurate diagnosis of CNS lesions is further required for choosing between surgery and alternative therapeutic strategies. [2] Overall accuracy of preoperative radiological diagnosis ranges between 10%-30% as per literature. [3]

In the neurosurgical practice, although histopathology is the gold standard, intraoperative cytological diagnosis is now well established and continues to gain momentum. The biggest advantage of cytological diagnosis is rapid intraoperative diagnosis which further helps the surgeon to plan the extent of surgery and modify it accordingly. [4] The squash smear technique has gained importance because of its technical simplicity and its ability to display abnormal cellularity, nuclear and cytoplasmic details and even tissue architecture. Furthermore, squash smear technique can be applied not only to neoplastic lesions but also to non neoplastic lesions. [5]

Thus, this study was undertaken to compare the efficacy of intraoperative squash smear cytology with histopathological diagnosis.

Materials and Methods

The present study was a retrospective study conducted in the Department of Pathology for a period of 3 years. As such, the Institutional policy does not envisage an Institutional Ethical clearance for such studies as no Ethical issues were involved.

Three hundred and sixty nine cases of CNS neoplasm or lesions sent for intraoperative smear cytology (squash preparation) diagnosis for which subsequent histopathological examination was done were retrieved from the archives. Also relevant clinical and radiological data were retrieved and noted. The biopsy samples obtained at the time of surgery were transported immediately to the neuropathology laboratory in isotonic saline for processing. Smears were prepared by placing 1-2 mm of biopsy material at one edge of clean, dry and labeled slide and crushing with another slide with just enough pressure to spread the tissue into thin film. Gross and naked eye examination was done to evaluate nature of spread. In most cases 6-8 cytological smears were availaible. Out of which half were immediately fixed in method for staining with Hematoxylin and Eosin (H and E). Remaining smears were air dried and stained with May-Grunewald-Giemsa stain (MGG). Smears were mounted with DPX. Paraffin H&E stained sections were prepared from the residual tissue as well as additional tissue sent for histopathology. Smear cytology diagnoses were correlated with the histopathological findings.

Squash cytology results were classified into the following categories: true negative (absence of malignancy correctly diagnosed); true positive (presence of malignancy correctly diagnosed); false negative (the cytological specimen failed to diagnose as malignancy); and false positive (the cytological specimen was incorrectly considered or suspect of malignancy). The tumors were classified according to the World Health Organization classification of CNS neoplasm 2007.[7]

Study design included a comparison between results of squash cytology with final histopathological diagnosis. Data analysis was based on Galen and Gambino method which calculated sensitivity and specificity of cytology in differentiating benign and malignant lesions (Table 1).

Table 1: Galan and Gambino method

Sensitivity	a/a+c X100
Specificity	d/b+d x100
Positive predictive value	a/a+b x100
Negative predictive value	d/c+d x100
Accuracy	a+d/a+b+c+d x100
a = True Positive b= False Positive c= False Negative d= True Negative	
Statistical Analysis was done and student T- Test was applied to calculate p value to evaluate the errors in diagnosis by squash cytology technique	

Results

A total of 369 cases referred from Neurosurgery department for squash cytology and subsequent histopathology were included in the study.

Demographic Details: The age of the patients varied from 4 to 80 years. Maximum number of cases (22.8%) were seen in the age group of 41-50 years comprising 22.8%.

Only one case was seen after the age of 70 years. Male to female ratio of all patients irrespective of age group was 1.8:1.

Clinical Characteristics: Clinically, the patients had variable presentations. Most of the patients presented with seizures, headache, nausea, vomiting, vertigo, tinnitus and difficulty in hearing. A few patients also presented with weakness on one side of the body, ataxic gait and drowsiness.

Clinico-Radiological Diagnosis: Out of 369 cases, a definitive diagnosis could not be offered radiologically for 25 cases(6.7%). A provisional clinicoradiological diagnosis could be given in remaining 344 cases. Of these, 303 cases (82.11%) were neoplastic and 41 cases (11.1%) were non neoplastic or inflammatory. Of 303 neoplasms, 151 cases (40.9%) were malignant and 152 cases (14.1%) were benign.

Radio imaging techniques showed maximum number of lesions in the cerebral hemisphere (41.5%). Amongst the lesions with more precise location the frontal lobe had the largest number of cases (15.3%) followed by supratentorial location (14.2%).

SQUASH CYTOLOGY

The cytological features of 369 lesions sent for squash cytology were studied (Table 2). On squash cytology 312 cases (84.55%) were designated as neoplastic and 46 cases (12.4%) as non neoplastic. Eleven cases were inconclusive on squash cytology.

Of all the 312 neoplastic lesions, 178 cases (48.2%) were malignant and 134 cases (36.3%) were benign. Overall, gliomas was the most frequent cytological diagnosis (97 cases, 26.28%), followed by meningiomas (62 cases, 16.82%). Amongst the non neoplastic benign lesions Epidermoid cyst and Tuberculoma were the most frequent lesions constituting 12 cases each (3.25%).

HISTOPATHOLOGY:

Out of 369 cases histopathological diagnosis was rendered in 368 cases. Only one case could not be diagnosed histologically due to inadequate material. Of all the 368 cases, 318 cases (86.4%) were neoplastic and 50 cases (13.6%) were non neoplastic. All the CNS neoplasms were classified according to WHO classification of CNS tumors (Table 3).

The most frequently identified lesions on histopathology were Astrocytic tumors (91 cases, 24.7%). Amongst all the Astrocytic tumors maximum number of cases of Astrocytoma (64 cases, 17.34%) were reported. Meningiomas constituted (66 cases, 17.8%) and were the second largest group of neoplasms in our study. Besides, Schwannomas (32 cases, 8.7%), pituitary Adenoma (27 case, 7.3 %), Glioblastoma Multiforme (23 cases, 6.23%) and metastatic lesion (23 cases, 6.23 %) were the other most frequently reported lesions in our study. Amongst the various non neoplastic lesions, Tuberculomas were seen most frequently (12 cases, 3.25%) followed by Epidermoid cysts (11 cases, 2.9 %).

Cytological diagnosis was correlated with histopathological diagnosis (Table 4). Overall diagnostic accuracy of squash cytology was 95.25% excluding 11 inconclusive cases. Diagnostic accuracy for neoplastic lesion was higher (87.82%) in contrast to benign non neoplastic lesion (82.6%). Total discrepancy between cytological and histological diagnosis was seen in thirty three cases (Table 5). Complete correlation was considered when the intraoperative squash cytology diagnosis was same as the histological diagnosis without grading deviation.

The results were statistically analyzed. Sensitivity, specificity, positive predictive value and negative predictive value of squash smear cytology were 94.3%, 95.6%, 95.3%, 95.1% respectively (Table 6). Further false negative rate and false positive rate of squash cytology when calculated were 5.2% and 4.32%.

Student T-test for correlating cytology and histological findings was applied and T value (0.35113) and P value (0.363347) were calculated. Thus, a significant correlation was found between intraoperative squash cytology diagnosis and histopathology ($P > 0.05$) and errors in diagnosis by squash cytology technique were found to be statistically insignificant on applying student T-test.

Discussion

Presently, the stereotactic biopsies are employed as a primary diagnostic tool in the evaluation of both neoplastic and more recently non neoplastic intracranial lesions and to differentiate metastatic from primary lesions. [8,9]

The present study included a total of 369 CNS lesions comprising both neoplastic and non neoplastic lesions. All the CNS lesions were subjected to detailed squash cytology and the final results were then compared with histopathological diagnosis as gold standard.

The submitted small biopsies for squash cytology were analyzed employing H&E, PAP and May Grunewald Giemsa. The best cytological details were seen with MGG and the best nuclear details including nuclear membrane outline and chromatin pattern were seen with PAP stain. Mouriquand et al, Kontozogtu et al and Fri Piaton in their studies have found a combination of MGG and PAP stain

to reveal complementary information and better images as compared to H&E stain. [10,11,12]. Besides, the use of H&E and Giemsa stains in contrast to the supravital stains have facilitated a permanent preparation and these smears in concert with paraffin sections have been employed for accurate interpretation. Of 369 lesions, subjected to squash cytology a cytological diagnosis could not be rendered in 11 cases. Common causes for no opinion on cytology were fibrosis, inflammation, calcification, necrosis and lack of definite cytological details. Also the lesions with increased fibrous component, tissue from cyst wall and tissue containing calcified material were difficult to smear, hence rendered inconclusive. Other authors have attributed similar causes for misinterpretation or no opinion on cytological evaluation. [13]

In our study, the median age of presentation of patients was 45 years and M: F ratio was 1.8:1 which corresponds to studies by other authors such as Cappabianca et al and Nguyen et al who have reported the median age of about 40-45years. [3, 14] A higher incidence of lesions in males has been reported cross sectionally in all the age groups. [10, 11]

Of 358 cases, for which a final cytological diagnosis could be offered 51 cases were non neoplastic and 307 cases neoplastic. Of 307 neoplastic lesions 164 cases (53.4%) were malignant and 177 cases (57.6%) cases were benign. Eight false positive cases and 9 false negative cases on squash cytology in malignant cases were seen in our study which corresponds to studies by other authors. [15]

Diagnostic accuracy achieved in present study was 95.25% and was comparable with series of other studies varying from 85.4% to 97%. [16, 17, 18]

Also the sensitivity and specificity of squash cytology in our study 94.79% and 95.67% respectively are consistent with studies by other authors. [15]

The cyto-histological concordance rates were 87.82% for neoplastic lesions and 82.6% for non neoplastic lesion in our study. In a retrospective study conducted by Jaiswal et al in 2010, that included 326 cases of CNS lesions, concordance of 83.7% was achieved between the intraoperative diagnosis and final diagnosis. [19]

The largest number of cases on cytology was of glial tumors (97 cases, 27.1 %) which could be easily identified in the smears due to fibrillary background (Fig.1-a,b). However, a complete correlation could not be offered due to sampling error as a high grade tumor may be undergraded because of avoidance of necrotic tissue deliberately, while preparing a crush smear which is the key diagnostic features on histology. Such grading deviations have been reported by Marshall et al. [20] Two cases of reactive gliosis were rendered false positive on cytology as low grade astrocytoma in our study. Similar misinterpretation of diagnosing reactive gliosis as low grade astrocytoma has been reported by others authors due to similar cytological features. [21]

On review of the smears, reactive astrocytes had abundant cytoplasm and more prominent numerous, long and symmetrical processes. As compared to neoplastic astrocytes these lack hyperchromatic and lobulated nuclei, progressive atypia and mitosis. Smears of low grade Astrocytoma had minimal anisocytosis with finely to coarsely granular chromatin and inconspicuous nucleoli; the cytoplasm was scanty and showed variable processes with fibrillary background. Two cases of Ependymomas were misdiagnosed as high grade Astrocytoma due to absence of true rosettes on squash. Similar opinion has

Table 2: Intraoperative Squash cytology Diagnosis

Broad Squash cytology categorization	Benign n=134	Cytological typing (N) Pituatary adenoma 26 Craniopharyngioma 05 Meningioma 62 Schwannoma 23 Neurofibroma 03 Spindle cell lesion 12 Choroid plexus Papilloma 03
Neoplastic n=312	Malignant n=178	Gliomas 97 GBM 07 Oligodendroglioma 08 Ependymoma 11 DCG 01 Central Neurocytoma 01 Pineoblastoma 01 Neuroblastoma 01 Metastatic 22 Vascular lesion 10 Chondroma 02 Round cells 11 Melanoma 01 Medulloblastoma 02 Hemangioblastoma 03
Non neoplastic n =46		Epidermoid cyst 11 Dermoid cyst 01 Arachnoid cyst 02 Tuberculoma 12 Aspergillosis 03 Abscess/Reactive gliosis 02 Inflammatory 07 Hydatid cyst 01 Neurocysticercosis (NCC) Fibrous
	Inconclusive	11

Table 3: Distribution of CNS neoplasms among various WHO categories ofCNS tumours on Histopathology:

Neuroepithelial	**Astrocytic tumors**	Diffuse Astrocytoma	64
		Anaplastic Astrocytoma	01
		Glioblastoma Multiforme (GBM)	23
		Gliosarcoma	02
		Sub Ependymal Giant cell Astrocytoma (SEGA)	01
	Ependymal tumors	Ependymoma	10
		Myxopapillary Ependymoma	01
	Oligodendroglial tumor	Oligodendroglioma	16
	Choroid plexus tumors	Choroid plexus papilloma	03
		Choroid plexus carcinoma	01
	Neuronal tumor	Gangliocytoma	05
		Dysplastic Cerebellar Gangliocytoma (DCG)	01
		Central Neurocytoma	01
	Tumors of pineal region	Pineoblastoma	01
	Embryonal tumor	Medulloblastoma	05
		CNS neuroblastoma	01
		Ewings/PNET	03
	Tumors of cranial and paraspinal nerves	Schwannoma	32
		Neurofibroma	04
	Tumors of the Meninges	**Tumors of meningothelial cells Meningioma**	66
		Mesenchymal tumors	
		Chondroma	01
		Chondrocarcoma	01
		Primary Melanocytic lesions	
		Malignant melanoma	01
		Mesenchymal tumor	
		Hemangioma	
		Other neoplasm related to meninges	08
		Hemangioblastoma	03
		Hemangiopericytoma	01
	Lymphomas & Hematopoietic Neoplasm	Malignant lymphoma	04
		Plasmacytoma	01
		Plasma cell granuloma	01
	Tumors of sellar region	Craniopharyngioma	05
		Pituatry adenoma	27
	Metastatic tumours& local extension of regional tumor	Metastasis	23
		Squamous Cell Carcinoma (SCC)	01

Table 4: Correlation of Histopathological Versus cytological Diagnosis

Histopathological Diagnosis	Total number(Histopath)	Cytological Diagnosis(N)	Accuracy (%)
Neoplastic Astrocytoma (Grade I,II,III)	83	97	85.56%
GBM	06	07	85.7%
Oligodendroglioma	06	08	75
Ependymoma	06	11	54.54
Choroid plexus papilloma	02	03	66.66
DCG	01	01	100
Central Neurocytoma	01	01	100
Pineoblastoma	01	01	100
Neuroblastoma	01	01	100
Medulloblastoma	02	02	100
Round cell tumor	09	11	81.8
Schwannoma	31	33	93.93
Neurofibroma	04	05	80
Meningioma	58	62	93.54
Chondroma	01	02	50
Primary CNS Melanoma	01	01	100
Hemangioma	08	10	80
Hemangioblastoma	03	03	100
Craniopharyngioma	05	05	100
Pitutary Adenoma	26	26	100
Metastatic	21	22	95.95
BENIGN LESION			
Epidermoid cyst	11	11	100
Dermoid cyst	01	01	100
Arachnoid cyst	02	02	100
Hydatid cyst	01	01	100
Tuberculoma	12	12	100
Aspergillosis	03	03	100
NCC	03	03	100
Abscess	01	02	50
Inflammatory	04	07	57
Fibrous	00	04	-
Inconclusive	01	11	

Table 5-Discordant cases on cytology:

Squash cytology Diagnosis	Number (N)	Histopathology Diagnosis	Number (N)
Gliomas/Astrocytoma	5	Reactive gliosis GBM Ependymoma	2 2 1
GBM	1	Gliosarcoma	1
Oligodendroglioma	2	Astrocytoma Pitutary Adenoma	1 1
Ependymoma	5	Astrocytoma PilocyticAstrocytoma Ganglioma	3 1 1
Meningioma	4	Ependymoma Gliosarcoma Hemangiopericytoma Squamous Cell Carcinoma	1 1 1 1
Neurofibroma	1	Fibrous Meningioma	1
Choroid Plexus Papilloma	1	Choroid plexus carcinoma	1
Metastatic deposit	1	Meningioma	1

Squash cytology Diagnosis	Number (N)	Histopathology Diagnosis	Number (N)
Inflammatory	3	Metastatic deposit Adenocarcinoma Astrocytoma Oligodendroglioma	1 1 1
Reactive gliosis	1	Meningioma	1
Round cell malignancy	2	Medulloblastoma	2
Hemangioma	2	Hemangioblastoma	2
Fibrous	4	Choroid plexus papilloma Meningioma Tuberculoma	1 2 1
Chondroma	1	Chondrosarcoma	1
Total	**33**		**33**

Table 6: Sensitivity, specificity, Positive predictive value and Negative predictive value of squash smear

Squash	Cytological Diagnosis	Final Diagnosis Benign	Malignant	Sensitivity	Specificity
Malignant	172	8	164	94.79%	95.67%
Benign	186	177	9		

Accuracy	PPV	NPV
95.25%	95.34%	95.16%

been expressed by Rossler et al who reported the absence of rosettes or rosettoid appearance on cytology leading to erroneous diagnosis on cytology. [4]

A diagnostic accuracy of 85.7% was achieved for Glioblastoma Multiforme (GBM) (Fig.1-c,d). A case of gliosarcoma was misdiagnosed as GBM, as the sarcomatous element was missed on cytology. Similar errors have been encountered by Mouriquad et al in their study. [10]

Diagnostic accuracy for Oligodendroglioma was 75% in our study (Fig.1e,f). One case of Astrocytoma and another of pituitary adenoma were erroneously diagnosed as oligodendroglioma on squash cytology. The erroneous misdiagnosisdiagnosis on cytology may be due to interpretation of edema as perinuclear halo and neovascularisation as chicken wire pattern that are pathognomic of Oligodendroglioma.

Misdiagnosing pituitary adenoma as Oligodendroglioma leading to diagnostic dilemma has been pointed out by Nguyen et al and Bonner.[14,21] The problem arises due to overlapping cytological features, absence of clear halo around nuclei in oligodendroglial cells and pituitary tumor extending beyond the confines of sella turcica.

For Ependymomas, the diagnostic accuracy was 54.54%. Smears showing close mixture of cuboidal epithelial cells merging with spindle fibrillated cells clinch the diagnosis in favour of Ependymona. Two cases of astrocytoma were erroneously diagnosed as Ependymomas on squash cytology. Similar opinion was given by Ho-keung Ng who said that low grade Astrocytomas and mixed gliomas are important differential diagnosis in case of Ependymomas. [22] One case of Pilocytic Astrocytoma was misdiagnosed as Ependymoma on Squash cytology and stays one of the major differential diagnoses. The principal challenge is to distinguish between these tumors since they belong to different grades. On retrospective analysis of crush smear it was found that diffuse fibrillary Astrocytomas were more cellular with a fibrillary back ground as compared to Pilocytic Astrocytoma which showed fine fibrillarity and absence of well defined bipolar cells (Fig.1 g,h). Teo et al have also described similar findings in their study.[23] One case of Ganglioma was misdiagnosed as Ependymoma due to decreased number of Ganglion cells with poorly preserved outline.

The cytohistological correlation for Meningiomas was 93.54% (Fig.-2a,b). In most cases meningothelial cells were easily identifiable as oval to round cells containing vesicular nuclei and conspicuous nucleoli. We misdiagnosed a case of ependymoma as meningioma due to absence of perivascular Rosette. Another case of gliosarcoma was also diagnosed as meningioma due to absence of necrosis and sarcomatous mesenchymal elements in the cytological smears simulating spindle cells leading to diagnostic error. Furthermore, Hemangiopericytoma was misdiagnosed as Meningioma due to presence of spindle cells. A case of moderately differentiated Squamous Cell carcinoma was also misdiagnosed as Meningioma due to smearing difficulty and presence of scattered spindle cells only on crush smear. Two cases of Meningioma were diagnosed as fibrous lesions

on crush cytology due to the presence of elongated spindle cells and absence of cellular whorls in the smear.

The cytohistological correlation for Schwannoma was 93.93% (Fig.-2c,d). One case of fibrous meningioma was diagnosed as Schwannoma. Kobayashi also described similar misinterpretation in their result. [24]

A 100% correlation was seen in the diagnosis of pituitary adenoma(Fig.-2e,f). The cells appeared uniform with well defined cell border and round to oval nuclei. Pseudorosette like arrangement and vascular proliferation was seen occasionally. The cytohistological correlation for Neurofibroma was 80%. One case of fibrous meningioma was misdiagnosed as Neurofibroma since the tumor cells showed elongated nuclei, long cytoplasmic processes and absence of whorled pattern. Similar opinion has been expressed by Kobayashi. [24]

Cytologically diagnosed two cases of Round cell malignancy were histopathologically diagnosed as Medulloblastoma thus accounting a diagnostic accuracy of 81.8%. On reviewing cytology, the smears were highly cellular with small round dyscohesive cells, high N/C ratio, nuclear hyperchromasia and structures appearing as lympho glandular bodies. Folkerth et al in their study have elaborated the close resemblance of Medulloblastoma with Round cell malignancy. [25]

For metastatic lesions, the cytohistological correlation was 95.45% in our study (Fig-3a,b). One case of Meningioma was misinterpretated as metastatic deposit where the atypia was over diagnosed cytologically. In literature misdiagnosis has been reported in cases of metastatic carcinoma, undifferentiated malignant tumor and rare types of histology such as gliomatous and xanthomatous lesions that may be responsible for misdiagnosis. [26, 27]

Of two cytologically proven cases of Chondroma, one of the case was histologically diagnosed as Chondrosarcoma and the discordance was due to sampling error.

One case of choroid plexus carcinoma was misinterpretedas choroid plexus papilloma on crush cytology thus giving a cytohistopathological correlation of 66.66%. The reason for erroneous diagnosis may be attributed to inadequate sample. Likewise, a diagnosis of fibrous lesion was given cytologically which on histopathology was diagnosed as Choroid plexus papilloma and may be attributed to improper smear preperation on review.

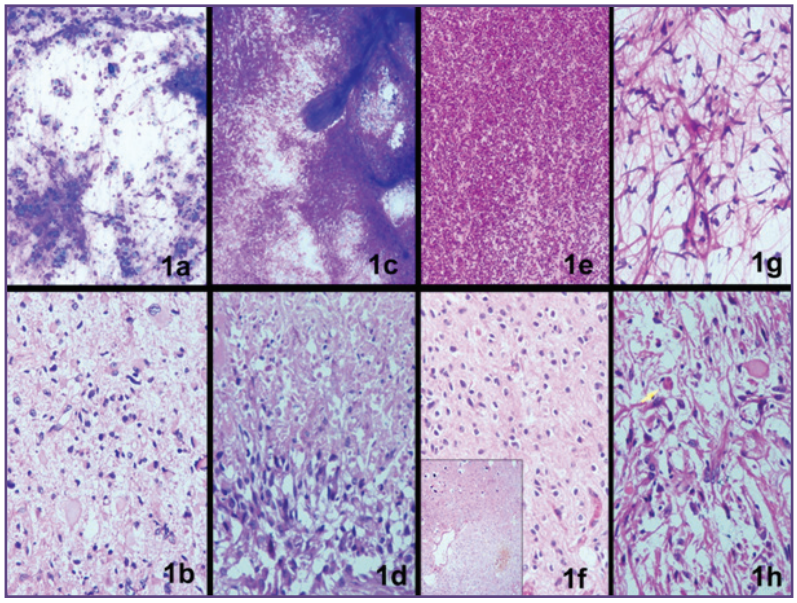

Fig. 1a: Squash cytology of high grade Astrocytoma showing vascular proliferation and astrocytes with nuclear atypia in a fibrillary background (H&E, 400X) with corresponding tissue section in showing nuclear atypia and pleomorphism in 1b(H&E, 400X) .

Fig. 1c: Squash cytology of GBM showing glomeruloid appearance of blood vessels (MGG, 100X) with corresponding tissue section showing palisading of neoplastic astrocytes around necrosis in 1d (H&E ,100X).

Fig. 1e: Squash smears showing sheets of neoplastic oligodendrocytes (MGG,100X) with corresponding tissue section showing sheets of uniform round cells with perinuclear halo exhibiting (Inset: calcification) in 1f (H&E, 100X).

Fig. 1f: Squash preparation showing bipolar hair like processes of astrocytes in a fibrillary background (MGG,400X) with corresponding tissue section showing pilocytic cells,Rosenthal fibres and eosinophillic granular bodies in 1g (H&E,400X)

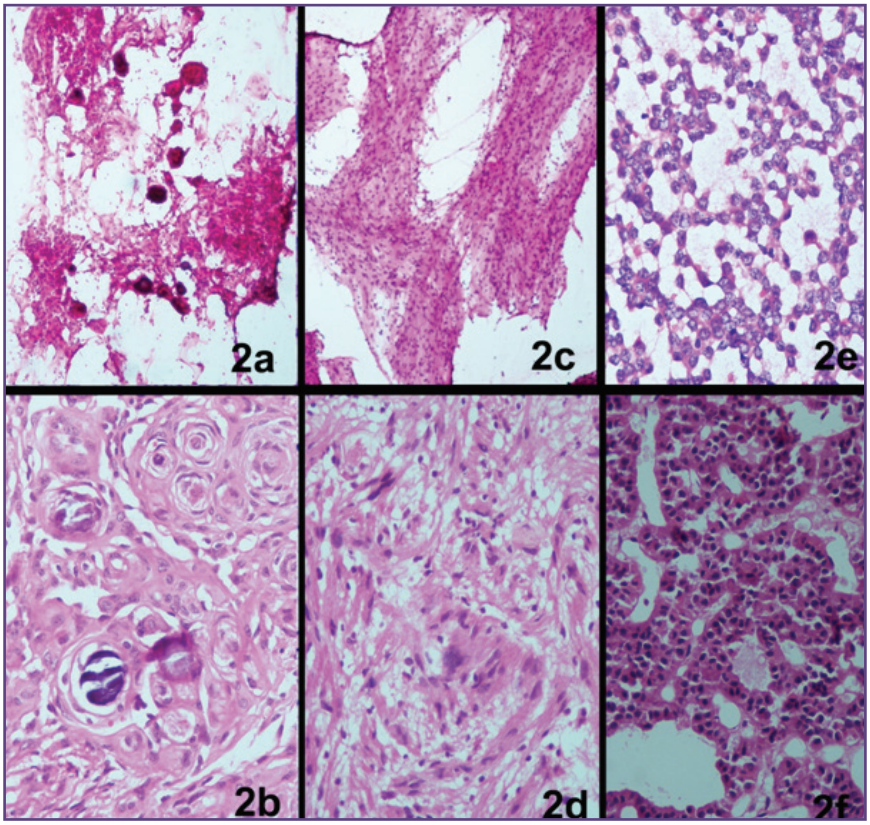

Fig. 2a: Squash cytology of Meningioma showing psammoma bodies (H&E, 100X) with corresponding histological section showing psammoma bodies in 2b (H&E, 100X).

Fig. 2c: Squash showing thick fragment of spindle cells (MGG 100X) with tissue section exhibiting Verocay bodies 2d (H&E, 400X)

Fig. 2e: Squash cytology of Pitutary Adenoma showing monomorphic appearance of cells (H&E, 400X) with corresponding histological section showing uniform arranged in acini and sheets in 2f (H&E,100X)

A complete 100% cytohistological correlation was seen in cases of Dysplastic cerebellar gangliocytoma, Pineoblastoma, Neuroblastoma, Medulloblastoma (Fig.-3c,d), Primary CNS Melanoma (Fig-3e,f) and Hemangioblastoma (Fig.-3g,h).

Benign Lesion

In our study, 12 case of tuberculoma were reported on cytology which showed a 100% correlation on histology. The smears showed mainly caseous necrotic background, fibrous tissue, few clusters of epitheloid cells, Langhan's multinucleate giant cell and amorphous calcified debris. ZN stain should be mandatory to demonstrate acid fast bacilli (AFB), however in absence of AFB the diagnosis of consistent with tuberculoma can be given. These findings are consistent with Burger et al.[28]

Two cases diagnosed cytologically as Fibrous lesion were histologically diagnosed as Choroid Plexus papilloma and Tuberculoma respectively. The discordance was due to improper smear preparation revealing only spindle cells on crush cytology.

Eleven cases of epidermoid cyst and one case of dermoid cyst diagnosed cytologically showed a 100% correlation with histology. Epidermoid cyst showed a large number of keratinized mature squamous cells with keratin having lamellated appearance. The Dermoid cysts showed mature squamous epithelium with fibrous tissue and fragments of adipose tissue against a background of amorphous debris, macrophages and having similar morphological findings have been described by Smith et al who further opined histopathology to be done to differentiate between Epidermoid cyst and cystic teratomas. [29]

Three cases diagnosed as inflammatory lesions on squash cytology were histologically proved as metastatic deposit of Adenocarcinoma, Astrocytoma and Oligodendroglioma respectively.These false negative diagnosis on squash cytology may be attributed to improper sampling.

There were 11 cases (2.98 %) in our study for which a cytological definite opinion could not be given. These

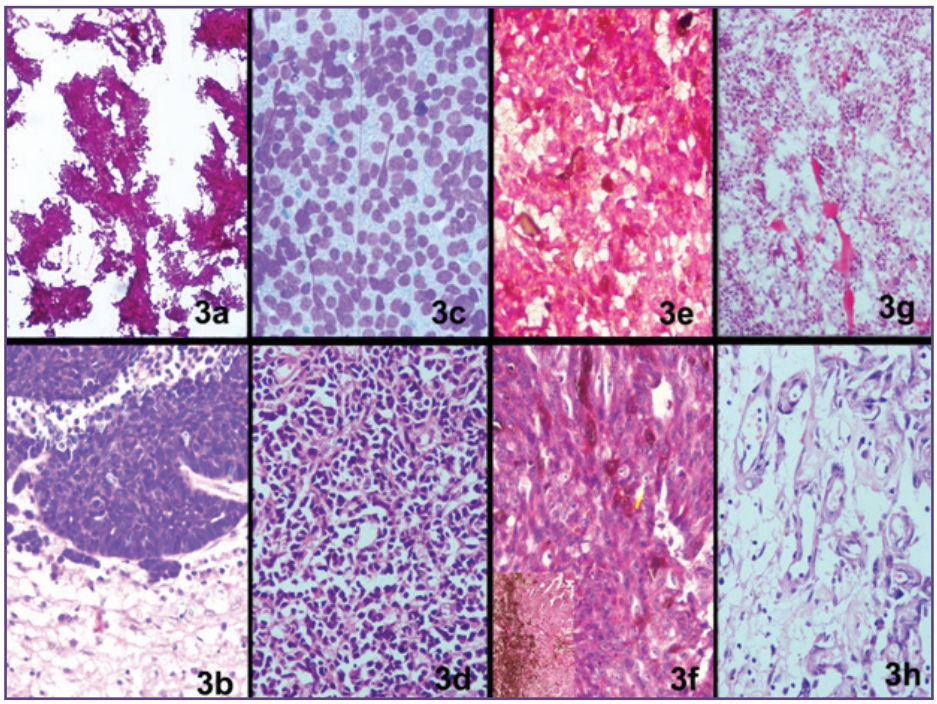

Fig. 3a: Squash cytology of metastatic tumour showing pleomorphic cells in clusters (MGG,100X) with corresponding tissue section showing tumour cells infiltrating into brain tissue in 3b (H&E,400X)

Fig. 3c: Smear showing uniform round cell in sheets and clusters (MGG, 400X) with corresponding tissue section exhibiting rosettes in Medulloblastoma in 3d (H&E, 400X)

Fig. 3e: Squash smear of Malignant Melanoma showing elongated cells in clusters along with pigment (H&E, 400X) with coressponding histological sections showing tumour cells (Inset: tumour cells and pigment) in 3f (H&E, 100X)

Fig. 3g: Smear showing cellular Hemangioblastoma with small capillaries (MGG 100X) with corresponding tissue section showing many capillaries and cellular stroma in 3h (H&E, 100X)

include 1 case each of pituitary adenoma, dermoid cyst, bronchogenic cyst, vascular lesion, inflammatory lesion and plasma cell granuloma. In these cases the opinion was inconclusive due to low cellularity, crush artifacts, increased fibrous component from the wall, predominantly fluid aspirate with low cellularity and morphology obscuring inflammation.

There were 4 cases of seizure related lesions for which surgery was done. These include 2 cases (0.54%) of microdysgenesis and 2 cases (0.54%) of medial sclerosis.

The smears of microdysgenesis showed brain tissue with fibrillary background along with mature ganglion cells and few oligodendroglial like cells that were confirmed on histology and correlated with clinical findings. Similarly, there were 2 cases of medial sclerosis in our study which were characterized by large neuronal cells and astrocytic cells along with intermediate cells with ballooned glassy cytoplasm. Both the cases were subsequently confirmed by histopathology. In all the 4 cases, definite opinion could not be offered on cytology due to lack of clear cut cytological criteria in the available literature.

The correlate percentage of cytohistological correlation reported by other authors are, 92.2% by Tores et al, 87.5% by Mouriquand et al, 88% by Willems et al and are comparable with our cytohisto correlation.[5,10,30]

Conclusion

To conclude, this study shows a very high degree of cytohistological correlation. With better and precise radioimaging and stereotactic biopsies, the percentage of cytohistological correlation can improve and increase further. Some cases will always require histopathological study and/or immunohistochemical markers for definitive diagnosis but for most of the lesions, cytology can render a definite opinion.

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None declared

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