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Feasibility and accuracy of touch imprint cytology for rapid cancer diagnosis in resource-constrained environments

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Abstract

Background: Conventional cancer diagnosis is largely dependent on histology and frozen sections (FS) and thus, presents challenges in resource-limited settings due to cost and technical demands. Conversely, Touch Imprint Cytology (TIC) is rapid, easy to perform, and requires less expertise and facilities. This study investigated TIC's diagnostic performance in Ghana.

Objective: This study investigated TIC's diagnostic performance in Ghana.

Methods: A descriptive cross-sectional study of 28 participants with suspected tumour lesions was conducted. Four tumour imprints were prepared for each sample: two smears were immediately fixed with 95% ethanol and stained with Papanicolaou stain, and the remaining two smears were air-dried and Giemsa-stained. The tissues from surgery were fixed in 10% neutral buffered formalin, processed into paraffin wax blocks, sectioned and stained with Haematoxylin and Eosin for histopathological analysis.

Results: TIC diagnosed 32.1% (n = 9), 60.7% (n = 17) and 7.1% (n = 2) cases as malignant, benign and atypical, respectively. Histopathology diagnosed 35.7% (n = 10) cases as malignant and 18 (64.3%) as benign. There was an almost perfect agreement between TIC and histopathology (Cohen's Kappa: 0.856). TIC showed high diagnostic performance, with a sensitivity of 90% (95% CI: 59.6% - 98.2%) and specificity of 100% (95% CI: 82.5% - 100.0%). The overall accuracy was 96.4% with 95%CI (82.3% - 99.4%)

Conclusion: TIC demonstrates high diagnostic accuracy for malignancies. Its ease of use and affordability support its potential as a viable substitute for FS and a valuable adjunct to histopathology in resource-limited countries.

Keywords: Touch imprint cytology, intraoperative diagnosis, rapid cancer diagnosis

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INTRODUCTION

Globally, an estimated 19.3 million new cancer cases occurred in 2020, and 10.0 million cancer deaths were recorded [1]. The number of cancer cases is predicted to increase due to the ageing population and adoption of high cancer-risk lifestyles, particularly smoking, in economically developing countries [2]. hence the urgent need for rapid and precise diagnostic procedures [3,4]. Currently, histopathological diagnosis confirmatory test for cancers [5], and frozen-section analysis is widely

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used in developed countries to provide rapid intraoperative guidance for therapeutic decision-making, including ruling out malignancy, confirming provisional diagnoses, and assessing margin status [6,7]. Intraoperative diagnosis is critical for achieving negative surgical margins and, hence, reducing the risk of local tumour recurrence [8].

Developing countries in sub-Saharan Africa face numerous challenges in histopathological diagnosis and frozen-section analysis due to a lack of required infrastructure and equipment, as well as the availability of only a few consultant pathologists [9,10]. Frozen section analysis requires sophisticated and expensive equipment/facility (such as a cryostat and a constant supply of electricity) as well as technical expertise [11,12]. Even though several efforts have been made to address these challenges, including training of pathologists with international support [13], surgical pathology services in Ghana remain poor. This necessitates a viable alternative that is quicker, cheaper, and requires less expertise, such as touch imprint cytology.

Touch imprint cytology has the advantage of being relatively simple to perform, non-invasive, and a quick procedure that does not alter tissue or produce unwanted artefacts [14]. The specificity, sensitivity and diagnostic accuracy of TIC are relatively at par with FSA; thus, TIC can be used as an intraoperative assessment of cancer and a good alternative to intraoperative FSA [15]. The most common reason for a frozen-section evaluation is the need for a quick decision during a surgical operation to distinguish between benign and malignant neoplasms for intraoperative or postoperative patient management [16]. Frozen section analysis is very expensive and requires precision, skill, and competency [17]. In developing countries where the use of a cryostat is not financially feasible, touch-imprint cytology may play an important role in intraoperative diagnosis [18]. TIC has been applied in a wide range of cancers, including lung cancer [19]; oral squamous cell cancer [14]; liver, bone and soft tissue masses, lymph node [20], bone marrow aspirate [21], prostate core biopsies [22] and Sentinel lymph nodes for breast cancer [23].

In all these cancer specifics, there was no statistically significant difference in the accuracy of categorical diagnosis between TIC and final histological diagnosis. Also, TIC was found to detect macro-metastasis and micro-metastasis to a lesser degree [24]. Hence, for the first time, this study sought to investigate the role of TIC for intraoperative diagnoses in Ghana.

MATERIALS AND METHODS

Study area

This study was a hospital-based, descriptive, cross-sectional study conducted using biopsy specimens suspected of malignancy between November 2021 and December 2022 at the Histopathology Laboratory in the Department of Pathology, Komfo Anokye Teaching Hospital (KATH). KATH in Kumasi, Ashanti Region, Ghana, is the second-largest hospital in Ghana and the only tertiary health institution in the Ashanti Region. The facility serves as a referral hub for other hospitals in the central and northern regions of Ghana.

Study population and sampling

A total of 28 patients with clinically suspected malignancies referred for specialist diagnostic evaluation were consecutively recruited for this study. The study population consisted of 30 eligible patients during the study period. The number was small because many patients in Ghana do not seek care early and are referred to the diagnostic unit only when the disease has progressed. Consecutive sampling was used to minimise selection bias, as all eligible patients who presented during the study period were included without the investigator's discretion. Based on this accessible population, the Yamane formula yielded a required sample of 28. Although a priori sample size calculation for sensitivity and specificity was not feasible due to limited local prevalence data, the precision of our estimates is indicated by the 95% confidence intervals reported for sensitivity and specificity.

Inclusion and exclusion criteria

Patients of all ages and genders presenting with clinically identified mass lesions were eligible. All participants were newly diagnosed with no prior confirmatory testing. Informed consent was obtained from each participant.. Patients with inflammatory lesions or non-diagnostic smears, including poor cellularity, air-drying artefact, or excessive blood obscuring the sample, were excluded.

Sample collection and processing for Touch Imprint Smears

Study samples were obtained from excised biopsies by directly sampling the lesion site to ensure maximum yield of diagnostic cells. Biopsies were obtained through surgery, and areas of the individual tumour biopsies were cut, one at a time. Blood from the outer surface of the tumour part was gently cleaned with a cotton ball soaked in normal saline. Touch imprints were prepared immediately after excision by pressing the freshly cut tumour surface lightly onto a correspondingly labelled glass slide with gentle, even fingertip pressure for 2–5 seconds, ensuring that the imprint covered not less than 60% of the slide surface. Only a single touch was made per slide to minimise cell distortion and blood contamination.

The imprint protocol was in accordance with the procedure outlined by Zafar et al. [18]. For each specimen, four labelled glass slides were imprinted. Two slides were immediately sprayed with 95% ethanol within 30–60 seconds of preparation and subsequently stained with Papanicolaou stain, while the other two were allowed to air dry completely and then stained with Giemsa stain. Imprints were made only from viable, non-necrotic tumour surfaces. If a surface was excessively bloody or wet, the slide was discarded and the imprint repeated on another

slide until a barely opaque imprint was obtained; on average, four slides were prepared per specimen.

Staining procedures for touch imprint smears

Two slides from each specimen were fixed in 95% ethanol (BDH Chemicals Ltd., UK) [25] within 30–60 seconds of imprint preparation and stained using the standard Papanicolaou (Pap) method [26]. Briefly, slides were hydrated through descending grades of ethanol (95%, 80%, 70%; 2 minutes each), rinsed in distilled water, and stained in Harris hematoxylin (Sigma-Aldrich, USA) for 5 minutes [27]. After bluing in Scott's tap water substitute (2 minutes), slides were dehydrated in 70% ethanol and counterstained in OG-6 (Sigma-Aldrich) for 2 minutes, followed by EA-50 (Sigma-Aldrich) for 3 minutes. Slides were dehydrated in ascending alcohol grades (95% and absolute ethanol, 2 minutes each), cleared in xylene (2 changes, 5 minutes each), and mounted with DPX mountant (Merck, Germany). The other two slides were air dried and subsequently stained using the May–Grünwald–Giemsa (MGG) method [28].

Air-dried smears were fixed in absolute methanol (BDH Chemicals Ltd.) for 3 minutes, then stained with May–Grünwald solution (Merck) diluted 1:1 with phosphate buffer (pH 6.8) for 5 minutes. Without washing, slides were transferred into freshly diluted Giemsa solution (1:10 in phosphate buffer, pH 6.8) for 15 minutes. After gentle rinsing in buffered water, slides were air-dried at room temperature and mounted with DPX. All staining procedures were carried out in accordance with the protocols outlined by Bancroft et al. [29].

Histopathology of tumour mass fixed in formalin

After touch imprint, the tumour was fixed immediately in 10% neutral buffered formalin. The formalin fixed tissues were grossed and processed to paraffin wax blocks, sectioned at 3 µm and stained with Haematoxylin and Eosin stains.

Blinding and Reproducibility

Each specimen was assigned a unique study identification number by laboratory staff not involved in slide interpretation or analysis at the time of collection. Cytology smears and histopathology slides were labelled only with this code; no patient details, clinical information, or collection dates were available to evaluators. Cytology smears were independently examined by two cytologists, and histological evaluation was carried out prospectively. Discordant cytology cases were reviewed by a senior pathologist, who was blinded to prior results to ensure objective resolution. To assess reproducibility, inter-observer agreement was evaluated on a subset of 8 randomly selected slides that were double-reported independently by the two cytologists.

Inter-observer agreement was 75% (6/8 slides), with a Cohen's kappa of 0.55 (95% CI: 0.11 – 0.99), indicating moderate agreement. Intra-observer reproducibility was assessed on 10 slides re-examined by one cytologist after a 3-week washout period, yielding 90% concordance (9/10 slides) with a Cohen's kappa of 0.82 (95% CI: 0.48 – 1.00), reflecting almost perfect agreement. Although inter-observer agreement between cytologists was moderate, overall TIC agreement with histology remained high. Most discordant cytology readings occurred on atypical or borderline slides, whereas most slides were concordant with histology, resulting in strong overall diagnostic performance.

Statistical analysis

The conclusions for tumour characteristics and the final diagnoses for both touch imprint cytology and histopathological findings were entered, coded, edited, and cleaned in Microsoft Excel 2016. All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) Version 26.0 (Chicago IL, USA) [30] and GraphPad Prism version 8.0 (GraphPad Software, San Diego, California, USA, www.graphpad.com) [31]. Descriptive statistics were used to examine the distribution of the study variables. Categorical variables were presented as frequencies (n) and percentages (%). The nuclear and cytoplasmic staining indices between Giemsa and Pap stains were compared using the Chi-square test. Inter-rater agreement between the two methods (touch imprint cytology versus histopathology) was determined using Cohen's Kappa method. P-values less than 0.05 ($p < 0.05$) were considered statistically significant. Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of touch imprint cytology were calculated according to the following formulas: Sensitivity = True positive / (True positive + False negative) [32]; Specificity = True negative / (True negative + False positive) [32]; PPV = True positive / (True positive + False positive) [32]; NPV = True negative / (True negative + False negative) [32]; Accuracy = (True positive + True negative) / Total number of samples [32].

Cellularity Assessment

Touch imprint smear cellularity was graded as scant (+), moderate (++) and high (+++) based on the criteria used by Layfield, et al. [33] where low cellularity (scant) represented 1-10 cell clusters per field, moderate and high cellularity defined as 11-30 cell clusters per field and more than 30 cell clusters per field, respectively.

Assessment of Nuclear and Cytoplasmic Staining

A field with adequate cellularity was used for the evaluation of the cells in each slide. The cytoplasmic staining were assessed using a 3-point scale from Sujathan et al [17] as follows: 0—Cytoplasmic details not preserved, transparent; 1—Non-transparent, masking of nuclear details; 2—Transparent cytoplasm, without masking nuclear details. The nuclear staining was assessed as follows: 0—Poor preservation and Smudgy; 1—Fair preservation, chromatin not appreciable; 2—Excellent preservation with crisp chromatin. To ensure consistency in rating the slides, only values with agreement were included in the assessment; any discordance was resolved through simultaneous slide

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observation by the observers, and concordance was reached.

Criteria for TIC diagnoses

The cytological samples were classified according to the criteria outlined by Tsou et al [34] as follows:

The smear was categorised as negative for malignancy if there was no evidence of malignancy, such as hyperchromasia, a high Nuclear to Cytoplasmic ratio, pleomorphism, coarse chromatin, or irregular nuclear outlines.

Atypical: The smears were labelled as atypical when a small number of abnormal squamous epithelial cells were identified, showing features such as irregular cell shape, although they did not meet the criteria for benign or malignant classification. For analysis, TIC results were categorised as malignant (positive) or benign (negative). Smears showing atypical features were included in the benign category to allow binary classification for the calculation of diagnostic accuracy measures.

Benign: Benign classification was assigned to smears containing a small population of epithelial cells with moderately enlarged nuclei, an elevated nuclear-cytoplasmic ratio, and moderately hyperchromatic nuclei with prominent or multiple nucleoli. Malignant: Smears were classified as malignant when they showed enlarged nuclei with an increased nuclear-to-cytoplasmic ratio, hyperchromatic nuclei with prominent or multiple nucleoli, and the presence of mitotic figures.

RESULTS

Baseline characteristics of the study population

In this study, a total of 28 participants were included, with the majority (78.6%) being females and males accounting for a third (21.4%) of the study population. The participants' age range was 23 - 85 years, with more than half (67.8%) aged 30 - 59 years. Participants aged ≥80 years were the fewest (4.2%) in the study. The mean age of the participants was 47.93 ± 15.49 years, as shown in Table 1.

Tumour distribution and cellularity assessment of imprints

The study involved tumour imprints from ten different body sites. More than one-fourth (35.7%) of the tumours were from the breast. One-fourth 7(25.0%) of the tumours were from the myometrium. The highest cellularity yield was observed in breast imprint (5), followed by thyroid (3). An increased moderate cellularity yield was seen in breast imprint (5) (Figure 1a), followed by the myometrium (4) and then the thyroid (2). Imprints from the myometrium were observed to have the highest number of scant cellularity (2) (Figure 1b).

Nuclear and cytoplasmic staining characteristics of Giemsa and pap stain

Pap-stained slides (Figure 2a) showed better nuclear and cytoplasmic details in comparison to Giemsa stain (Figure 2b). The nuclear and cytoplasmic staining characteristics by pap stain (1.92 and 1.98) were higher compared to Giemsa stain (1.13 and 1.08). There was a significant difference between Pap and Giemsa staining of nuclei and cytoplasm ($p < 0.01$) (Table 2).

Comparison of TIC diagnosis to histopathological reports

Analyses were classified as malignant, benign, or atypical based on the cytological features of the cells observed under the microscope. The majority (five) of the malignant cells observed were from the breast. The malignant cases represented more than a quarter (32.1%) of the total cases. The benign cases observed were more than half (60.7%) of the total cases. Only 7.1% (n = 2) of the cases were diagnosed as atypical. Out of the 28 tumour cases, TIC diagnosed 60.7% (n = 16) cases as benign. The histology report of these tumours affirmed they were all benign (Table 3)

Inter-Rater agreement between touch imprint cytology and histopathology

The concordance between touch imprint cytology and histopathology was an almost perfect agreement with a Cohen's Kappa of 0.856 (Table 4).

Accuracy of touch imprint cytology

For the primary analysis, TIC results were categorised as malignant (positive) or benign (negative), with atypical smears included in the benign category to allow binary classification. This analysis yielded a sensitivity of 90% (95% CI: 55.5 – 99.7%), specificity of 100% (95% CI: 81.5 – 100%), positive predictive value (PPV) of 100%, negative predictive value (NPV) of 94.7%, and overall accuracy of 96.4% (Table 5). To assess the impact of including atypical smears as benign, a sensitivity analysis excluding the two atypical smears was performed. In this analysis, the sensitivity was 100% (9/9; 95% CI: 66.4 – 100%), specificity was 100% (17/17; 95% CI: 80.5 – 100%), and PPV 100% (26/26; 95% CI: 86.8 – 100%) (Table 6). These results demonstrate that classifying atypical smears as benign in the primary analysis did not substantially alter the diagnostic accuracy of TIC.

Table 1. Baseline characteristics of study participants

Age category (Years)	Frequency (N= 28)	Percentage (%)
20-29	3	10.7
30-39	6	21.4
40-49	7	25
50-59	6	21.4
60-69	4	14.3
≥ 80	2	7.1
Gender		
Male	6	21.4
Female	22	78.6

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Table 2. Staining indices of Pap and Giemsa stains

Stain	Mean	Standard Deviation	p-value
Pap (nuclear)	1.92	0.82	Pap vs Giemsa (nuclear) < 0.01
Giemsa (nuclear)	1.13	0.84	
Pap (cytoplasmic)	1.98	0.89	Pap vs Giemsa (cytoplasmic) < 0.01
Giemsa (cytoplasmic)	1.08	0.79	

Table 3. Comparison of TIC diagnosis to histological reports

TIC Diagnosis	Number (n)	Histological Diagnosis	Number (n)
Malignant		Malignant	
Rectum	1	Adenocarcinoma of Rectum	1
Sub mandible	1	Diffuse Large B Cell Non-Hodgkin's Lymphoma	1
Breast	5	Invasive Carcinoma	3
		Invasive Carcinoma NST	2
Thyroid	1	Papillary carcinoma	1
Gastric	1	Invasive Moderately Differentiated Adenocarcinoma	1
Benign		Benign	
Thyroid	5	Multinodular colloid goitre	4
		Toxic goitre	1
Breast	4	Hamartom	1
		Fibrocystic Disease	3
Myometrium	7	Leiomyoma	7
Appendix	1	Appendicitis	1
Atypical		Atypical	
Breast	1	Fibroadenoma (Benign)	1
Bowel	1	GIST (Malignant)	1
Total (n)	28		28

Table 4. Inter-rater agreement between histopathology and TIC

Histopathology	Malignant	Benign			Kappa interpretation	P value
Touch imprint						
Malignant	9	0	Cohen's Kappa	0.856	Almost perfect	<0.001
Benign	0	17				
Atypical	1	1				

Table 5. Diagnostic performance of touch imprint cytology compared with histopathology (primary analysis: Atypical included as benign)

Measure	Estimate (Proportion)	Estimated values	95% CI lower (%)	95% CI upper (%)
Sensitivity	9/10	90.0	59.6	98.2
Specificity	18/18	100.0	82.5	100.0
Positive predictive value	9/9	100.0	70.1	100.0
Negative predictive value	18/19	94.7	75.4	99.1
Accuracy	27/28	96.4	82.3	99.4

DISCUSSION

Developing countries, including Ghana, encounter several challenges in surgical pathology services for effective cancer diagnosis, which is typically achieved through the use of histopathological and frozen-section analyses. These surgical pathology challenges stem from financial, infrastructure and technical expertise constraints. This study sought to evaluate the diagnostic utility of touch imprint cytology for intraoperative diagnosis (which is expensive in Ghana) and as a viable alternative to histopathological diagnosis, which usually takes several weeks to generate diagnostic reports in a resource-limited setting such as Ghana. A total of 28 patients suspected of having tumours were recruited to evaluate the diagnostic utility in Ghana, with females accounting for the majority (78.6%, n = 22). We observed that all the sampled tumour cases yielded cellularity on touch imprint cytology, consistent with the

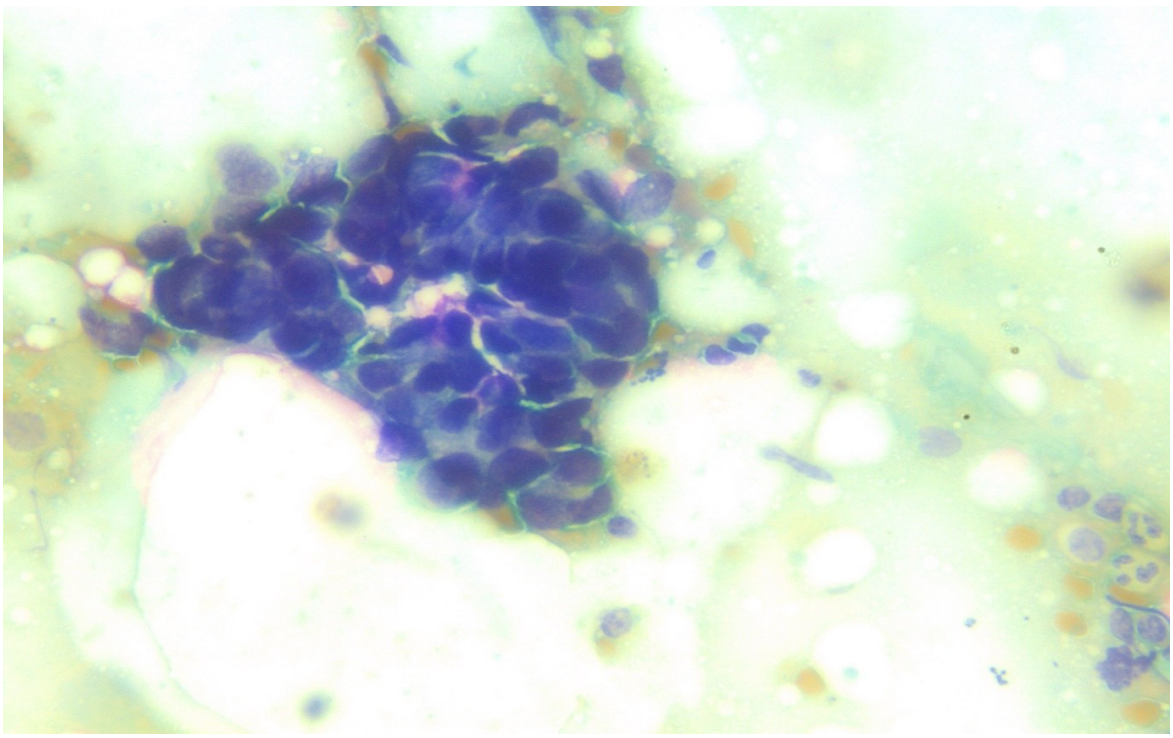

Figure 1a. A photomicrograph of malignant tumour cells showing high cellularity, cellular enlargement, increased nuclear/cytoplasmic ratio and nuclear hyperchromasia

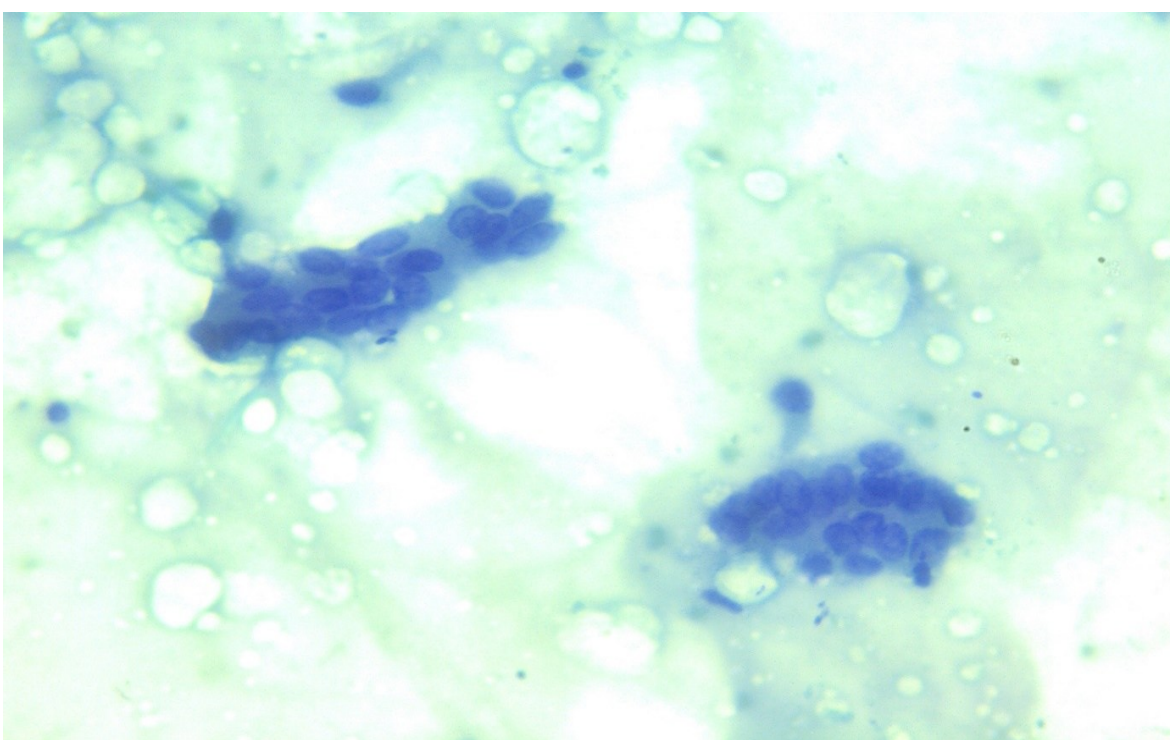

Figure 1b. A photomicrograph of benign tumour showing moderate cellularity and irregular nuclear membranes

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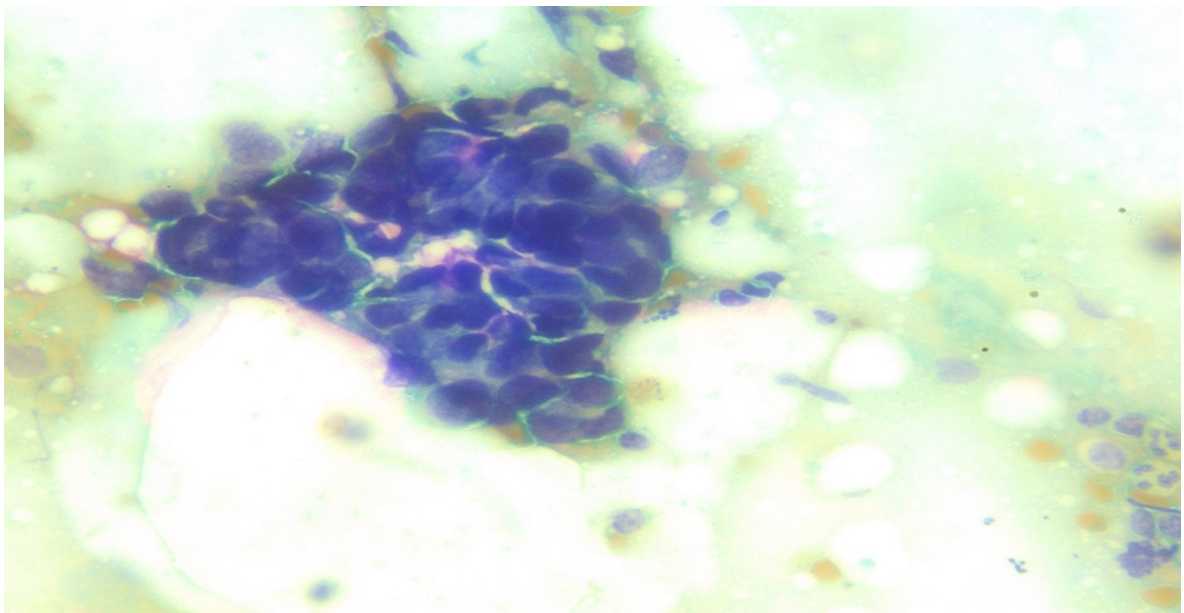

Figure 2a. A photomicrograph of malignant cells with well-preserved nuclei and cytoplasmic details from gastric imprint stained with Pap stain (Pap-stained slides showed better nuclear and cytoplasmic details)

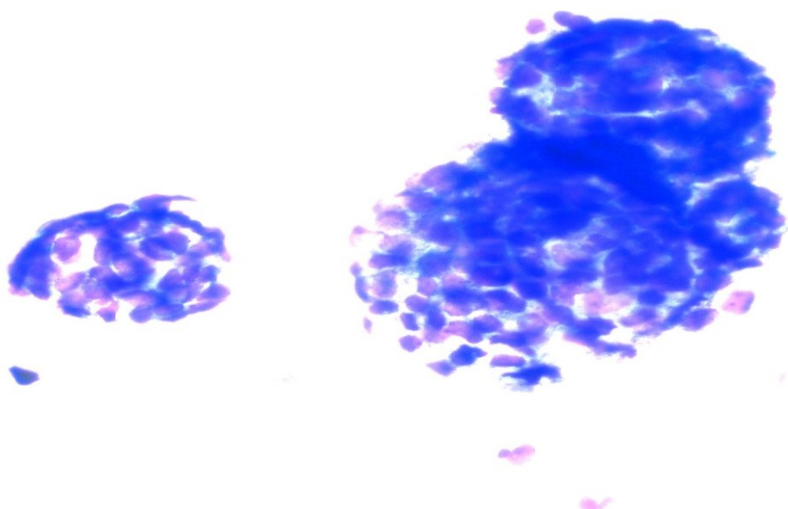

Figure 2b. A photomicrograph of a Giemsa-stained gastric imprint (Giemsa-stained slides showed poor nuclear and cytoplasmic details)

Table 6. Diagnostic performance of touch imprint cytology compared with histopathology (sensitivity analysis: atypical excluded)

Measure	Estimate (Proportion)	Estimated values	95% CI lower (%)	95% CI upper (%)
Sensitivity	9/9	100.0	66.4	100.0
Specificity	17/17	100.0	80.5	100.0
Positive predictive value	9/9	100.0	66.4	100.0
Negative predictive value	17/17	100.0	80.5	100.0
Accuracy	26/26	100.0	86.8	100.0

findings of Naveed et al. [35], who reported cellularity in all 70 of their samples. Decreased cellularity associated with TIC, as reported by Zafar et al. [18], largely depends on the sample preparation technique. In this study, tumour samples were carefully wiped with a cotton ball soaked in normal saline, which may have contributed to the high cellularity. However, different cellularity patterns were observed with respect to the various tumours. Cell imprints from breast tumours showed higher cellularity than those from the thyroid. Our current study contradicts prior work by Anila et al. [36], where hypocellularity was observed in thyroids. This is probably attributable to the sampling technique and immediate fixation of imprint smears.

Significantly, Pap-stained smears showed superior nuclear and cytoplasmic staining compared with Giemsa. The Pap-stained smears provided well-defined nuclear details. On the other hand, Giemsa-stained smears showed poor nuclear and cytoplasmic staining. Our result partially contradicts a study by Sidhu et al. [37] but is consistent with the findings of Zafar et al. [18]. Sidhu et al. [37] observed better nuclear staining with pap but poorer cytoplasmic staining than with Giemsa, whereas Zafar et al. [18] confirmed better nuclear and cytoplasmic staining with pap. Importantly, there was an almost perfect agreement between touch imprint cytology and histopathology (Cohen's Kappa: 0.856), comparable with Webala et al. [38]. Similarly, Moriki et al. [4, 39] demonstrated 100% concordance between cytology and histopathology.

Using histological diagnosis as the gold standard, we observed a sensitivity of 90.0%, specificity of 100.0%, a positive predictive value (PPV) of 100.0%, a negative predictive value (NPV) of 94.7%, with an overall diagnostic accuracy of 96.4% and a statistically significant agreement ($\kappa = 0.856$, $p<0.001$). Our findings are comparable to those of Vaidya et al. [4], who reported a sensitivity of 100.0%, specificity of 91.7%, PPV of 98.9%, and NPV of 100.0% in their intraoperative cytology study. Zafar et al. [18] reported a sensitivity of 90.9%, specificity of 94.7%, a PPV of 90.9%, and an NPV of 94.7%, which are comparable to our study results. Similar research findings have also been reported in studies conducted in low-resource settings across Africa. For instance, A study by Alice Kagongo et al. [40] in Kenya reported a sensitivity of 81.5%, specificity of 100%, PPV of 100%, and NPV of 25%, with an overall diagnostic accuracy of 90.75% and a statistically significant agreement ($\kappa = 53\%$, $p = 0.033$) between touch imprint cytology and histopathology. In other resource-limited settings, such as Pakistan, Naveed et al. [35] reported an overall diagnostic accuracy of 96.7% with a sensitivity and specificity of 96% and 100%, respectively, while the PPV and NPV of touch imprint cytology were 100% and 84%, respectively. These similarities highlight that, even in resource-constrained environments, touch imprint cytology remains a reliable and rapid diagnostic tool when performed by trained personnel. Although the study provides useful insights into the diagnostic value of touch imprint cytology, certain factors should be considered when interpreting the results. The single-centre design may limit the generalizability of findings to other settings with different patient populations and laboratory conditions. While TIC demonstrated high diagnostic accuracy in our study, the small sample size limits the precision of these estimates. Nevertheless, the inclusion of exact counts and confidence intervals provides statistical credibility and supports the feasibility of TIC for rapid cancer diagnosis in this setting. The relatively small sample size reduced statistical power and restricted subgroup analysis. While breast, myometrial, and thyroid lesions accounted for the majority of cases, the small sample size did not allow reliable statistical comparisons of diagnostic performance across these sites. However, preliminary observations suggested comparable diagnostic accuracy among them, aligning with previous reports on the versatility of touch imprint cytology in different tissue types. Additionally, the inclusion of heterogeneous tumour lesions could have introduced variability in smear quality and cellular yield, potentially influencing diagnostic precision. The technique is also operator dependent, and differences in smear preparation or interpretation may affect reproducibility. Despite these constraints, the findings support the practicality of touch imprint cytology as a rapid, cost-effective, and reliable adjunct or alternative to histopathology, particularly in resource-limited settings. However, TIC should not be considered a full substitute for frozen section at this stage, and its wider clinical use should undergo prior validation through larger multicentre studies.

Our study provides useful findings to guide surgeons and pathologists during cancer treatment. We recommend using TIC as a complementary diagnostic method to histology in the evaluation of malignant cases, especially when a rapid diagnosis is required. Future studies should include larger prospective validation studies involving multiple centres and the development of standardised training protocols for cytologists to enhance reproducibility and diagnostic consistency.

Conclusion

The results of our study demonstrate the high accuracy of Touch Imprint Cytology, which is sensitive and reliable and can be used for intraoperative diagnosis when rapid diagnosis is needed in surgical management. Our findings also indicated that Pap staining provides better cellular details than Giemsa staining. Touch Imprint Cytology is an affordable technique that can be adopted for tumour diagnosis in developing countries with limited resources, such as Ghana.

DECLARATIONS

Ethical consideration

The study was approved by the Committee on Human Research, Publications and Ethics, School of Medical Sciences, Kwame Nkrumah University of Science and Technology and Komfo Anokye Teaching Hospital (KATH). The ethical approval reference is KATH

IRB/CA/149/21. The subjects were given a detailed description of the study's protocol and a guarantee of their confidentiality. Participants' written informed consent was also obtained. All methods were carried out under relevant guidelines and regulations.

Consent to publish
All authors agreed on the content of the final paper.

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Competing Interest
The authors declare no conflict of interest

Author contribution
EA, KOD, and BD conceptualised and designed the project. EA, KOD, BD, IK, AK, and BBA developed the methodology. EA, IK, BEP, MN, RS, and AKB recruited patients and performed laboratory experiments. EA and KO procured resources. EA, KOD, VCKT, and MN drafted the manuscript. EA and KOD reviewed cytology slides, while BEP, NKT, and PPSO reviewed histology slides. EA, KOD, BD, PPSO, NKT, CS, and NAB reviewed and edited the manuscript. EA, KOD, AK, and IK acquired funding and supervised the project. All authors approved the final manuscript.

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Availability of data
Data is available upon request to the corresponding author

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