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# Diagnostic Accuracy of Oral Brush Biopsy Versus Scalpel Biopsy for Detecting Epithelial Dysplasia in Oral Potentially Malignant Disorders

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## ABSTRACT:

**Introduction:** Oral squamous cell carcinoma is often preceded by potentially malignant disorders, yet clinically distinguishing dysplastic or malignant lesions from benign mimics remains challenging, and routine biopsy of all suspicious lesions is impractical. The OralCDx® Brush Biopsy ('O' Test) has been proposed as a non-invasive adjunct for triaging such lesions, though its diagnostic reliability remains uncertain. This study evaluated the 'O' Test in predicting dysplasia or malignancy in clinically innocuous-looking oral potentially malignant disorders.

**Aim and objective:** To evaluate the diagnostic accuracy of the OralCDx® Brush Biopsy ('O' Test) in predicting epithelial dysplasia or malignancy in clinically innocuous-looking oral potentially malignant disorders, using scalpel histopathology as the reference standard.

**Materials and Methods** : In this prospective diagnostic study, 40 patients with clinically confirmed oral potentially malignant lesions (>6 mm, unresponsive to empirical antimicrobial therapy) underwent both brush biopsy and concurrent scalpel/punch biopsy at the same lesion site. Diagnostic accuracy of the 'O' Test was assessed against histopathology using sensitivity, specificity, predictive values, McNemar's test, and Cohen's kappa; habit and demographic associations were assessed using the Chi-square test

**Results:** Of 40 patients (mean age 38.15 ± 9.45 years; 92.5% male), scalpel histopathology confirmed dysplasia in 20 (50%), whereas the 'O' Test identified dysplasia in only 5 (12.5%). The brush biopsy showed low sensitivity (25.0%; 95% CI 8.66–49.10%) but high specificity (100%; 95% CI 83.16–100%),with diagnostic accuracy of 62.5% and a false-negative rate of 75%. McNemar's test showed significant discordance between the two methods ($p < 0.001$), with only fair agreement (Cohen's $\kappa = 0.25$).

**Conclusion:** The 'O' Test demonstrated poor sensitivity and an unacceptably high false-negative rate for detecting dysplasia in clinically innocuous oral lesions. Despite its non-invasive appeal, it cannot reliably substitute scalpel biopsy, which remains essential for definitive diagnosis.

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## INTRODUCTION

Squamous Cell Carcinoma (SCC) is the most common oral cavity malignancy, carrying an overall disease-specific relative mortality of 49%.[1] In Northern India, the prevalence of oral mucosal lesions is estimated at 16.8% .[2] Early detection remains significantly hindered by the challenge of clinically differentiating early dysplastic or malignant lesions from benign conditions.[3] Although the World Health Assembly (2007) urged member states to integrate oral cancer prevention and early diagnosis into national programs [4], no cost-effective mass screening method has yet proven to reduce population mortality[5] .

Globally, oropharyngeal cancer ranks as the sixth most common malignancy (>400,000 cases annually)[6], making early detection vital to improve survival and reduce morbidity or disfigurement .[7] Heavy smoking and alcohol consumption exert a synergistic effect, imparting a 38-fold increased cancer risk over abstainers [8], with a threshold of 20 pack-years[9] that gradually declines back to baseline 10 years post-cessation .[10] India is the second-largest producer[11] and consumer[12] of tobacco worldwide, with an adult prevalence of 35% [13] representing more than 250 million users consuming smoked (beedi) and chewable (paan) preparations.[14] Furthermore, regular alcohol consumption—present in 4.5% of the population[15] across varied beverage types [16] acts as a major co-carcinogen with tobacco.[17,18] Additional etiologic factors include Human Papillomavirus (HPV)[19] and poor oral hygiene with high polymicrobial bacterial loads .[20]

Oral malignancies are typically preceded by precursor states termed "Potentially Malignant Disorders" (OPMDs).[21]These include Tobacco Pouch Keratosis, which takes 1–5 years to develop at the habit site [22]; Oral Leukoplakia, which must be distinguished from benign entities (frictional keratosis, cheek biting, linea alba, leukoedema)[23], has a population prevalence of 2% [24], and carries an annual transformation rate of 0.3%–1% [25]; and Oral Lichen Planus (<1% transformation over 20 years).[26]

Because routine screening reveals oral mucosal abnormalities in 5%–15% of individuals, scalpel biopsy of every lesion is clinically impractical .[27]The 'O' Test (OralCDx® Brush Test) offers a non-invasive, trans-epithelial alternative; while initial paired studies in high-risk lesions demonstrated sensitivity and specificity exceeding 90%[28], concerns remain regarding reduced accuracy [29]and false-positive rates in low-risk populations.[30] Standardized criteria such as the UK National Guidelines for urgent referral (including persistent red/white patches or ulcers >3 weeks) [31] highlight the need for reliable triaging.

Therefore, this study was undertaken to evaluate the potential of the 'O' Test (Brush Biopsy) as an adjunctive diagnostic tool in predicting dysplasia or malignancy in clinically innocuous-looking oral potentially malignant disorders.

## MATERIALS AND METHODS

### Study Design and Patient Selection

This prospective diagnostic evaluation was conducted in the Department of Oral Medicine and Radiology, I.T.S. Dental College, Hospital and Research Centre, Greater Noida. A total of 40 patients (aged 20–62 years, of either sex) presenting with clinically identifiable oral potentially malignant disorders were enrolled after obtaining written informed consent. Lesion diagnoses were independently verified visually by two calibrated observers. Detailed demographic and habit histories were recorded using a structured questionnaire.

### Inclusion and Exclusion Criteria

**Inclusion Criteria**: Clinically confirmed potentially malignant/high-risk oral mucosal lesions (keratotic, erythematous, erosive, or ulcerative) >6 mm in diameter, that persisted after 2–3 weeks of empirical antifungal/antibiotic therapy to rule out transient infectious etiologies.

**Exclusion Criteria:** Submucosal lesions with intact epithelium(e.g., cysts, salivary gland tumors, fibromas); pigmented lesions (nevi, amalgam tattoos); lip lesions involving the vermilion border or cutaneous surface; infective /traumatic mucosal ulcerations; underlying coagulopathies or blood disorders; Oral Submucous Fibrosis (OSMF); and known hypersensitivity to nylon or local anesthetics.

### Diagnostic Procedures

**Brush Biopsy ('O' Test):** A specialized cyto-brush (Fig.1,2)was applied to the selected lesion and rotated repeatedly in one spot until pinpoint epithelial reddening or hemorrhage was achieved to ensure full-thickness trans-epithelial sampling. Collected cellular material was transferred to a glass slide, fixed immediately with spray fixative, air-dried, and dispatched to a diagnostic laboratory (Reflections Promotion Pvt. Ltd., Mumbai) for computer-assisted cytological analysis.

**Scalpel/Punch Biopsy:** Following brush sampling, a definitive scalpel or punch biopsy was performed at the same lesion site under local anesthesia (2% lignocaine with adrenaline). Tissue specimens were fixed in 10% formalin and submitted to the Department of Oral Pathology for histopathological confirmation. Biopsy sites were closed using 3-0 nylon or vicryl sutures (removed at 7 days). Patients received post-biopsy care instructions, pain management, follow-up, and appropriate psychological counseling.

**Infection Control**

Standard infection control protocols were strictly observed. Clinical procedures utilized disposable PPE and sterilized instrument sets autoclaved at 121°C at 15 lbs pressure for 15–20 minutes.

**Statistical Analysis**

Data were processed using Statistical Software SPSS version 16.0. Normality was evaluated using Kolmogorov-Smirnov and Shapiro-Wilk tests. Descriptive statistics summarized demographic variables and habit profiles.2 x 2 contingency tables were utilized to calculate the sensitivity and specificity of the 'O' Test in comparison with scalpel histopathology.Sensitivity, specificity, and positive predictive value of the 'O' Test were calculated against histopathology, and associations between habits, demographics, and diagnosis were assessed using the Chi-square test."McNemar's test was used to assess the discordance between the 'O' Test and histopathological diagnosis, and Cohen's kappa coefficient was calculated to quantify the level of agreement between the two diagnostic methods."




**FIGURE 1**: ORAL CDx BRUSH TEST KIT




**FIGURE 2:** 'O' TEST KIT

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## RESULTS

### Demographic and Clinical Profile

The study evaluated 40 patients (n = 40; 37 males [92.5%], 3 females [7.5%]) with a mean age of 38.15 with SD of 9.450 (range: 20–62 years). Out of total 40 patients, 10 patients (25%) were from lower socioeconomic status, 29 patients (72.5%) were from middle socioeconomic status and 1 patient (2.5%) was from upper middle socioeconomic status.

Homogenous Leukoplakia was the most common clinical entity, followed by Reticular Oral Lichen Planus and Speckled Leukoplakia(Fig.3)

- **Homogenous Leukoplakia:** 22 (55.0%)
- **Reticular Oral Lichen Planus:** 9 (22.5%)
- **Speckled Leukoplakia:** 3 (7.5%)
- **Erythroplakia / Ulcerative Lichen Planus / Erosive Lichen Planus / Chronic Ulcer / Verrucous Carcinoma / Tobacco Pouch Keratosis:** 1 each (2.5% each)

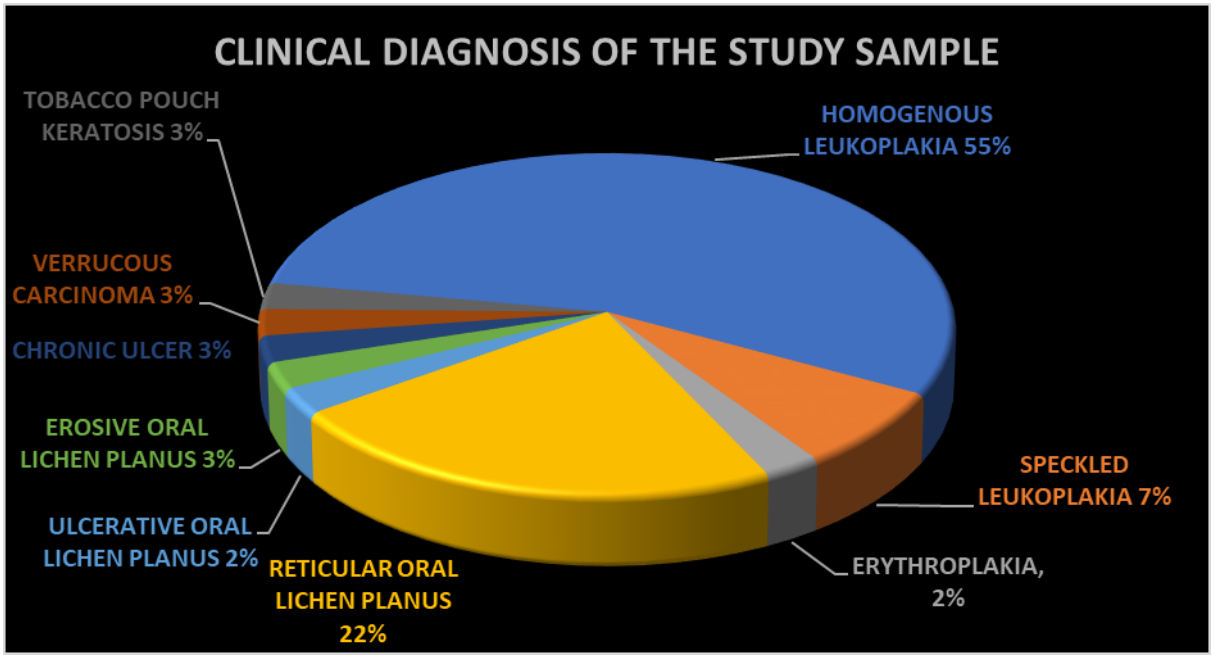



**FIGURE 3**: LESION WISE SAMPLE SIZE DISTRIBUTION

### Habit Patterns and Cross-Correlations

Overall, 92.5% (n = 37) of patients reported risk habits. Smoking tobacco was most prevalent (42.5%, n = 17), followed by combined smoking and alcohol consumption (22.5%, n = 9), alcohol alone (17.5%, n = 7), and smokeless tobacco (10.0%, n = 4).

- **Sex vs. Habits:** Statistically significant association ($p < 0.001$); all 37 habit-positive patients were male, while all 3 female patients reported no habits.
- **Diagnosis vs. Socioeconomic Status:** Statistically significant association ($p < 0.001$).
- **Non-Significant Correlations:** Sex vs. Socioeconomic status ($p = 0.911$), Sex vs. Diagnosis ($p = 0.998$), and Habits vs. Socioeconomic status ($p = 0.397$).

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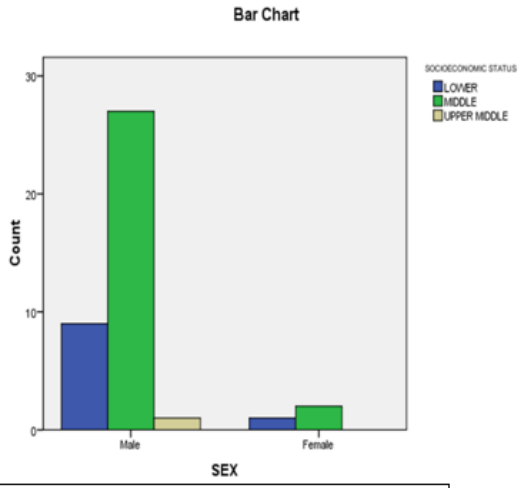



**FIGURE 4:** RELATION BETWEEN SEX AND

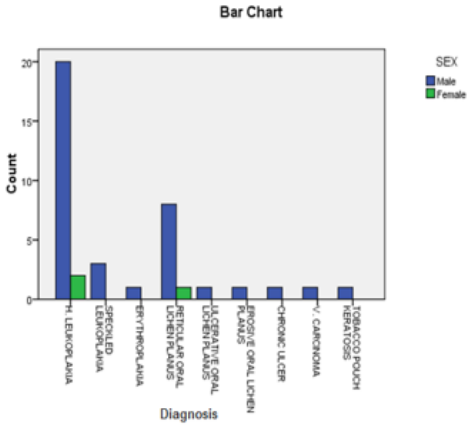



**FIGURE 5:** RELATION BETWEEN

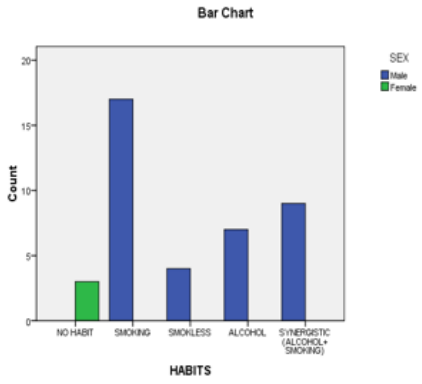



**FIGURE 6:** RELATION BETWEEN SEX AND DELETERIOUS HABITS

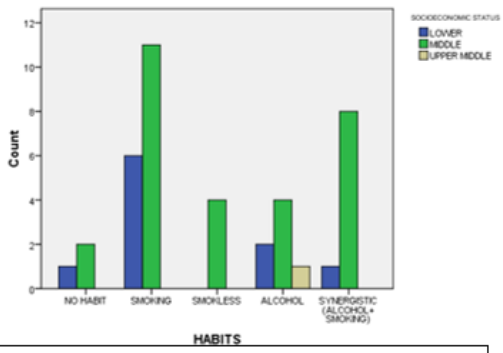



**FIGURE 7:** RELATION BETWEEN HABITS

**FIGURE 8 :** RELATION BETWEEN DIAGNOSIS AND SOCIOECONOMIC STATUS

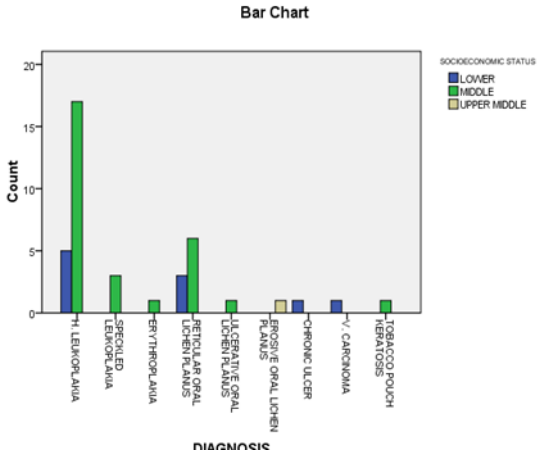



**FIGURE 9:** SHOWING SITE DISTRIBUTION OF SAMPLE SIZE

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**Anatomic Distribution**

The buccal mucosa was the predominant site of lesion involvement (85.0%, n = 34), followed by the buccal vestibule (10.0%, n = 4) and tongue (5.0%, n = 2). All female cases (n = 3) presented with lesions located on the buccal mucosa.

| Site | No. of cases | | |
|---|---|---|---|
| | Male | Female | Total |
| **Buccal Mucosa** | **31** | **03** | **34** |
| **Buccal Vestibule** | **04** | **00** | **04** |
| **Tongue** | **02** | **00** | **02** |
| **Total** | **37** | **03** | **40** |

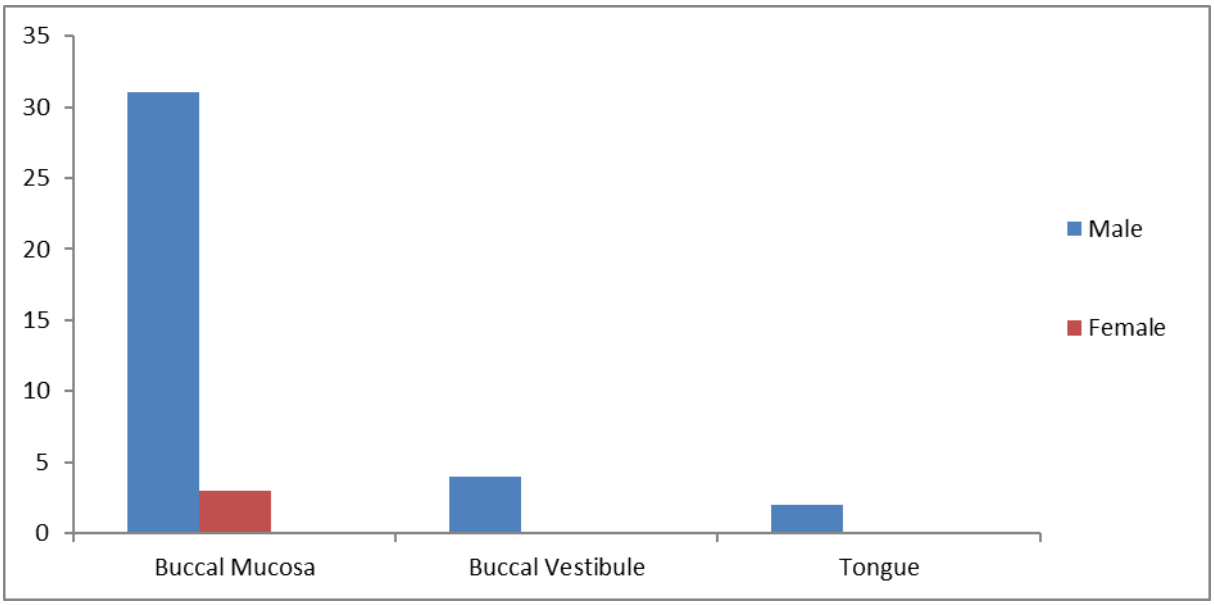



**FIGURE 10 :** RELATION BETWEEN GENDER AND SITE DISTRIBUTION

**Diagnostic Evaluation: Scalpel Biopsy vs. 'O' Test (Brush Biopsy)**

Histopathological analysis via scalpel biopsy (gold standard) confirmed dysplasia in 20 of 40 patients (50.0%; 19 males, 1 female), comprising Homogenous Leukoplakia (n = 14), Speckled Leukoplakia (n = 2), Reticular Oral Lichen Planus (n = 2), Erythroplakia (n = 1), and Verrucous Carcinoma (n = 1).

In contrast, the 'O' Test (Brush Biopsy) identified dysplasia in only 5 patients (12.5%; all male: 2 Homogenous Leukoplakia, 1 Speckled Leukoplakia, 1 Erythroplakia, 1 Verrucous Carcinoma).

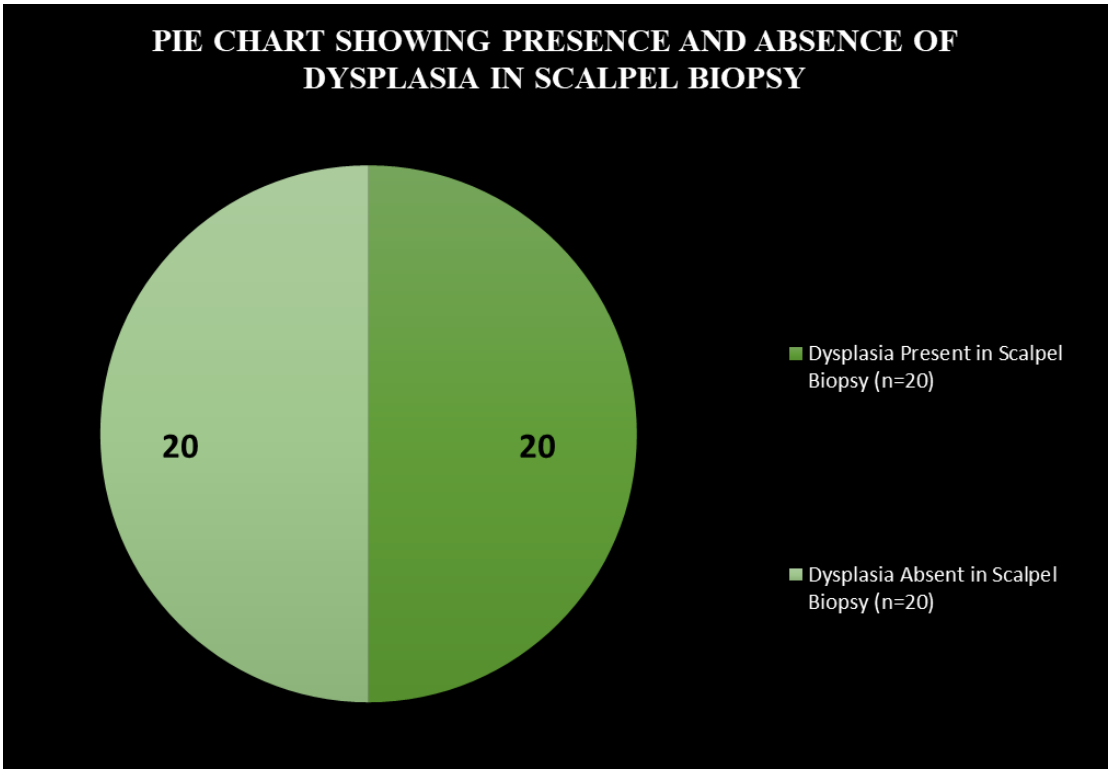



**FIGURE 11:** PRESENCE & ABSENCE OF DYSPLASIA IN SCALPEL BIOPSY

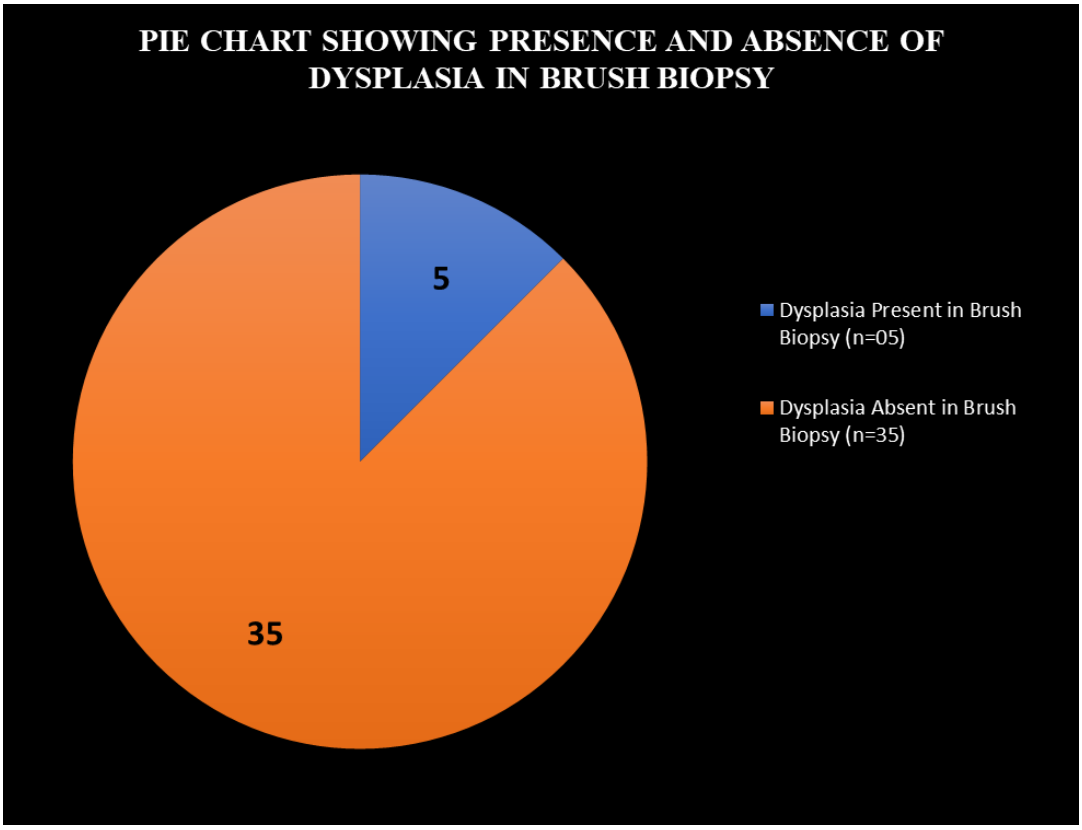



**FIGURE 12 :** PRESENCE & ABSENCE OF DYSPLASIA IN BRUSH BIOPSY

Of 40 patients (20 dysplastic, 20 non-dysplastic on histopathology), the 'O' Test showed a sensitivity of 25.0% (95% CI 8.66–49.10%), specificity of 100% (95% CI 83.16–100%), PPV of 100% (95% CI 47.82–100%), and NPV of 57.1%, with an overall diagnostic accuracy of 62.5%. All five brush-biopsy-positive cases were histopathologically confirmed as dysplastic (no false positives), but 15 of 20 dysplastic lesions were missed (false-negative rate 75%).

| Metric | Percentage | 95% Confidence Interval / Range |
|---|---|---|
| **Sensitivity** | 25.00% | 8.66% – 49.10% |
| **Specificity** | 100% | 83.16% – 100.00% |
| **Positive Predictive Value (PPV)** | 100% | 47.82% – 100.00% |

McNemar's exact test revealed significant discordance between the 'O' Test and histopathological diagnosis ($p < 0.001$), and the level of agreement between the two methods was fair (Cohen's $\varkappa = 0.25$).

**DISCUSSION**

Pre-cancerous and early cancerous oral lesions are frequently asymptomatic and clinically subtle, leading to diagnostic delays; notably, over 25% of general dental practitioners fail to accurately recognize innocuous-looking potentially malignant disorders (OPMDs).[32] Globally, cancer represents the second and tenth leading cause of mortality in developed and developing nations, respectively, with oral cancer accounting for ~13% of all malignancies (~30,000 new cases annually).[33] In South Asia, smokeless tobacco products (betel quid, tobacco with lime, tooth powder) are consumed extensively, with escalating adoption among women and adolescents .[34,35,36] In India, oral cancer constitutes up to 40% of all malignancies, making routine scalpel biopsy impractical at mass screening centers due to specialist shortages and patient compliance challenges .[37]

Because visual inspection alone cannot reliably differentiate early dysplasias from benign mucosal conditions [3], transepithelial brush biopsy was developed as a chair-side test to harvest cellular material across full-thickness epithelium non-invasively.[38] Dysplasias and early carcinomas are often misdiagnosed as benign entities due to their asymptomatic nature1, further complicated by smoking-induced alterations in mucosal keratinization.[39] In our cohort, most patients were unaware of their lesions prior to examination. Patient age (mean 38.15 with SD of 9.45 years) and habit distribution (smoking, smokeless tobacco, alcohol) were consistent with documented literature.[40] The buccal mucosa was the predominant lesion site (85%), mirroring findings by Sciubba et al.[3], Poate et al.[40], and Christian et al.[41] .

Regarding socioeconomic factors, Hashibe et al.[34] and Kadashetti et al.[42] associated OPMDs predominantly with lower socioeconomic status. In contrast, our study observed a higher proportion among middle-income individuals (72.5%) who continued habit use despite reported awareness of tobacco-related risks.

A critical limitation of earlier landmark studies was methodological bias: trials by Sciubba et al.[3] (where 73.9% of negative brush cases lacked histological confirmation), Svirsky et al.[43], and Christian et al.[41] did not systematically perform scalpel biopsies on negative brush samples, while Scheifele et al.[44] limited sampling to specific entities (sensitivity 61%, specificity 97%). In our study, all 40 lesions underwent concurrent brush and scalpel biopsies. This design aligns with Reddy et al.[45], who reported a sensitivity of 43.5%, specificity of 81.25%, and PPV of 58.3%. Similarly, Poate et al.[40] reported a sensitivity of 71% and specificity of 32% (identifying 6 false negatives among 15 dysplasias). In our cohort, the 'O' Test demonstrated a lower sensitivity of 25.0% and specificity of 100%, yielding a false-negative rate of 75% (15 out of 20 dysplastic cases missed).

This sensitivity disparity may be attributed to sample size, intrinsic apparatus limitations, tissue sample degradation during transit, or brush bristle properties (soft vs. stiff nylon).[3] Although brush biopsy provides a non-invasive alternative for non-compliant patients or general dental triaging[3,7], its high false-negative rate limits its reliability as an independent diagnostic tool for innocuous-looking OPMDs.[7] Future multi-center studies with larger sample cohorts across diverse OPMD categories are required to validate its diagnostic efficacy.

## CONCLUSION

Early opportunistic screening during routine dental practice remains the cornerstone of oral cancer prevention and control .[46] Although non-invasive diagnostic adjuncts like the 'O' Test (Oral Brush Biopsy) offer procedural convenience and patient acceptance, the findings of this study demonstrate that brush biopsy is not a reliable or predictable tool for detecting epithelial dysplasia in clinically innocuous oral potentially malignant disorders. Given its high false-negative rate, a negative brush biopsy result in low-risk lesions should be interpreted with extreme caution, and scalpel incisional biopsy with histopathological evaluation remains indispensable for definitive diagnosis.

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**CONFLICTS OF INTEREST** -There are no conflicts of interest

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