RESEARCH PAPER

A Cytomorphometric and Cytopathological Evaluation of Cervico-Vaginal Smears (Pap Smears) in Patients with Type 2 Diabetes Mellitus

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ABSTRACT

Type 2 diabetes mellitus (T2DM) is associated with chronic hyperglycemia, leading to immune dysfunction, increased susceptibility to infections and metabolic stress- induced cellular alterations. These factors may influence cervical epithelial morphology and contribute to the persistence of Human papillomavirus infection and progression of cervical lesions. Cytomorphometric analysis offers an objective method to detect subtle cellular changes in cervical smears.

Aims and objectives: To comprehensively evaluate the cytological and cellular morphometric features of cervico-vaginal smears (Pap smears) in women with T2DM.

1. To determine the prevalence of epithelial cell abnormalities as per the Bethesda System (2014) in Pap smears of diabetic women.
2. To identify and compare the spectrum and frequency of specific vaginal infections (e.g., Candidiasis, Bacterial Vaginosis, Trichomoniasis) and inflammatory patterns in diabetic group.
3. To perform a quantitative cytomorphometric analysis of normal-appearing intermediate squamous cells in poorly controlled and well-controlled diabetic populations as per latest American diabetes association (ADA) 2026

a. Nuclear Diameter (ND) b. Cytoplasmic Diameter (CD) c. Nuclear-to-Cytoplasmic (N:C) Ratio

4. To correlate cytopathological findings (presence of epithelial cell abnormalities, inflammation, and infection) with the degree of glycemic control as measured by Glycated Hemoglobin (HbA1c) levels within the diabetic group.
5. To correlate the cytomorphometric parameters (ND, CD, N:C ratio) with the HbA1c levels within the diabetic group.
6. To investigate any association between the age of the patient, the diabetes, and the observed cytological changes.

Materials and Methods: This cross-sectional study was conducted at a tertiary care center in CHRI,Tamilnadu and included women. Cervical- vaginal smears were collected using conventional Pap smear technique and reported according to Bethesda system (2014). Cytomorphometric parameters namely CD, ND and N:C ratio, were measured using Image J software. Glycemic indices including fasting blood sugar (FBS), Postprandial blood sugar (PPBS) and HbA1c were documented. Data analysis was carried out using SPSS version 25, with ANOVA and t-tests; p

-value of less than 0.05 was considered statically significant.

Results: The study population demonstrated poor glycemic control (mean HbA1C: 8.49%) as per ADA 2026. Even though majority of cases were tested negative for intraepithelial lesion, significant number of epithelial abnormalities were observed including ASCUS (4.3%), LSIL (0.7%) and HSIL (2.9%). Infective conditions were present in 16.7% of cases, with Candida being the most common. Cytomorphometric analysis revealed increased nuclear diameter and a higher N:C ratio in patients with poor glycemic control. A statistically significant association was found between elevated HbA1c levels and increased N:C ratio($p=0.002$). Additionally, N:C ratio showed significant variation across cytological categories ($p <0.001$), increasing with severity of epithelial abnormalities.

Conclusion: Inadequate glycemic control in patients with Type 2 diabetes mellitus is significantly associated with cytomorphometric alterations in cervical squamous epithelial cells, characterised by nuclear enlargement, cytoplasmic reduction and increased N:C ratio. These changes may represent early indicators of epithelial atypia and increased susceptibility to cervical dysplasia. Increase in HbA1c is associated with squamous intraepithelial lesion. Incorporating

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cytomorphometric analysis into routine Pap smear screening may enhance early detection of epithelial abnormalities, particularly in high-risk diabetic patients. Strict glycemic control may play a role in maintaining cervical epithelial integrity and reducing disease progression.

Keywords: Type 2 Diabetes Mellitus, Pap smear, Cytomorphometry, HbA1c, Cervical epithelial abnormalities, Bethesda System, Nuclear to Cytoplasmic ratio, Glycemic control.
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INTRODUCTION

Metabolic syndrome (MetS), which is a group of disorders including hyperglycaemia, obesity, dyslipidemia, and hypertension has been identified as a risk factor for many cancers. Metabolic processes play a critical role in modulating the growth and regression of various cancers(1). Cervical cancer ranks as the fourth most frequently diagnosed cancer among women globally following breast, colorectal and lung cancers and contributes significantly in cancer related deaths among women in developing countries(2). Chronic hyperglycemia creates a state of impaired immunity, hormonal imbalance and local tissue vulnerability. Diabetes is known to be associated with:

- Increased risk of persistent Human Papillomavirus (HPV) infection due to immune dysfunction(3,4).
- Higher prevalence of vaginal infections (e.g., Candidiasis, Bacterial Vaginosis).
- Cellular changes due to metabolic stress, including cytological atypia(5)

While liquid-based cytology is the standard in developed nations, conventional Pap smear testing remains the primary screening method for cervical cancer in low-resource settings, where it effectively enables detection and prevention(6,7).The adoption of the revised Bethesda System has standardized the reporting of Pap smears by replacing overlapping terminologies with a unified framework. This system ensures laboratory reports include a descriptive diagnosis and an assessment of specimen adequacy. Employing this standardized approach, the current study was conducted to determine the prevelance of cervical epithelial abnormalities(8) For people with diabetes who are in good overall health , functioning well and at minimal risk from their treatment regimen, targeting a stricter A1C threshold , such as below 6.5% as per the latest ADA 2026, preprandial capillary plasma glucose of 80-130mg/dl and Peak postprandial capillary plasma glucose of below 180mg/dl are recommended(9).

MATERIALS AND METHODS

This study was carried out at Department of Pathology CHRI, Tamilnadu after obtaining IHEC approval. Pap smear is a screening procedure to obtain exfoliated epithelial cells from cervix, especially in the transformation zone, for cytological evaluation. The patient was counselled and informed to undergo Pap smear test in the mid-cycle period at 14th day of a period of cycle. Consent was obtained from patients undergoing conventional Pap smear test. Received a 95% ethanol fixed Pap smear which is then stained using standard Pap smear staining protocol. The study will include women with a confirmed diagnosis of Type 2 Diabetes Mellitus, as defined by the American Diabetes Association (2026 criteria), for a duration of at least one year. Participants will be categorized based on glycemic control into two groups: those with good control, defined as HbA1c < 6.5% over the past six months, and those with poor control, defined as HbA1c ≥ 6.5% over the same period. Exclusion criteria for both groups will include a history of hysterectomy; known pregnancy or a history of delivery or abortion within the preceding six months; known HIV infection or other immunocompromised states; prior cervical surgery such as loop electrosurgical excision procedure (LEEP) or conization; current or recent use of immunosuppressive therapy; and the presence of active pelvic inflammatory disease or severe vaginal bleeding at the time of sampling. Smears were examined under the Magnus advanced laboratory binocular microscope model MLXi- plus LED microscope and cytological evaluation was done.

High resolution digital images of the microscopic fields were taken from a using a Magnus advanced MLXi-plus LED microscope equipped with 10x and 40x ocular objective. Each image measured 1162x1280 Pixels, corresponding to 238.11x262.29µm (208 pixels for 50 µm) in image J analysis. Multiple fields were photographed from each slide, focusing on intermediate cells as it is the most common cell in early and mid age group woman. From these fields 20-25 cells per slide were selected according to the criteria of being well spread, non overlapping and clearly visible so that a proper and accurate analysis can be performed using image J analysis. All measurement were made using measurement tools in image J analysis software. Details of the parameter measured Cytoplasmic diameter (CD): The diameter was calculated as the diameter of a circle having an area equivalent to that of the outlined cell. Nuclear diameter (ND): The diameter was defined as that off a circle having an area equal to the measured nuclear area. Nuclear to cytoplasmic ratio (ND/CD ratio): Diameter of the nucleus/ cytoplasmic diameter. CD, ND are measured parameters, while NC Ratio is a calculated parameter.

STATISTICAL ANALYSIS

The cytonucleomorphometric parameters were analysed by comparing them with the diabetic (well and poorly) controlled group as well as among the study groups. Statistical analysis was performed using the statistical package for the social sciences (SPSS version 25), which was used to compute the mean, standard deviation and range for both nuclear and cytoplasmic features. One way analysis of variance (ANOVA) was applied to assess differences among groups. For intergroup comparisons, a post hoc comparison test was used. A value of less than 0.05 was considered statistically significant.

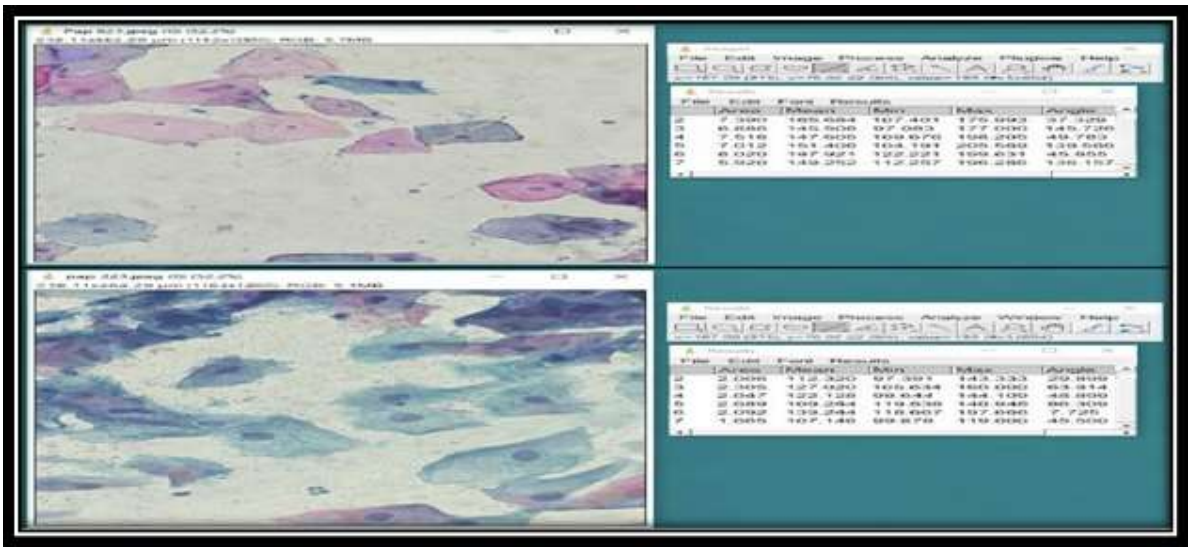

Figure 1: Measurement of cell and nuclear size using image J analysis software.

RESULTS

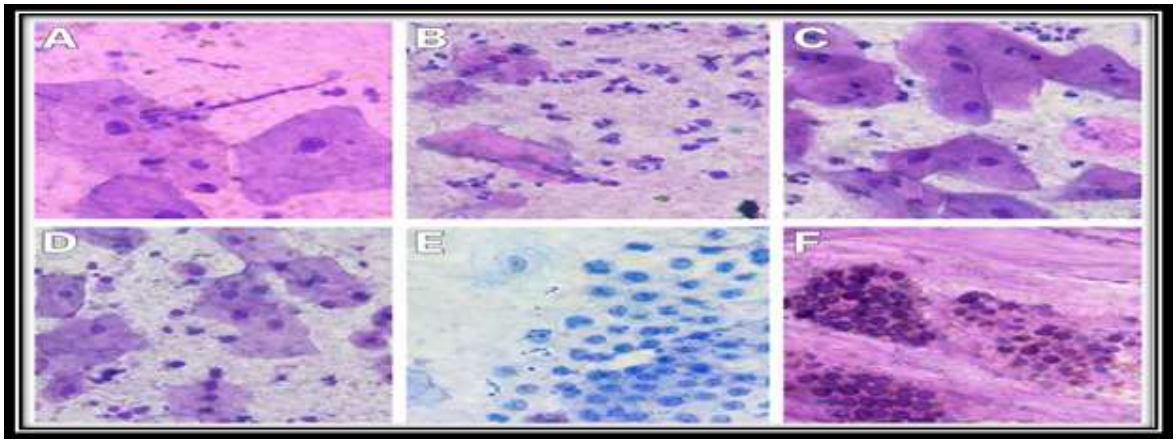

Figure 2- A – Highlights the hyphae form of candidia B- shows the Trichomaonas vaginalis C- Shows ASCUS(Atypical squamous cells of undetermined significance) D -LSIL- Low grade squamous intraepithelial lesion E- HSIL- high grade squamous intraepithelial lesion F- AGUS- Atypical glandular epithelial abnormality of undetermined significance.

Table 1: Descriptive Statistics of Glycemic and Cytomorphological Parameters analysed.

Variable	Mean	Std. Deviation	Minimum	Maximum	Normal Reference Range
FBS (mg/dL)	177.10	64.133	92	380	70–110 mg/dL
PPBS (mg/dL)	266.94	83.942	145	599	<140 mg/dL
HbA1c (%)	8.49	2.119	6.00	16.00	<5.7%
Cytoplasmic Diameter	30.83	4.889	13.26	44.24	30–50 µm
Nuclear Diameter	5.83	1.362	2.81	9.87	8–12 µm
N:C Ratio	0.194	0.054	0.107	0.409	~0.25–0.50

The descriptive analysis of glycemic and cytomorphological parameters indicates that the study population exhibits poor glycemic control, with mean FBS (177.10 mg/dL) and PPBS (266.94 mg/dL) exceeding normal ranges, and a mean HbA1c of 8.49%, suggesting chronic hyperglycemia. Cytomorphometric evaluation

revealed a mean cytoplasmic diameter of 30.83µm, which was within the lower normal range. The mean nuclear diameter was 5.83 µm, lower than the reference value, leading to a decreased mean N;C ratio of 0.194. These findings may represent early cytological alterations

associated with poor glycemic control and elevated HbA1C levels in individuals with diabetes mellitus.

Table 2: Frequency Distribution of Cytological Diagnosis with N:C Ratio

Diagnosis Category	Frequency	Percent	Category Type	NC Ratio
NILM (including inflammatory variants)	85	61.6	Normal	0.15 – 0.20
Reactive cellular changes	20	14.5	Benign	0.18 - 0.22
ASCUS	6	4.3	Epithelial abnormality	0.22 – 0.28
AGUS	3	2.1	Glandular lesion	0.25 – 0.30
ASC-H	2	1.4	Epithelial abnormality	0.28 – 0.35
LSIL	1	0.7	Epithelial abnormality	0.30 – 0.40
HSIL	4	2.9	Epithelial abnormality	0.40 – 0.60
Infections (Candida, BV, Trichomonas)	23	16.7	Infective	0.18 – 0.24

The cytological evaluation of study participants revealed that the majority (61.6%) had NILM, including inflammatory variants, indicating normal cytology. Reactive cellular changes , representing benign cellular alterations, were identifies in 14.5% of cases. Epithelial abnormalities were 11.4%, with ASCUS (4.3%), AGUS (2.1%), ASC-H (1.4%), LSIL (0.7%), and HSIL (2.9%), suggesting significant number of patients had cervical epithelial abnormalities. Infective findings, including Candida, bacterial vaginosis, and Trichomonas, were present in 16.7% of participants. Overall, the data indicate that most participants exhibited normal or benign cytology, with a significantl proportion showing epithelial atypia or infections.

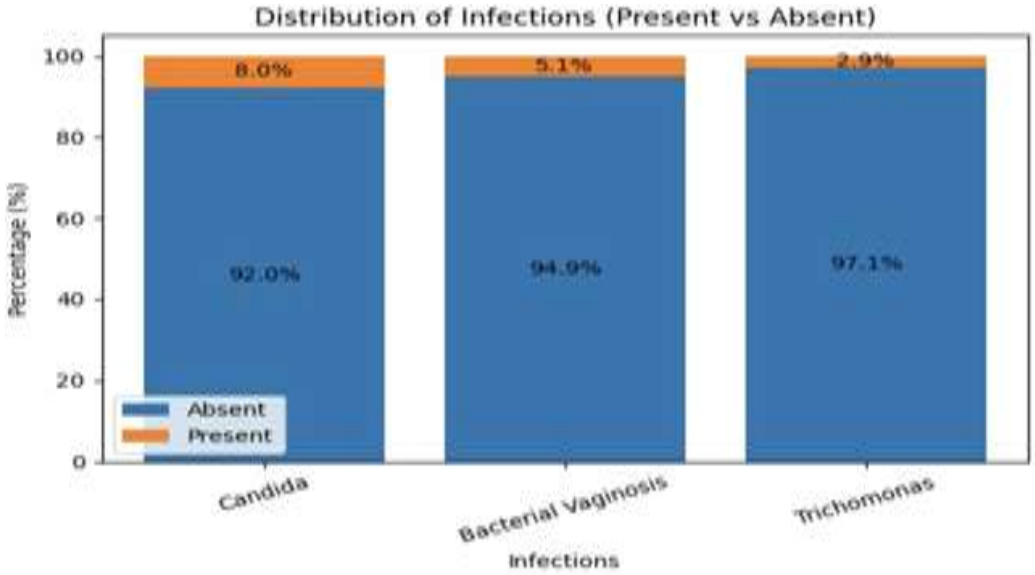

Figure 3: Distribution of Infection Among Diabetic Study Population

Fig 3 demonstrates the distribution of infection among study participants shows that the majority (92%) were free of infection, 8% had a positive Candida status, 5.1% had bacterial vaginitis and 2.9% had Trichomonas vaginalis. Totally 16% of the study population had infection which shows people with diabetes has higher risk of infection.

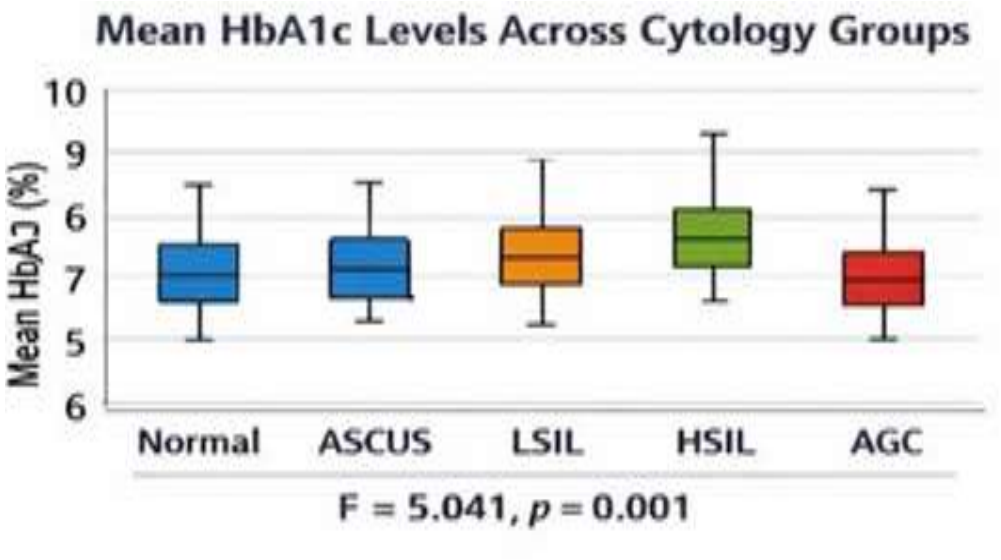

Figure 4: Mean Hba1c Levels Across Cytology Groups

This box and whisker plot comparing mean HbA1c(%) across different cytology groups. Mean HbA1c levels demonstrated a progressive increase across cytological categories, with the highest values observed in HSIL(Fig 4) A significant positive association was noted between worsening cytological abnormalities and elevated HbA1c levels. The trend was statistically significant (ANOVA: F=5.041, P=0.001)

Table 3: Comparison of Nuclear Size, Cytoplasmic Size, and N:C Ratio

Parameter	Under Control (HbA1c <6.5%) (n=28)	Not Under Control (HbA1c ≥6.5%) (n=110)
Nuclear Diameter (µm)	~5.2 ± 1.1	~6.0 ± 1.3
Cytoplasmic Diameter (µm)	~32.5 ± 4.5	~30.2 ± 4.8
N:C Ratio	0.165 ± 0.030	0.202 ± 0.055

The comparison of cytomorphological parameters between controlled and uncontrolled diabetic groups demonstrates notable cellular alterations associated with poor glycemic control. Participants with HbA1c ≥6.5% showed increased nuclear diameter and reduced cytoplasmic diameter compared to those with HbA1c <6.5%. Consequently, the N:C ratio was higher in the uncontrolled group (0.202 ± 0.055) than in the controlled group (0.165 ± 0.030). These findings indicate that chronic hyperglycemia contributes to nuclear enlargement and relative cytoplasmic reduction, reflecting early cellular atypia. Overall, poor glycemic control appears to significantly influence cytomorphological changes, supporting the role of HbA1c as an important indicator of cellular alterations.

Table 4: Association Between HbA1c Control Status and N:C Ratio

HbA1c Category	Frequency (n)	Mean	SD	t-value	p-value
Under control (<6.5%)	28	0.165	0.030	3.12	0.002
Not under control (≥6.5%)	110	0.202	0.055		
Total	138	0.194	0.054		

Combined analysis demonstrated that individuals with poor glycemic control (HbA1c ≥6.5%) had a significantly higher mean N:C ratio than those with controlled blood glucose levels. The association was statistically significant (p=0.002), suggesting a relationship between eleveated HbA1c levels and cytomorphological changes, especially an increase in the nuclear to cytoplasmic ratio.

Table 5: Comparison of Mean across various groups

Comparison of Mean HbA1C levels across Cytological Diagnosis Groupa					
Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	90.312	4	22.578	5.041	0.001
Within Groups	595.809	133	4.480		
Comparison of Mean Nuclear Size Across Diagnosis Groups					
Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	18.00	2	9.00	4.50	0.013
Within Groups	265.86	133	2.00		
Comparison of Mean N:C Ratio Across Cytological Categories					

Source	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.204	2	0.102	34.99	<0.001
Within Groups	0.388	133	0.0029		

Anova analysis demonstrated significant cytomorphological differences among the study groups (F=5.041, p=0.001). The variation in mean cytoplasmic and nuclear measurements between groups suggest an association between the study categories, such as HbA1C status and cellular morphology. These findings indicates that poor glycemic control may be associated with alterations in cytoplasmic and nuclear diameters, leading to increased N:C ratios. This supports the role of hyperglycaemia in influencing cervical cytological features and highlights the importance of maintaining adequate glycemic control. Comparison of the mean nuclear size among the diagnostic group also showed a statistically significant difference (F=4.50, P=0.013). The greater variation observed between groups compared to within groups suggests that factors such as HbA1C levels or other clinical classifications significantly affect the measured cytomorphological parameters. These observations may reflect underlying pathophysiological changes associated with altered glycemic status. Similarly, comparison of mean N:C ratio across different cytological categories revealed a highly significant difference (F= 34.99, p<0.001). This indicates that the nuclear-to-cytoplasmic ratio varies significantly with changes in cytological diagnosis. Higher N:C ratios are typically associated with increasing severity of epithelial abnormalities, reflecting nuclear enlargement and reduced cytoplasmic volume. Therefore, the null hypothesis is rejected. These findings suggest that N:C ratio is a useful cytomorphological parameter in distinguishing between different grades of cellular abnormalities and may aid in early detection and classification of precancerous lesions.

DISCUSSION

Cervical cytology continues to be the cornerstone in the early detection and prevention of cervical cancer, particularly in resource limited settings where conventional Pap smear screening remains widely utilized. In the present study, a combined cytomorphometric and cytopathological evaluation of cervical vaginal smear in patients with Type 2 diabetes, mellitus was undertaken to explore the impact of chronic hyperglycaemia on cervical epithelial cells.

The cytological evaluation of study participants revealed that the majority (61.6%) had NILM, including inflammatory variants, indicating normal cytology. Reactive cellular changes were observed in 14.5% and inflammatory smear in 24.6% of cases, reflecting benign alterations. Eventhough epithelial abnormalities were 11.4%, including ASCUS (4.3%), AGUS (2.1%), ASC-H (1.4%), LSIL (0.7%), and HSIL (2.9%) indicating significant number had intraepithelial lesions (Table 2). Infective findings, including Candida, bacterial vaginosis, and Trichomonas, were present in 16.7% of participants with the highest incidence of Candida (8%) (FIGURE 3) among infections in the diabetic population. The studies by Harisha et al(10) and Seth et al(11)study supports our study,showing that the majority had NILM(60.24% and 84%), other lesions being ASCUS (7.41% and 0.6%),ASC-H (4.89% and 0.6%), LSIL

(7.19% and 5.8%), HSIL (6.73% and 2.6%) AND AGC(1.6% and 1.9%) respectively, REACTIVE CHANGES(13.59%) AND INFECTIONS (20.55% and 30.8%) with Candida being the most prevelant (6.98% and 12.8%) amongst all and INFLAMMATORY SMEAR(50.76%) AND ATROPHIC SMEAR(26.65% and 10.3%) Infective conditions, including candida, bacterial vaginosis and Trichomonas infection were observed in considerable subset of patients. This finding alings with the established understanding that diabetes predisposes individuals to infection due to impaired immune response and altered vaginal microenvironment. These infections may also contribute to reactive cellular changes and should be carefully differentiated from true epithelial abnormalities during cytological evaluation. Although the majority of cases in the studied were categorised as NILM, a notable proportion demonstrated reactive changes, abnormalities and infections (Figure 4). The prevalence of pre-malignant lesions such as a HSIL and LSIL may reflect the study population characteristics. The presence of such lesions alongside elevated HbA1c levels, suggest a possible association between poor glycaemic status and progression of epithelial abnormalities supporting our study Harshita et al (10)shows poor control of diabetes with HbA1c >7% had increase incidence of cervical intraepithelial lesion compared to controlled diabetic patients (HbA1c<7%). The significant increase in mean HbA1c levels with worsening cytological diagnosis further supports this relationship indicating that chronic hyperglycaemia may act as a contributing factor in cervical epithelial dysplasia, which may also indicate the persistence of HPV infection in diabetes and the modulation of cervical epithelial cells(5,12) The findings of the study demonstrate that poor glycaemic control, as reflected by elevated HbA1c levels, is associated with measurable cytomorphological alterations (Table 3). Specifically, patients with uncontrolled diabetes exhibited increased nuclear diameter, reduced cytoplasmic diameter, and a consequent rise in the nuclear to cytoplasmic ratio which is supported by Sahay et al(13), who showed increased nuclear area and reduced cytoplasmic area in oral mucosal cells of diabetic patients. These changes are indicative of early cellular atypia and or consistent with the known effects of metabolic stress on cellular structure and function. Chronic hyperglycaemia is known to induce oxidative stress and the accumulation of advanced glycation end products within the walls of major blood vessels and the basement membranes of smaller ones. This causes the vessel lumen to narrow leading to a slowing down of cell renewal, which may collectively contribute to cell retention with increased nuclear size(14,15) The N:C

ratio progressively increases from normal to epithelial abnormality categories. NILM cases show low ratios, while HSIL demonstrates markedly elevated ratios, reflecting nuclear enlargement and cytoplasmic reduction. Infective and reactive conditions show mild elevation but remain lower than dysplastic lesions(Table 2 & 4). This supports the role of the N:C ratio as an important marker in cytological grading. This is supported by Mishra et al (2) who showed an increase in nuclear size and decrease in cytoplasmic diameter from low grade to high grade lesions and the N:C ratio in high grade squamous lesion. The observed progressive increase in the N:C ratio across cytological categories- from NILM to high grade squamous intraepithelial lesions HSIL- highlights its utility as a reliable quantitative indicator in cytological grading A higher N:C ratio corresponds to nuclear enlargement and relative cytoplasmic reduction which are hallmark features of dysplastic transformation. The statistically significant variation in the N:C ratio across diagnostic groups underscores its diagnostic relevance and support its incorporation into routine cytomorphometric assessment which is supported by Seifi et al(16), who showed an increased nuclear to cytoplasmic ratio in diabetic individuals.(17) The statistical analysis performed, include ANOVA and t- tests, revealed significant differences in cytomorphometric parameters between groups stratified by glycaemic control and cytological diagnosis. There was a significant association in nuclear diameter with a p- value of 0.013 (Table 5). The significant association between HbA1c levels and increased N:C ratio underscores the influence of metabolic status on cellular morphology; this was supported by Karthik et al (18) in oral baccal mucosa cells of controlled and uncontrolled diabetic patients. These findings indicate that glycemic control is important not only for overall systemic health but also for preserving normal cervical epithelial morphology. Impaired glucose metabolism and insulin resistance have been associated with HSIL and the progression of cervical cancer. This may occur through increased IGF-1 levels and reduced insulin like growth factor binding proteins (IGFBPs), resulting in greater growth factor availability and activation of oncogenic pathways such as PI3K/AKT and MAPK. In addition, HPV oncoproteins E6 and E7 can influence the IGF pathway by altering IGFIR expression and interfering with IGFBP activity, thereby promoting cell proliferation and reducing apoptosis(19). Epigentic changes, including loss of IGF2 imprinting and interactions between E7 and long noncoding RNAs, may further contribute to dysregulation of the PI3K/AKT/mTOR and Wnt/ β- catenin pathways, ultimately facilitating cervical carcinogenesis(20) Overall, the study demonstrates the potential usefulness of cytometric analysis as an adjunct to routine cytology for detecting subtle cellular changes in diabetic patients. Quantitative parameters such as nuclear diameter, cytoplasmic diameter and the N:C ratio may improve screening sensitivity, particularly among high-risk individuals.

LIMITATIONS

The relatively small sample size may limit generalisability of the study findings. In addition, cross-sectional nature of the study does no not allow the determination of casual association between glycaemic control and cytological alterations. Further longitudinal studies involving largest study, population and inclusion of HPV testing or needed to better understand that relationship between diabetes, HPV infection and Cervical carcinogenesis.

CONCLUSION

This study demonstrated a significant association between inadequate glycaemic control in patient which Type 2 diabetes mellitus and measurable cytomorphological changes in cervicovaginal smears. The findings showed that chronic hyperglycaemia was associated with increase nuclear diameter, decrease cytoplasmic diameter, and corresponding rise in the nuclear to cytoplasmic ratio suggesting early cellular atypia. Although most participants had normal cytological findings, a significant number showed epithelial abnormalities. Candida infection was the most common infectious finding, which is in accordance with increase susceptibility of the diabetic individuals to opportunistic infections. The study concludes that inadequate glycemic control in Type 2 diabetes mellitus is associated with significant cytomorphometric alterations in cervical epithelial cells. These changes may reflect metabolic stress, impact cellular turnover and an increased risk of persistent HPV infection and cervical dysplasia. Incorporation of a quantitative cytomorphometric assessment into routine conventional Pap smear evaluation may improve the sensitivity of cervical cancer screening, particularly among diabetic women. Maintaining strict glycaemic control should therefore be emphasised not only for overall metabolic health, but also for preserving cervical epithelium integrity.

REFERENCES

1. Ashique S, Upadhyay A, Kumar N, Chauhan S, Mishra N. Metabolic syndromes responsible for cervical cancer and advancement of nanocarriers for efficient targeted drug delivery- A review. Advances in Cancer Biology - Metastasis. 2022 Jul;4:100041.
2. Mishra S, Khurana U, Kapoor N, Joshi A, Joshi D. Evaluation of the Cytonucleomorphometric Parameters for Cases Diagnosed as Squamous Cell Abnormality on Conventional Cervico-Vaginal Pap Smears. J Cytol. 2023;40(1):5–11.
3. Miller EA, Pinsky PF. Cervical cancer screening and predictors of screening by diabetes status. Cancer Causes Control. 2022 Oct;33(10):1305–12.
4. Yue C, Zhang C, Ying C, Jiang H. Diabetes associated with cervical carcinoma among high-risk HPV-infected patients with cytologically diagnosed high grade squamous intraepithelial lesion. Front Endocrinol (Lausanne). 2022 Oct 27;13:993785.
5. Frontela-Noda M, Delgado-Herrera DC, Cabrera-Rode E, Hernández-Menéndez M, Durán-Bornot R,

Villarreal-Acosta A, et al. Association between components of the metabolic syndrome and degree of cervical squamous intraepithelial lesions in Cuban women. Diabetes Metab Syndr. 2019 Feb 8;13(2):1443–8.

6. Dasgupta S. The Efficiency of Cervical Pap and Comparison of Conventional Pap Smear and Liquid-Based Cytology: A Review. Cureus. 2023 Nov 6;15(11):e48343.
7. Singh S, Gupta A, Nath D, Shobha HJ. A study of comparison of liquid-based cytology versus conventional pap smear for evaluation of cervical cytology at a tertiary healthcare hospital. Int J Res Med Sci. 2019 Apr 26;7(5):1869.
8. De nitions, Criteria, Notes E. The Bethesda System for Reporting Cervical Cytology.
9. American Diabetes Association Professional Practice Committee for Diabetes*. Summary of Revisions: Standards of Care in Diabetes-2026. Diabetes Care. 2026 Jan 1;49(1 Suppl 1):S6–12.
10. Harisha S, Talukdar L, Aziz N. A RETROSPECTIVE STUDY ON THE PATTERNS OF CERVICAL PAP SMEAR FINDINGS IN DIABETIC AND NON-DIABETIC WOMEN AT A TERTIARY CARE HOSPITAL.
11. Kolongolo SS, Omondi T, Kutolo E, Guyah B. Cytomorphological Characteristics of Cervical Scrape from Controlled and Uncontrolled Diabetes Mellitus Patients Attending Tertiary Healthcare, Kenya. Acta Cytol. 2025 Jun 21;69(6):567–75.
12. Durrer Schutz D, Busetto L, Dicker D, Farpour-Lambert N, Pryke R, Toplak H, et al. European Practical and Patient-Centred Guidelines for Adult Obesity Management in Primary Care. Obes Facts. 2019 Jan 23;12(1):40–66.
13. Sahay K, Rehani S, Kardam P, Kumra M, Sharma R, Singh N. Cytomorphometric analysis and morphological assessment of oral exfoliated cells in type 2 diabetes mellitus and healthy individuals: A comparative study. J Cytol. 2017;34(1):27–33.
14. Hallikerimath S, Sapra G, Kale A, Malur PR. Cytomorphometric analysis and assessment of periodic acid Schiff positivity of exfoliated cells from apparently normal buccal mucosa of type 2 diabetic patients. Acta Cytol. 2011 Feb 15;55(2):197–202.
15. Gaddikeri K, Abidullah M, Bhorgonde D. Cytological and cytomorphometric study of exfoliated cells of the oral mucosa in diabetic patients. J Pharm Bioallied Sci. 2020 Aug 28;12(Suppl 1):S86–90.
16. Seifi S, Feizi F, Moazzezi Z, Mehdizadeh M, Zamani B. Evaluation of oral mucosal epithelium in diabetic male patients by exfoliative cytology method. J Diabetes Metab Disord. 2014 Sep 10;13:77.
17. Saravani S, Karimkoshteh A, Samaei Rahni M, Kadeh H. Cytomorphometric assessment of buccal mucosa cells and blood sugar status in diabetic patients in zahedan (2019). Med J Islam Repub Iran. 2021 Dec 18;35:168.
18. Karthik KR, Malathi N, Poornima K, Prakash S, Kadhiresan R, Arunmozhi U. Evaluation of Glycemic Control in Type 2 Diabetes Mellitus using Cytomorphometry of Buccal Cells and Correlation with Glycosylated Hemoglobin. J Int Oral Health. 2015 Feb;7(2):20–4.
19. Pickard A, McDade SS, McFarland M, McCluggage WG, Wheeler CM, McCance DJ. HPV16 Down-Regulates the Insulin-Like Growth Factor Binding Protein 2 to Promote Epithelial Invasion in Organotypic Cultures. PLoS Pathog. 2015 Jun 24;11(6):e1004988.
20. Faramarzi S, Dianatpour A, Ghafouri-Fard S. Discovering the Role of Long non-coding RNAs in Regulation of Steroid Receptors Signaling in Cancer. JBTW. 2017;6(12).