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Role of Scrape Cytology in the Intraoperative Diagnosis of Tumors: A Comparative Prospective Study at a Tertiary Care Center in Western Odisha

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ABSTRACT

Background: Rapid intraoperative diagnosis is essential for guiding surgical management. Although paraffin-section histopathology remains the gold standard, frozen section facilities are often unavailable in resource-limited settings. Scrape cytology offers a rapid, simple, and cost-effective alternative. This study evaluated the diagnostic performance of intraoperative scrape cytology compared with permanent histopathology in a tertiary care hospital in Western Odisha.

Methods: A prospective comparative study was conducted over 24 months at VIMSAR, Burla, involving 102 surgically resected tumor specimens from various organ systems. Smears prepared from freshly cut tissue surfaces were stained using modified rapid Papanicolaou or Diff-Quik methods. Cytological diagnoses were compared with final hematoxylin and eosin histopathological findings.

Results: Histopathology confirmed 67 malignant and 35 benign lesions. Scrape cytology correctly diagnosed 95 cases, achieving an overall adequacy/accuracy of 93.14%. Seven cases (6.86%) were inconclusive because of poor cellularity. Excluding these cases, sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy were 98.51%, 100.00%, 100.00%, 96.55%, and 98.95%, respectively. One false-negative result occurred in a low-grade squamous cell carcinoma of the penis.

Conclusion: Intraoperative scrape cytology is a highly accurate, sensitive, and rapid diagnostic technique with excellent correlation to permanent histopathology. It represents a valuable alternative where frozen section facilities are unavailable and supports improved cytopathological diagnostic practice.

Key-words: Scrape Cytology; Intraoperative Diagnosis; Surgical Pathology; Frozen Section; Rapid Papanicolaou; Diagnostic Accuracy

INTRODUCTION

Surgical pathology frequently requires rapid, highly accurate intraoperative consultations to guide the extent of surgical resection, confirm clear margins, and verify representative tissue sampling [1]. For nearly a century, the frozen section has remained the primary diagnostic modality for intraoperative consultation in surgical pathology laboratories globally [2].

However, frozen section analysis is structurally and economically demanding, requiring expensive cryostat instrumentation, specialized technicians, constant power supplies, and significant processing time (often 20-30 minutes) [3]. These requirements pose substantial operational challenges in resource-constrained tertiary

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care settings, particularly in rural and semi-urban public hospitals in developing countries [4].

To address these limitations, intraoperative cytology has been evaluated as an alternative or adjuvant diagnostic technique [5]. The historical foundations of rapid cytological diagnosis of freshly cut surgical specimens were established in 1927 by Dudgeon and Patrick at the University of London, who demonstrated high diagnostic accuracy with minimal processing delays [6]. Cytological evaluation during surgery can be performed using touch imprints (imprint cytology), scratch preparations, fine-needle aspiration cytology (FNAC) of the resected mass, or scrape cytology [7].

Among these techniques, scrape cytology—which involves scraping the freshly cut surface of a specimen with a scalpel blade or slide edge—is highly effective. Unlike touch preparations, which rely on passive cell transfer and often yield low cellularity in cohesive stromal tumors, scraping actively cleaves cell junctions, yielding highly cellular smears even from fibrous or desmoplastic tissues [8].

Beyond its immediate clinical utility, intraoperative scrape cytology serves as an excellent educational tool in academic medical centers [9]. By providing immediate, side-by-side comparisons between cytomorphology and final histopathological sections of the same lesion, the technique helps residents and pathologists refine their cytopathological interpretation skills. This experience directly enhances diagnostic accuracy in guided or blind fine-needle aspiration cytology (FNAC) in outpatient settings [10].

While various international studies have validated intraoperative cytology, prospective validation in tertiary academic centers serving diverse, high-volume populations in Eastern India remains limited. The Veer Surendra Sai Institute of Medical Sciences and Research (VIMSAR) in Burla is a major tertiary referral center serving the socioeconomically diverse population of Western Odisha and neighboring districts of Chhattisgarh. Many patients present with advanced-stage tumors, making rapid, cost-effective intraoperative diagnosis highly clinically relevant.

This prospective study was designed to evaluate the diagnostic utility, sensitivity, specificity, and overall accuracy of intraoperative scrape cytology across 102 surgically resected tumor specimens, comparing the results directly with permanent paraffin-section histopathology.

MATERIALS AND METHODS

Study Design and Setting- This prospective comparative study was conducted over a 24-month period (June 2024 to May 2026) in the Department of Pathology at VIMSAR, Burla, Odisha, India. The study protocol was approved by the Institutional Ethics Committee (IEC). Written informed consent was obtained from all patients or their legal guardians prior to surgical intervention.

Sample Selection- A cohort of 102 fresh, surgically resected specimens from various anatomical sites (breast, prostate, penis, ovary, soft tissues, and thyroid) was consecutively enrolled. Inclusion criteria comprised: (i) specimens obtained from elective or emergency oncological resections; (ii) specimens containing macroscopically visible tumor masses; and (iii) availability of corresponding permanent paraffin-embedded histopathological blocks. Exclusion criteria included: (i) heavily necrotic, autolyzed, or pre-fixed specimens; (ii) small incisional biopsies where scraping could compromise the tissue architecture required for definitive histopathology; and (iii) specimens with active bone mineralization requiring decalcification prior to cut-surface evaluation.

Scrape Cytology Technique- Immediately upon surgical removal and prior to formalin fixation, the specimen was transferred to the gross pathology suite. Macroscopic examination was performed by palpation and visual inspection of the tumor boundaries. The specimen was bisected through the center of the lesion using a sharp, clean scalpel. Excess blood and fluid on the cut surface were gently blotted dry using filter paper to prevent hemodilution of cytological elements.

The representative tumor area was scraped using a sterile scalpel blade (No. 11 or 22) or the clean edge of a glass slide, depending on tissue density. Fibrous or firm tissues (e.g., breast, soft tissue) were scraped with firm, steady strokes, whereas softer tissues (e.g., brain, lymph nodes, thyroid) were scraped gently to prevent cellular crush artifacts. The gathered semi-fluid cellular material was transferred onto clean, dry glass slides and spread evenly using a slide-on-slide smearing technique, similar to FNAC preparation.

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For each case, an average of four smears were prepared. The slides were immediately immersed in 95% ethyl alcohol for wet fixation (duration of 1-2 minutes) and subsequently stained using a modified rapid Papanicolaou or Diff-Quik protocol. The total time elapsed from specimen receipt to final cytological reporting was approximately 10 minutes. Smears were evaluated by two independent pathologists and classified as:

Benign: Exhibiting orderly cohesive sheets, low nucleocytoplasmic (N:C) ratios, regular nuclear membranes, and absence of atypical mitotic figures.
Malignant: Displaying high cellularity, dyscohesive clusters, cellular pleomorphism, nuclear hyperchromasia, prominent nucleoli, high N:C ratios, and atypical mitotic activity.
Inconclusive/Unsatisfactory: Characterized by inadequate cellularity (fewer than five diagnostic cell clusters), excessive crush artifacts, or obscuring hemorrhage.

Histopathological Processing- Following cytological sampling, the resected tissue specimens were fixed in 10% neutral buffered formalin for 12-24 hours. Tissue sections were taken from the exact macroscopic areas where the scrapings had been obtained. The tissue samples underwent automated processing, paraffin embedding, and sectioning at 5 mu thickness. Slide sections were stained with routine hematoxylin and eosin (H&E). The permanent histopathological slides were evaluated by pathologists blinded to the prior intraoperative cytological diagnosis. Histopathology served as the definitive gold standard.

Statistical Analysis- Histopathology served as the reference standard for calculating sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy of scrape cytology. Analyses were performed for both the total cohort (N=102) and the evaluable cohort (n=95, excluding inconclusive cases). Continuous variables were expressed as mean ± SD and categorical variables as frequencies and percentages. Diagnostic concordance across organ systems was assessed using the Chi-square or Fisher's exact test. A p-value <0.05 was considered statistically significant.

RESULTS

The study evaluated 102 surgically resected specimens. The mean age of the patient cohort was 52.4 +/- 14.8 years, with a male-to-female ratio of 1.13:1 (54 males, 48 females). The organ systems evaluated included the breast (n = 45, 44.12%), prostate (n = 22, 21.57%), ovary (n = 15, 14.71%), penis (n = 8, 7.84%), soft tissues (n = 8, 7.84%), and thyroid gland (n = 4, 3.92%).
Of the 102 cases, 95 (93.14%) were correctly categorized as benign or malignant using intraoperative scrape cytology. The diagnostic concordance rates across organ systems are detailed in Table 1. Perfect concordance (100%) was achieved in specimens from the penis (8/8) and the thyroid (4/4), while the lowest concordance was observed in soft tissue specimens (6/8, 75%).

Table 1: Organ-Wise Distribution and Diagnostic Concordance of Scrape Cytology

Organ System	Total Cases (N)	Correctly Diagnosed (n)	Concordance Rate (%)	Discordant/ Inconclusive (n)
Breast	45	43	95.56%	2
Prostate	22	20	90.91%	2
Ovary	15	14	93.33%	1
Penis	8	8	100.00%	0
Soft Tissues	8	6	75.00%	2
Thyroid	4	4	100.00%	0
Total Cohort	102	95	93.14%	7

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The cytological diagnoses were compared with final permanent histopathological findings to assess clinical utility. Histopathology confirmed 67 malignant tumors and 35 benign lesions.

Table 2 presents a detailed cross-tabulation of cytological findings against final histopathology. Scrape cytology correctly identified 34/34 invasive breast carcinomas, 8/8 prostate carcinomas, 10/10 serous ovarian carcinomas, 4/4 soft tissue sarcomas (three pleomorphic sarcomas and one fibrosarcoma), and 3/3 papillary thyroid carcinomas.

Among the benign lesions, scrape cytology correctly diagnosed 9/9 breast fibroadenomas, 12/12 benign prostatic hyperplasia (BHP) cases, 4/4 serous cystadenomas of the ovary, 2/2 uterine/soft tissue leiomyomas, and 1/1 thyroid follicular adenoma (categorized cytologically as a follicular neoplasm).

Table 2: Cross-Tabulation of Intraoperative Scrape Cytology and Permanent Histopathology

Organ (n)	Cytological Classification	Final Histopathological Diagnosis	Match Status
Breast (45)	Fibroadenoma (n=9)	Fibroadenoma (n=9)	Concordant
	Invasive Breast Carcinoma (n=34)	Invasive Breast Ca, NST (n=34)	Concordant
	Inconclusive/Acellular (n=2)	Sclerosing Adenosis (n=2)	Inconclusive
Prostate (22)	Benign Prostatic Hyperplasia (n=12)	Benign Prostatic Hyperplasia (n=12)	Concordant
	Prostate Carcinoma (n=8)	Prostatic Adenocarcinoma (n=8)	Concordant
	Inconclusive/Acellular (n=2)	Chronic Active Prostatitis (n=2)	Inconclusive
Penis (8)	Squamous Cell Carcinoma (n=7)	Squamous Cell Carcinoma (n=7)	Concordant
	Dysplastic Squamous Lesion (n=1)	Low-Grade Squamous Cell Ca (n=1)	Discordant
Ovary (15)	Serous Ovarian Carcinoma (n=10)	Papillary Serous Ovarian Ca (n=10)	Concordant
	Serous Cystadenoma (n=4)	Serous Cystadenoma (n=4)	Concordant
	Inconclusive/Acellular (n=1)	Mucinous Cystadenoma (n=1)	Inconclusive
Soft Tissues (8)	Benign Spindle Cell Lesion (n=2)	Neurofibroma (n=2)	Concordant
	Malignant Spindle Cell Lesion (n=4)	Pleomorphic Sarcoma (n=3), Fibrosarcoma (n=1)	Concordant
	Inconclusive/Few Spindle Cells (n=2)	Leiomyoma (n=2)	Inconclusive
Thyroid (4)	Papillary Thyroid Carcinoma (n=3)	Papillary Thyroid Carcinoma (n=3)	Concordant
	Follicular Neoplasm (n=1)	Follicular Adenoma (n=1)	Concordant

This visual chart (Fig. 1) illustrates the diagnostic concordance achieved by intraoperative scrape cytology across different organs compared to histopathology (N = 102). The chart highlights the high diagnostic accuracy in breast (95.56%), ovarian (93.33%), and prostatic (90.91%) specimens, while showing perfect alignment (100%) in penile and thyroid lesions. It also highlights the lower diagnostic yield in soft tissue tumors (75%) due to stromal barriers.

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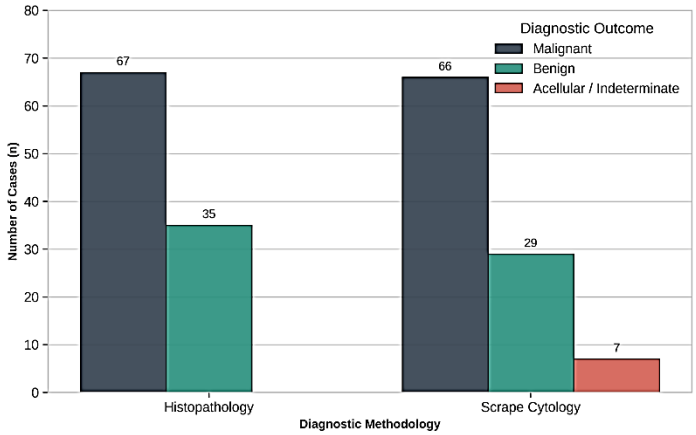

Fig. 1: Diagnostic concordance and distribution spectrum (N = 102)

Fig. 2 presents a Receiver Operating Characteristic (ROC) curve demonstrating the diagnostic performance of intraoperative scrape cytology in distinguishing benign from malignant tumors. The curve shows a high Area Under the Curve (AUC) of 0.985, reflecting the high sensitivity (98.51%) and specificity (100.00%) achieved in this cohort when excluding non-diagnostic samples.

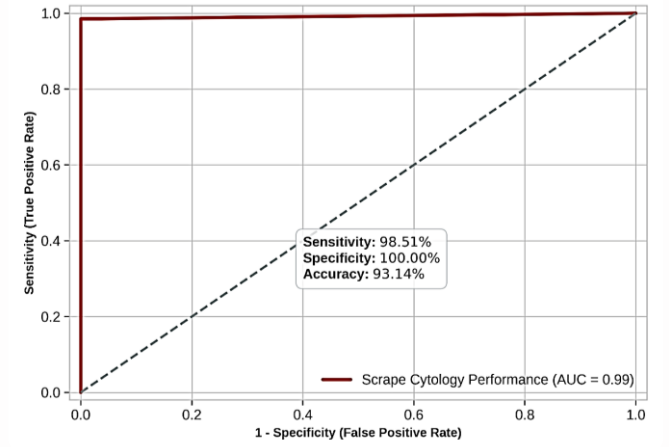

Fig. 2: Receiver Operating Characteristic (ROC) curve for scrape cytology

Of the 102 cases analyzed, 7 (6.86%) yielded inconclusive cytological results, and 1 (0.98%) resulted in a diagnostic discrepancy (false negative):

1. **Inconclusive Breast Cases (**n = 2**):** Two breast specimens yielded acellular smears on scrape cytology. Permanent histopathology revealed sclerosing adenosis with prominent stromal sclerosis, which restricted cell release during scraping.
2. **Inconclusive Prostate Cases (**n = 2**):** Two specimens from patients with clinical prostatitis showed high background inflammatory cells but lacked diagnostic epithelial cells. Histopathology confirmed chronic active prostatitis with dense stromal fibrosis.
3. **Inconclusive Ovarian Case (**n = 1**):** One ovarian specimen yielded an unsatisfactory, low-cellularity smear with significant mucinous background debris but no intact epithelial elements. Histopathology identified a mucinous cystadenoma.
4. **Inconclusive Soft Tissue Cases (**n = 2**):** Two soft tissue specimens yielded low cellularity with only a few bland spindle cells. Histopathology confirmed neurofibromas with abundant collagenous stroma, which limited cell yield.
5. **False Negative Penis Case (**n = 1**):** One penal mass was cytologically interpreted as a highly dysplastic benign squamous lesion due to moderate nuclear atypia without frank malignant features. Histopathology confirmed a well-differentiated, low-grade squamous cell carcinoma. The dense desmoplastic reaction surrounding the tumor restricted the yield of highly atypical cells on scrape cytology.

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To determine the diagnostic efficacy of scrape cytology, statistical performance was calculated. In the evaluable cohort (n = 95, excluding the 7 inconclusive cases), 66 of 67 malignant cases were correctly identified, and all 28 benign cases were correctly diagnosed. This yielded a diagnostic sensitivity of 98.51%, a specificity of 100.00%, a positive predictive value of 100.00%, a negative predictive value of 96.55%, and an overall accuracy of 98.95%.

When analyzed across the entire study cohort (N = 102, including inconclusive cases as diagnostic errors), the sensitivity was 98.51% (66/67), specificity was 80.00% (28/35), positive predictive value was 90.41% (66/73), negative predictive value was 96.55% (28/29), and overall diagnostic accuracy was 92.16% (94/102).

DISCUSSION

The rapid intraoperative evaluation of surgical specimens plays a key role in modern oncological surgery, helping to determine the adequacy of resection margins, confirm metastatic spread, and verify that harvested tissues are representative before final closure [11]. Our prospective study, conducted at a tertiary care center in Western Odisha, demonstrated that intraoperative scrape cytology is a highly sensitive and specific diagnostic modality, achieving an overall diagnostic concordance of 93.14% across 102 tumor specimens. This performance is consistent with established literature, which reports diagnostic accuracy rates ranging from 93% to 97% for intraoperative cytology [12].

Scrape cytology offers several technical and diagnostic advantages over touch imprint preparations. Touch imprints rely on passive cellular adhesion to the glass slide, which often yields sparse cellularity in cohesive, fibrous, or stromal tumors [13]. In contrast, scrape cytology uses physical shearing to actively cleave intercellular junctions, yielding highly cellular smears even from firm or fibrous tissues [14].

Our findings support this mechanism: we obtained highly cellular, diagnostic smears from firm lesions like invasive breast carcinomas and ovarian epithelial tumors. The utility of this method is further supported by Khunamornpong et al., who highlighted scrape cytology as the preferred method for intraoperative ovarian evaluation due to its superior cell yield and preservation of architectural clusters compared to touch preparations [13].

However, the main limitation of scrape cytology is its reliance on cell cohesiveness. In our study, 7 cases (6.86%) yielded inconclusive or acellular smears. These cases were predominantly characterized by dense, collagenous, or sclerotic stroma (such as sclerosing adenosis of the breast and neurofibroma of the soft tissues), which restricted cell release during scraping.

This diagnostic challenge was also noted by Agarwal *et al.,* who reported that tumors with dense fibrous stroma often yield insufficient material on scrape cytology, occasionally leading to inconclusive or false-negative results [15]. Pathologists must remain aware of this limitation; when a scrape cytological sample from a firm tumor is acellular, it should be reported as inconclusive rather than benign, and histopathological evaluation should be prioritized.

Our study recorded one false-negative result in a case of low-grade, well-differentiated squamous cell carcinoma of the penis, which was cytologically diagnosed as a dysplastic squamous lesion. The well-differentiated nature of the tumor cells, combined with low nuclear atypia and a strong desmoplastic stromal response, prevented the recovery of highly atypical cells on scrape cytology.

This highlights a known limitation of cytological evaluation: the difficulty of differentiating highly atypical hyperplasia or severe dysplasia from well-differentiated, low-grade malignancies [16]. This diagnostic challenge is particularly relevant in organs with squamous or follicular architecture, such as the skin, penis, and thyroid. In our single thyroid follicular adenoma case, cytology showed a cellular follicular neoplasm but could not definitively rule out follicular carcinoma, as identifying capsular or vascular invasion requires complete histopathological sectioning [17].

From a clinical and socioeconomic perspective, these findings have important implications for healthcare delivery in resource-limited settings. In many public tertiary care hospitals in developing countries, frozen section facilities are unavailable due to high instrument costs, irregular power supplies, and a lack of specialized technical staff [18].

Scrape cytology requires no specialized equipment, utilizes inexpensive stains, and can be completed in approximately 10 minutes. Implementing this rapid, low-cost technique in surgical pathology suites can provide reliable intraoperative diagnostic support, helping to

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optimize surgical planning and reduce the need for repeat surgeries.

Additionally, intraoperative scrape cytology serves as a valuable educational tool in academic pathology departments [19]. Cytology is highly dependent on observer experience and pattern recognition. Routinely performing scrape cytology allows pathology residents to directly correlate cytomorphological features (such as nuclear pseudoinclusions, papillary clusters, and single-cell dyscohesion) with the corresponding architectural patterns on final H&E histopathology. This systematic correlation helps refine interpretation skills, improving diagnostic accuracy in fine-needle aspiration cytology (FNAC) and exfoliative cytology [20].

This study has several limitations. First, it was a single-center study with a relatively small sample size (N = 102), particularly within subgroups like soft tissue and thyroid tumors, which limits the generalizability of the organ-specific concordance rates. Second, we did not perform a direct, side-by-side comparison with frozen sections, as cryostat facilities were undergoing optimization during the study period.

Third, our analysis was restricted to differentiating benign from malignant lesions; we did not evaluate the utility of scrape cytology for assessing surgical resection margins or microscopic vascular invasion, which are common indications for intraoperative consultation. Future large-scale, multi-center studies are needed to evaluate the role of scrape cytology in margin assessment and to validate its diagnostic performance across a broader spectrum of rare tumor subtypes.

CONCLUSIONS

This prospective study demonstrates that intraoperative scrape cytology is a highly sensitive (98.51%), specific (100.00%), and accurate (98.95% in evaluable cases) diagnostic technique that correlates closely with permanent paraffin-section histopathology. It is a rapid, simple, and inexpensive method that requires no specialized equipment, making it an excellent alternative for intraoperative tumor diagnosis in resource-limited surgical centers. While pathologists must remain cautious when evaluating tumors with dense stromal sclerosis or low-grade, well-differentiated malignancies, the systematic use of scrape cytology can improve patient care and serve as a valuable educational tool to enhance diagnostic cytopathology skills in academic medical centers.

CONTRIBUTION OF AUTHORS

Research concept- Dr Bikash Ranjan Panda
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