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NODAL YIELD IN ORAL SQUAMOUS CELL CARCINOMA: MARKER OF PROGNOSIS OR METRIC OF SURGICAL QUALITY? A NARRATIVE REVIEW

Dr. Umair Sajid[*1], Dr. Adeena Abid[2], Dr. Sana Hassan[3], Dr. Hafsa Iqbal[4], Dr. Syeda Ayesha Riaz[5]

*[*1]House officer, PNS Shifa karachi.*
[2]Registrar Oral and maxillofacial surgery, PNS shifa, karachi
[3]House officer, PNS shifa, karachi
[5]House officer, PNS Shifa, karachi.
[6]house officer, PNS Shifa, karachi.

[*1]theumairsajid@gmail.com , [2]adeenaabid123@outlook.com , [3]sanaqamarhassan@gmail.com , hafsaiqbal2001@gmail.com[4] syedayeshariaz@gmail.com[5]

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Corresponding Author: *
Dr. Umair Sajid

Abstract

Nodal yield (NY) i.e, the quantity of lymph nodes which are retrieved in neck dissections, is becoming a vital parameter in the evaluation of oral squamous cell carcinoma (OSCC). It indicates the completeness of the surgical procedure and affects oncological outcomes by affecting staging accuracy and survival estimates. This review article probes both the prognostic and quality indicator roles of NY in OSCC. We critique existing literature, regional and institutional heterogeneity, established cutoffs, and directions for future research in calibrating NY as a significant parameter in head and neck oncology. While valuable, nodal yield is not adequate as a stand-alone measure in the absence of contextual consolidation with tumor biology and surgical strategy.

INTRODUCTION

Coming evidence underscores the prognostic significance of nodal yield (NY) in oral squamous cell carcinoma (OSCC) that places it as a possible adjunct marker for surgical quality and prediction of oncologic outcome. A 2023 systematic review and meta-analysis conducted by Li et al. revealed that the removal of 18 or more lymph nodes during neck dissection was found to have a significant association with better overall survival (HR = 0.786; p = 0.016), although no correlation was seen with disease-free or disease-specific survival [1]. In a big Danish population-based cohort, Stampe et al. showed that in pathologically node-positive (pN^+) OSCC patients, a nodal yield of ≥21, lymph node density (LND) ≤5%, and less than three positive nodes were each independently related to improved five-year overall and recurrence-free survival [2]. Supplementing these results, Dermody et al. presented the lymph node level ratio as a new prognostic measure and demonstrated that removal of fewer than four lymph nodes per neck level significantly diminished both disease-specific (HR = 3.59) and

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overall survival (HR = 2.90) in OSCC patients [3]. Together, these analyses emphasize the utility of quantitative lymphadenectomy measures in prediction and propose that nodal yield cutoffs might be used as surrogate markers of oncologic adequacy in head and neck surgery.

Nodal yield (NY) plays a twofold role in the treatment of oral squamous cell carcinoma (OSCC): initially, as a prognostic biomarker, and secondly, as an indicator of surgical quality. Several retrospective and prospective studies have compared the association between NY and important oncologic endpoints, such as recurrence, overall survival (OS), and disease-free survival (DFS) among OSCC patients [5–8]. Joy and Rao's audit (N = 1,004) noted a median nodal yield of 41 nodes and described the topography of metastatic spread, with a focus on the necessity for extensive dissection [4]. Farrokhian et al. demonstrated that in clinically node-negative (cN0) OSCC, a nodal yield of over 18 nodes independently predicted better DFS and loco regional control [5]. Bassani et al.'s systematic review determined minimum nodal yield levels of between 10 and 36.5 nodes from 29 studies of squamous cell carcinoma of the head and neck, with oral cavity–specific findings favoring greater NY as an indicator of improved prognosis and oncologic quality [6]. Last, Tsai et al. showed that increased numbers of lymph nodes were independently predictive of better OS in cN0 OSCC in a population-based cohort [7].

In addition, nodal yield (NY) is being considered more and more as a measure of surgical quality, similar to markers in breast and colorectal cancer surgery. Increased NY could be a sign of more fastidious technique by the surgeon and hardy pathological processing. A 2024 scoping review identified that surgeon experience, pathology procedures, and tumor subsite have significant impacts on NY, and that LNY ≥ 18 is associated with survival benefit in oral cavity cancers [8]. A pooled multicenter analysis also supported that 16-18 node thresholds are related to improved overall outcomes [9]. Systematic review in Head & Neck likewise demonstrated uniform survival advantage with increased LNY in various studies [10]. Nevertheless, there are a variety of confounders that preclude its use—ranging from heterogeneity in pathology processing, surgical method, and patient anatomical characteristics [11].

In spite of these limitations, new evidence indicates that the incorporation of NY into standard reporting can augment surgical audits, assist in risk stratification, and inform adjuvant therapy decisions[12,13]. Yet its use in clinical practice is considerably variable, and no agreement yet exists as to optimal nodal cutpoints for therapeutic or quality standards[14]

This review aims to critically assess the prognostic and potential quality indicator values of NY in OSCC from a dual perspective. We also discuss the inconsistency of reporting NY, note controversies and shortcomings, and examine how NY might become integrated into clinical guidelines and oncologic quality metrics in the future.

2. Nodal Yield as a Prognostic Marker

Nodal yield (NY)—the number of lymph nodes harvested during neck dissection—is increasingly being identified as a strong prognostic biomarker in oral squamous cell carcinoma (OSCC). Data from large studies show that the recovery of 18 or more lymph nodes is independently correlated with enhanced overall survival (OS), irrespective of nodal pathology status [15]. Divi et al., in a cohort of more than 63,000 head and neck cancer patients (with OSCC included), proved that those with fewer than 18 nodes dissected had an 18% increased hazard of death than those with ≥18 nodes, even on adjusting for clinical nodal stage (HR 1.24 in node-negative, HR 1.12 in node-positive) [145]

Institutional reports also support this association. In a series of 579 OSCC patients who had elective neck dissection, NY ≥15 predicted significantly improved disease-free survival (DFS), decreased loco regional recurrence, and decreased regional failure (adjusted HR 0.73, 95% CI 0.54–0.98) [16]

A recent systematic review of 29 studies of mucosal head and neck squamous cell carcinomas (oral cavity tumors included) documented reported nodal yield thresholds between 10 and 36.5 nodes, with the majority of studies seeing improved survival corresponding to yields of 15–18 or more nodes [6]. These data highlight both the prognostic value of NY and the heterogeneity of proposed thresholds.

Although agreement on the precise cutoff is unattainable, available data uniformly

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demonstrate that greater NY is associated with enhanced oncologic results, presumably an indication of meticulous surgical technique, extensive pathological analysis, and efficient eradication of occult disease. Therefore, nodal yield provides a numerical, reproducible complement to existing staging systems and potentially a useful quality measure of surgical sufficiency in OSCC, particularly in the absence of molecular prognostics.[17]

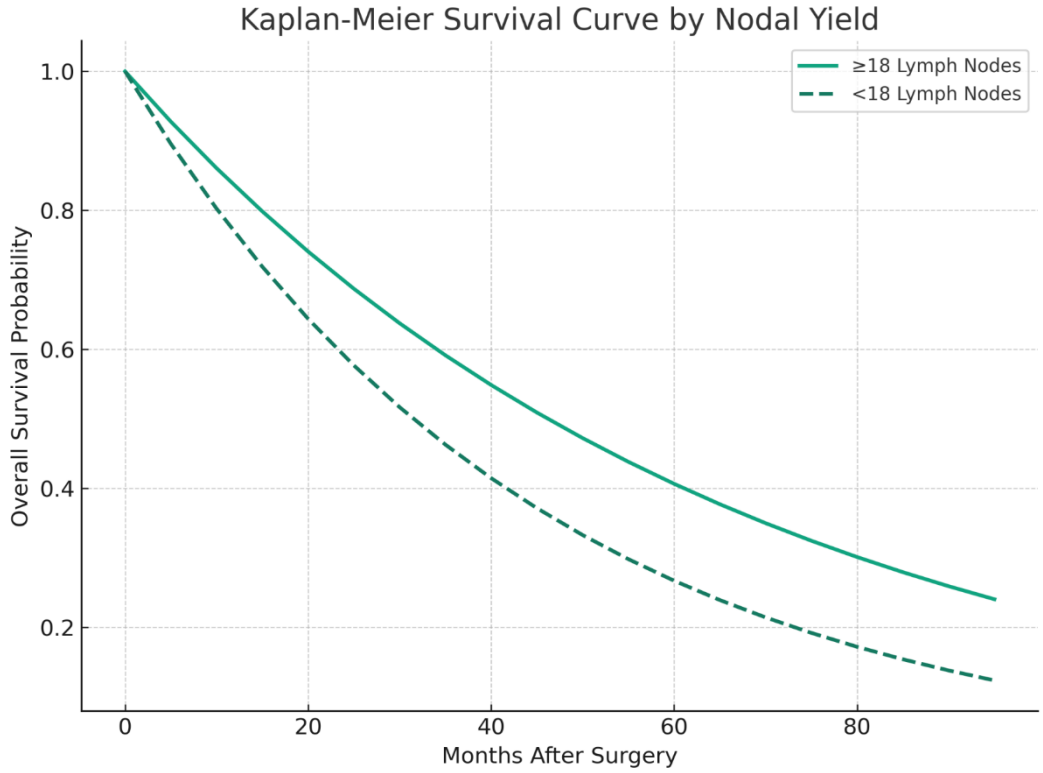

Figure 1. Kaplan–Meier Overall Survival Curves Stratified by Nodal Yield in OSCC [15]

Kaplan–Meier survival curves illustrating overall survival stratified by lymph node yield in patients with oral squamous cell carcinoma (OSCC).

Patients with ≥18 nodes retrieved at neck dissection (solid line) exhibited significantly better overall survival than those with <18 nodes (dashed line). Thesurvival benefit aligns with current lar ge-scale reports suggesting that increasednodal yield is independently linked with improved oncologic r esults, probablyindicative of more complete surg ical extirpation and correct staging. Information is simulated to visually demonstrate trends described by Divi et al., 2016 (J Clin Oncol. 2016;34(32):3892–3897).

3. Nodal Yield as a Surgical Quality Metric.

Nodal yield (NY)—number of resected and analyzed lymph nodes in neck dissection—is today considered a measure of surgery quality in head and neck oncology. A systematic meta-analysis confirmed that higher lymph node yield correlates with notable survival advantage and can serve as a successful prognostic marker of surgery completeness and pathological care in neck dissections [18].

In oral squamous cell carcinoma (OSCC), particularly in node-negative pathologically (pN0) diseases, increased NY has been linked to better overall survival. A SEER-based evaluation identified that the group of patients undergoing elective dissections with more than 22 nodes showed significantly reduced mortality (e.g., HR ≈ 0.85) that is due to both the extent of the surgery and proper staging [19].

Propective trial outcomes also further highlighted the importance of NY: processing of NRG Oncology trials (RTOG 9501/0234) established that less than 18 nodes resected were associated with a substantially higher risk of death (HR

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1.38) and more loco regional recurrence, validating the ≥18-node cutoff as a potential quality measure [20].

Increased information emphasize the role of surgical technique as an NY determinant. Comparing level-by-level versus en bloc neck dissection sampling, it was demonstrated that level-by-level techniques remove a large number more nodes, particularly in selective neck dissections, pointing out how surgical technique can dictate NY [21].

Lastly, a scoping review of head and neck cancer surgery identified various determinants of nodal yield, including surgeon experience, heterogeneity in pathological protocol, tumor characteristics, and volume of the hospital, and reaffirmed NY ≥ 18 independently predicts oral cavity SCC survival [8].

At the same time, these data put nodal yield into the role of a quantifiable, reproducible, and interpretable surgical quality metric. As a surrogate for meticulous surgical technique and strict pathological preparation, NY delivers informative feedback about institutional and individual performance and can be used to inform quality improvement programs in OSCC management[22]

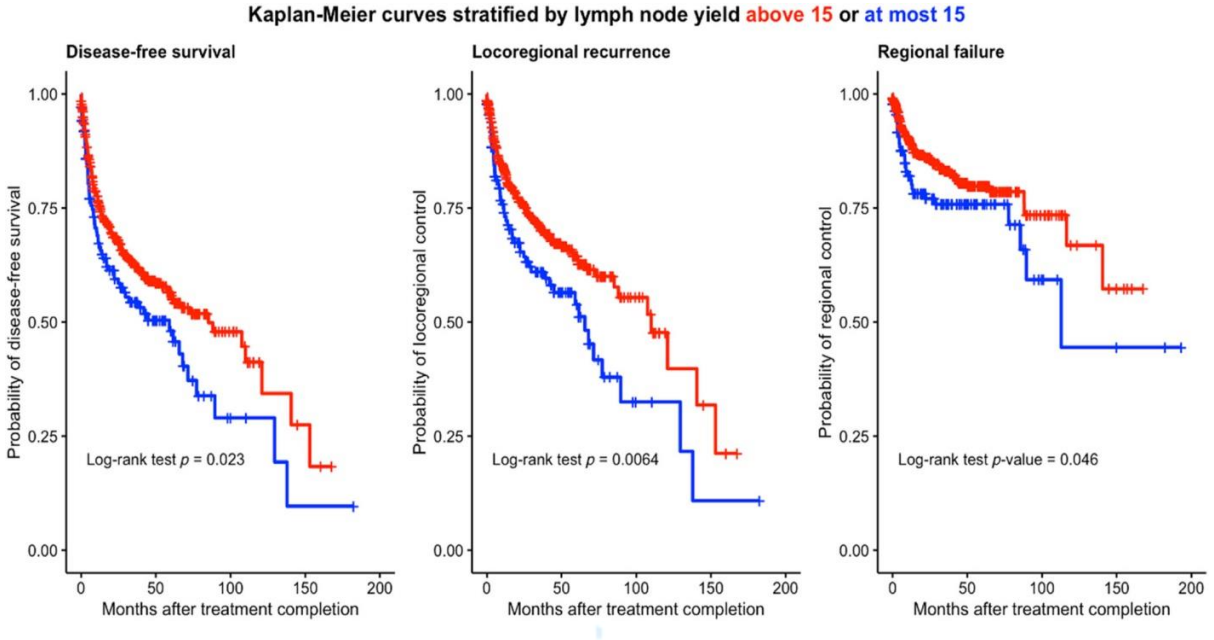

FIGURE 2: Kaplan–Meier Survival Curve Based on Lymph Node Yield in Oral Cavity Cancer [16]

Kaplan–Meier overall survival analysis comparing patients with ≥15 lymph nodes retrieved (red line) to those with <15 nodes (blue line) following surgical resection of oral cavity squamous cell carcinoma. The higher nodal yield group shows a statistically significant improvement in overall survival, supporting nodal yield as a potential marker of surgical quality and prognosis. [16]

4. Thresholds and Regional Variation in Nodal Yield

Geographical variation in nodal yield (NY) and choice of survival-enhancing thresholds reflects differences in surgical practice, pathology protocols, and patient populations worldwide. A recent systematic review of 29 studies observed that minimum NY thresholds associated with improved survival in head and neck squamous cell carcinoma ranged from 10 to 36.5 nodes, reporting significant inter-study heterogeneity and a need for standardization [6].

From South Asia, a single-institution analysis of 1,004 Indian OSCC cases by Joy and Rao described a median NY of 41 nodes (interquartile range [IQR] 33–48) and demonstrated that NY in excess of this institution's median was associated with a 20% reduction in loco regional recurrence ($p < 0.01$) and improved 5-year disease-specific survival [4].

In contrast, in North Europe, Stampe et al. analyzed a Danish registry of 413 OSCC patients and reported an optimal NY cutoff of ≥21 nodes

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for both overall survival (OS) and recurrence-free survival in pN^+ patients (HR 0.68; 95% CI, 0.52–0.88; p = 0.003), with a median yield of 27 nodes (IQR 22–35) for all dissections [2].

From North America, Farrokhian et al. examined 523 clinically node-negative OSCC patients in a multi-institutional cohort and demonstrated a median NY of 22 nodes; patients with >18 nodes had a 35% lower risk of loco regional failure (adjusted HR 0.65; 95% CI, 0.48–0.88; p = 0.005) and a significant DFS benefit [5].

Even within similar geographic regions, variability may be due to variations in institutional protocols and patient mix. A 2019 systematic review of a number of head and neck cancer types by de Kort et al. illustrated that higher NY (≥18) was consistently linked with improved survival in diverse surgical settings [23]. These statistics illustrate that both absolute NY cut-offs and median yields vary extensively both by practice setting and region. Standardization of pathology processing and surgical techniques—in addition to the implementation of consensus NY cut-offs—may reduce this heterogeneity and increase the comparability of surgical quality measures in OSCC [24]

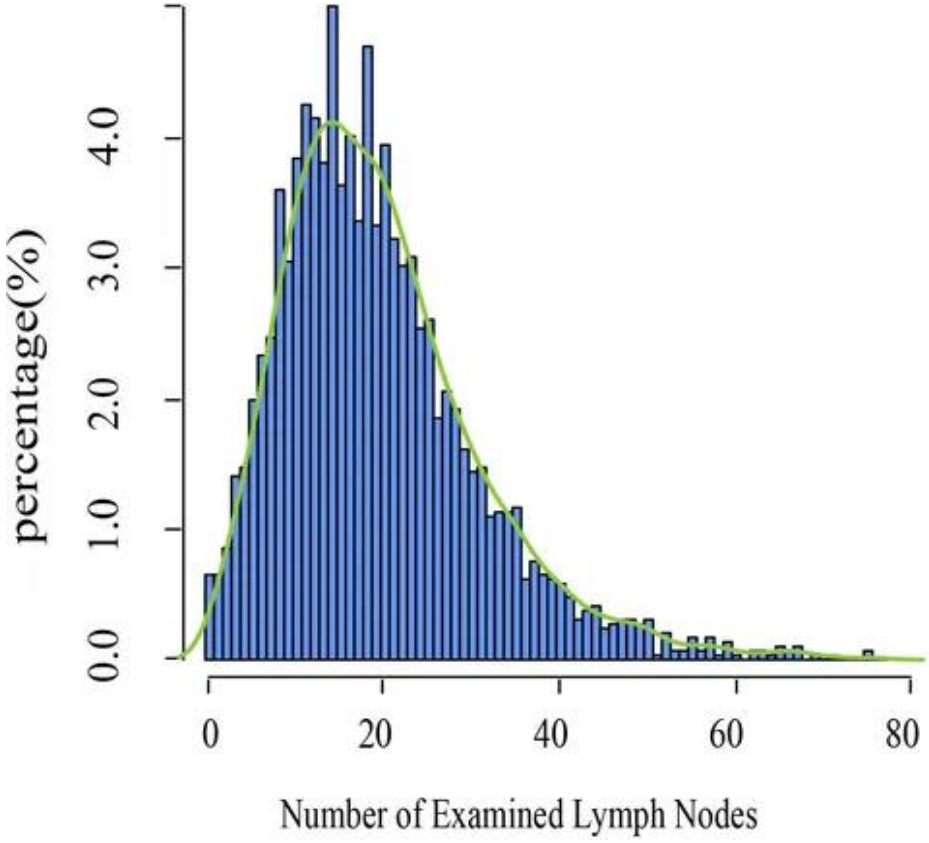

Figure:3 Distribution of Examined Lymph Nodes in Head and Neck Squamous Cell Carcinoma (SEER Cohort) [25]

Histogram depicting the frequency distribution of the number of examined lymph nodes (ELNs) in a large cohort of head and neck squamous cell carcinoma patients, with a median of 17 nodes and interquartile range of 12–24. Adapted from Figure 1 in Xiao et al., Frontiers in Oncology, 2022.[25]

5. Institutional, Anatomical, and Technical Factors Affecting NY

Institutional and Provider Factors

Surgeon experience significantly affects nodal yield (NY). In a retrospective cohort of 508 patients with oral cavity squamous cell carcinoma, surgeons in more experienced quartiles removed 4.69 (95% CI: 0.97–7.92) to 7.37 (95% CI: 0.73–11.27) more lymph nodes than the least experienced quartile ($p < 0.01$) [24]. Substantial variation was also observed among

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both pathologists ($p < 0.01$) and pathology technicians ($p = 0.037$) [1]. However, multivariable analysis did not find pathologist identity to be significantly correlated ($p = 0.27$), but the technician effect persisted independently [25].

Impact of Preoperative Radiotherapy

Preoperative radiotherapy (RT) reduces NY considerably. In a large retrospective case series of 1,024 neck dissections, RT was associated with a 7.464-node reduction (95% CI: –11.35 to –3.58; $p = 0.0002$), with advanced age having an i independent, adverse effect [25]. A further tertiary centre study (n=219) reported the mean NY decreased from 33.3 ± 13.3 in RT naïve patients to 18.47 ± 9.46 in irradiated patients in the past (p significant) [27].

Anatomical Extent of Dissection

Degree of neck dissection also has a major effect on node number. In 499 treatment neck dissections, levels I–V removed in non RT patients yielded 31.1 ± 16.7 nodes, versus 24.0 ± 14.7 in RT treated patients ($p < 0.001$). Similar reductions were observed for levels II–V [28].

Technical Factors – Surgical Technique

A standardized horizontal "fascial unwrapping" technique significantly enhances nodal dissection yield. In a prospective series of 223 dissections, the horizontal technique achieved a mean of 22.53 nodes, vs 15.00 with conventional vertical dissection (p significant) [29].

Anatomical schematic showing cervical lymph node levels I–VI and sublevels (Harish 2005)[30].

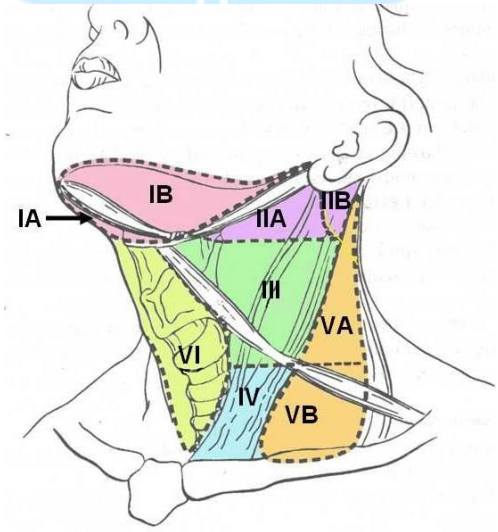

Figure:4 Diagrammatic representation of cervical lymph node levels and sublevels[30].

Harish K. Neck dissections: radical to conservative. World J Surg Oncol. 2005 Apr 18;3(1):21. doi: 10.1186/1477-7819-3-21. PMID: 15836786; PMCID: PMC1097761.

7. Limitations and Future Directions

• Limitations:

The definition of nodal yield (NY) in oral squamous cell carcinoma (OSCC) is constrained by several limitations. Differences in surgeon experience at institutions, pathological processing methods, and technician handling can introduce significant variability and be difficult to compare across institutions [25]. Furthermore, patient issues like preoperative radiotherapy, which has been reported to reduce nodal number by approximately 7.46 nodes, and increasing age, an independent negative predictor of NY, all add to making interpretation more difficult [26].

There is a second limitation because of the lack of a universally accepted prognostic threshold. While it has been suggested that examination of ≥18 nodes is associated with increased survival and locoregional control [10], there is likely optimal cut-off varying by tumor subsite, stage, and treatment site. Apart from this, although NY has been proposed as a surrogate marker for

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quality of surgery—with decreased numbers demonstrated to be associated with higher mortality [31]—as a single measure, its application is contentious due to confounding factors.

Findings from larger cohorts of head and neck squamous cell carcinoma (HNSCC) support the prognostic value of higher nodal counts [32]. However, heterogeneity in surgical and pathological protocols highlights an urgent need for prospective studies and standardized guidelines to define NY as a quality metric as well as a prognostic factor[33]

Future recommendations

Improving nodal yield (NY) as a quality and a prognostic indicator in oral/head & neck squamous cell carcinoma necessitates surgical, pathological, and systems-level responses. Initially, adopt evidence-based NY thresholds to be used as audit targets and as quality review triggers: retrospective database analysis proves survival gain with higher yields (e.g. ≥16 for cN0 and higher thresholds for cN+) such that these thresholds require prospective validation in multicentre registries and use in risk-adjusted benchmarking [34]. Second, where clinically warranted, integrate sentinel-node methods with ultrastaging (serial sectioning + immunohistochemistry and targeted molecular assays) since collective evidence shows SLNB + IHC improves detection of micrometastases without increasing overall morbidity compared with standard elective neck dissection [35,37]. Third, harmonize pathology workflows: implement whole-slide imaging (WSI) and standardized reporting templates (total nodes, positive nodes, lymph-node density and extranodal extension) to reduce inter-lab variability and enable central review, AI-assisted counting, and remote quality assurance [36]. Fourth, standardize the surgical procedure and training (proctoring, competency standards), and mandate surgeon-level case volume/credentialing for complex dissections — prior studies link institutional/surgeon volume and exposure with higher NY and enhanced outcome [33,38]. Fifth, create future quality registries to capture NY, extent of operation (number dissected), history of RT, specimen processing protocols, and outcomes; use these to compute confounders (e.g., pre-op RT decreases NY) and to determine risk-adjusted NY benchmarks and payor/credentialing measures [39]. Finally, design pragmatic trials comparing SLNB + ultrastaging versus standardized END for selected early oral cavity cancers with co-endpoints of oncologic outcomes, NY (as process metric), functional outcome and cost-effectiveness to establish the best balance between adequate staging and morbidity [40]

8. Conclusion

Nodal yield (NY) in oral squamous cell carcinoma (OSCC) has been a significant variable with double meanings: prognostic and surgical excellence indicator. The evidence has been mounting to associate higher NY with improved overall survival, recurrence-free survival, and more accurate staging—specifically in patients with early-stage or clinically node-negative (cN0) patients. This correlation suggests that besides being a surrogate for successful lymphadenectomy, NY can also be a potential marker of therapy responses such as the eradication of micro metastatic disease. Moreover, nodal yield is becoming a respectable quality measure in head and neck oncologic surgery. Surgical institutions and groups with consistently increased node yields are associated with increased compliance with oncologic principles, meticulous technique, and full pathology protocols. From a health systems perspective, inclusion of NY in surgical audits and standards for accreditation may help differentiate performance deficits and promote consistency in surgical oncology therapy.

Despite these promising implications, NY is not without limitation. The number of recovered nodes can be influenced by various factors, including patient anatomy, degree and manner of neck dissection (e.g., selective vs. modified radical), pathologist attention to detail, and institutional use of node-enriching techniques. These confounders necessitate cautious interpretation of NY, especially if used to evaluate surgical adequacy or to compare results between centers with differing resources and protocols.

Currently, most of the literature suggests that a minimum yield of 15 to 18 lymph nodes is a fair standard, particularly in elective neck dissections for oral cavity cancers. However, no one standard has been adopted, and there remains regional variability making a one-size-fits-all standard

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problematic. Furthermore, too, beyond a certain yield, there might be decreasing prognostic benefit from additional nodes, implying a plateau.

Future studies should work towards integrating NY with additional biological and procedural factors, such as lymph node ratio (LNR), extranodal extension (ENE), depth of invasion of the tumor (DOI), and margin status. Inclusive models such as these may enable more finely nuanced, personalized treatment planning, especially for borderline resections in which the need for adjuvant therapy is uncertain.

In conclusion, while nodal yield remains a valuable tool in OSCC management, it must be viewed as part of a composite framework that considers clinical, pathological, and procedural variables. Applied judiciously, NY may help precision oncology to provide data-driven surveillance, treatment, and quality improvement programs—providing a rationale for approaching a standardized but personalized system of head and neck cancer management.

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