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A Comparative Study of Serum Biochemical Parameters (Blood Sugar, RFT, LFT, Lipid Profile), and Copper Levels in Newly Diagnosed Oral Squamous Cell Carcinoma Patients and Age and Sex Matched Controls at SMS Medical College and Attached Hospitals, Jaipur

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Abstract

Aim and Objectives: To evaluate and compare serum biochemical parameters (Blood Sugar, RFT, LFT, Lipid profile), and copper levels in newly diagnosed patients with oral squamous cell carcinoma (OSCC) and age and sex matched control group.

Materials and Methods: A hospital-based comparative observational study was conducted in the Department of Biochemistry in collaboration with the Department of Oncology, SMS Medical College and Hospitals, Jaipur, over a period of 12 months. The study was approved by institutional Ethics committee for research work. A total of 126 subjects were enrolled in this study and were further divided into two groups: Group A consisted of sixty- three newly diagnosed oral squamous cell carcinoma cases, and Group B included sixty -three age- and sex-matched controls. Data were analysed using the student's *t*-test. A *p*-value of <0.05 was considered statistically significant, and <0.001 was considered highly significant.

Results: The comparative analysis of serum biochemical parameters (Blood Sugar, RFT, LFT, Lipid profile) and copper levels between oral squamous cell carcinoma (OSCC) patients and age- and sex-matched control groups revealed significant alterations. OSCC patients demonstrated significantly elevated mean levels of serum glucose, direct bilirubin, aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP), and copper compared to controls. Conversely, significantly reduced levels of urea, albumin, and lipid profile parameters—including total cholesterol, triglycerides, high-density lipoprotein (HDL), low-density lipoprotein (LDL), and very low-density lipoprotein (VLDL)—were observed in OSCC patients relative to the control group.

Conclusion: Newly diagnosed oral squamous cell carcinoma (OSCC) patients demonstrate significant metabolic and trace element alterations, characterized by hyperglycaemia, elevated hepatic enzymes, dyslipidaemia, hypoalbuminaemia, and increased serum copper levels. These findings likely reflect tumor-associated metabolic reprogramming, systemic inflammation, oxidative stress, and compromised nutritional status. The observed biochemical profile may serve as a useful adjunct in elucidating disease pathophysiology and holds potential value in prognostic assessment.

Key Words: Oral squamous cell carcinoma, Blood Sugar, Renal function test, liver function test, lipid profile, trace element

Introduction: Oral squamous cell carcinoma (OSCC) is a malignant tumor that originates from the mucosal epithelium in the mouth, displaying various degrees of squamous differentiation. It accounts for over 90% of oral malignancies, and the overall five-year survival rate is less than 50% [1]. Oral squamous cell carcinoma (OSCC) is the most prevalent malignancy of the oral cavity, accounting for over 90% of all oral cancers , with an estimated 389,000 new cases and 188,000 deaths annually globally each year [2,3]. OSCC is frequently diagnosed at an advanced stage, and the high mortality of patients is mainly due to the delay of diagnosis [4].

Cancer cells meet their heightened energy demands—essential for sustaining proliferation, invasion, and other

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hallmarks of malignancy through genetically orchestrated alterations in metabolic pathways. Well-studied examples include enhanced aerobic glycolysis and fatty acid oxidation, both critical for tumor growth and metastasis. Dysregulation of anabolic and catabolic processes is also prevalent across various cancers, directly contributing to carcinogenesis and progression. [5]
Elevated serum urea levels, the end product of amino acid catabolism, have been reported in carcinomas, positioning it as a potential early detection biomarker for these malignancies. Similarly, creatinine, derived from arginine and glycine degradation, exhibits prognostic utility across various epithelial cancers. [5]

Liver function was evaluated by measuring key serum parameters, including the major transaminases aspartate aminotransferase (AST/SGOT) and alanine aminotransferase (ALT/SGPT), alkaline phosphatase (ALP), total protein, albumin, and total bilirubin levels. These analytes collectively provide a comprehensive overview of hepatic status and aid in detecting potential functional impairment. AST and ALT serve as established indicators of hepatocellular injury, cellular turnover, and metabolic stress, while Hypoalbuminemia, a marker of reduced hepatic synthetic capacity, commonly arises from chronic inflammation, oxidative stress, and cancer-associated cachexia in OSCC patients. ALP, derived from liver, bone, and intestinal sources, may rise in OSCC owing to biliary obstruction, bone metastases, or tumor infiltration, correlating with disease extent and prognosis. [6-9]

Lipids, essential components of cell membranes, support critical biological processes including growth and division in both normal and malignant cells. Quantitative alterations in serum lipids occur during tumorigenesis, positioning them as potential biochemical markers for early cancer detection. Associations between serum lipids, lipoproteins, and various cancers have been documented. These lipids may influence malignancy pathogenesis by modulating tumor cell metabolism, promoting proliferation, integrating into neoplastic membranes, and acting as intercellular messengers or mediators of inflammation. [10]

Copper is primarily found in plasma (90–95%) as part of the oxidative enzyme ceruloplasmin. It also forms a component of various enzymes, including tyrosinase, uricase, and cytochrome oxidase, all of which participate in oxidative processes during cellular metabolism. Among trace elements, copper plays a crucial role in angiogenesis, oxidative stress regulation, and enzymatic activity. Altered serum copper levels have been associated with carcinogenesis and tumor progression, and elevated copper has been reported in oral cancer patients compared with controls. This suggests that copper may serve as a useful biomarker in OSCC.[11]
The aim of this study was to evaluate key biochemical parameters in newly diagnosed OSCC cancer cases compared to healthy controls, assess metabolic alterations during disease progression, and identify insights for improved treatment strategies.

Materials & Methods: This hospital-based comparative observational study was conducted over 12 months in the Departments of Biochemistry and Oncology at SMS Medical College and Hospitals, Jaipur, Rajasthan. Ethical approval was obtained from the Institutional Ethics Committee, and written informed consent was taken from all participants.
Study Participants: A total of 126 participants were enrolled, including 63 newly diagnosed, therapy-naive OSCC patients fulfilling inclusion criteria and 63 age-and sex matched healthy controls. Patients with prior malignancies, ongoing treatment, or steroid use were excluded. Without any chronic disease and non-smokers were enrolled as controls.
Statistical Analysis: Data were recorded in Microsoft Excel. Continuous variables were expressed as mean ± standard deviation and compared using Student's t-test. Statistical significance was set at $p < 0.05$.

Results

The participants were matched for gender in both the group (OSCC and control group) and the mean age in both group was also almost similar.
Table: 1 Age and gender distribution of OSCC Patients and control group.

Parameter	OSCC Patients (N=63)	Controls (N=63)
Age(years)	47.7 ± 11	48.27 ± 10.51
Gender(male: female	50:13	50:13

Table: 2 Comparison of mean Blood Sugar levels between OSCC Patients and controls group.

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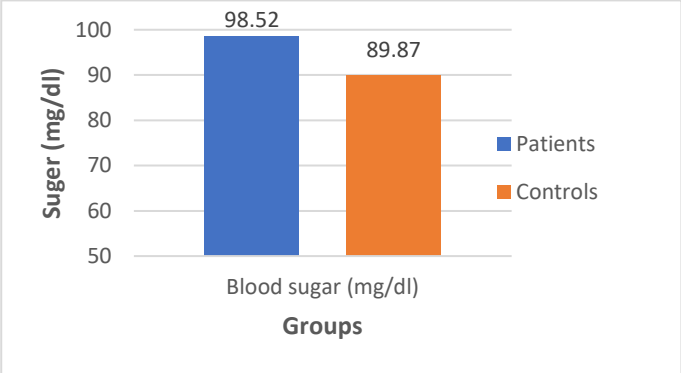


Fig:-1 Comparison of mean Sugar levels between OSCC Patients and controls group.

Table: 3 Comparison of mean RFT levels between OSCC Patients and controls group.

Parameter (mg/dl)	OSCC Patients (N=63)	Controls (N=63)	P-value
Blood Urea	23.02 ± 6.64	25.26 ± 5.78	0.001 (S)
Creatinine	0.80 ± 0.30	0.86 ± 0.14	0.24 (NS)

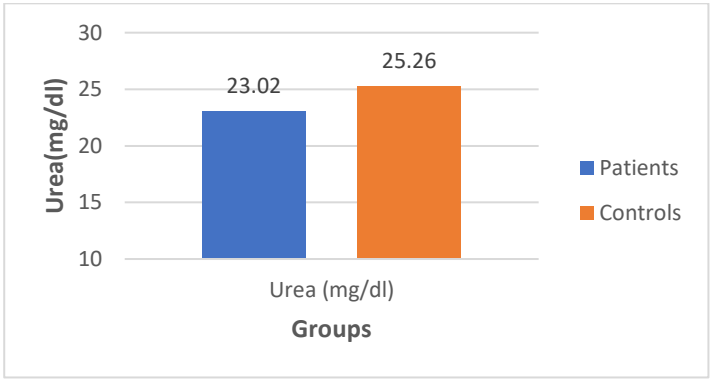
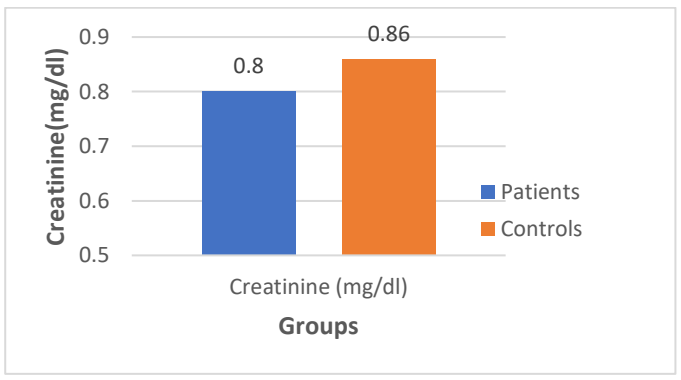


Fig: 2a Comparison of mean urea levels between OSCC Patients and controls group.



Parameter (mg/dl)	OSCC Patients (N=63)	Controls (N=63)	P-value
Blood Sugar	98.52 ± 19.51	89.87 ± 11.87	0.001 (S)

Fig: 2b Comparison of mean creatinine levels between OSCC Patients and controls group.

Table: 4 Comparison of mean LFT levels between OSCC Patients and controls group.

Parameter	OSCC Patients (N=63)	Controls (n=63)	P-value
Total Protein (g/dl)	7.56 ± 0.79	7.36 ± 0.40	0.052 (NS)
Albumin (g/dl)	3.65 ± 0.52	3.93 ± 0.27	0.001 (S
AST(OT) (IU/L	38.23 ± 25.4	29.32 ± 7.94	0.006 (S)
ALT(PT) (IU/L)	41.12 ± 29	29.84 ± 9.98	0.002 (S)
T. Bili (mg/dl)	0.58 ± 0.36	0.53 ± 0.24	0.12 (NS)
D. Bili (mg/dl)	0.23 ± 0.14	0.19 ± 0.09	0.016 (S)
ALP (IU/L)	124.43 ± 34.44	87.41 ± 22.65	<0.001 (S)

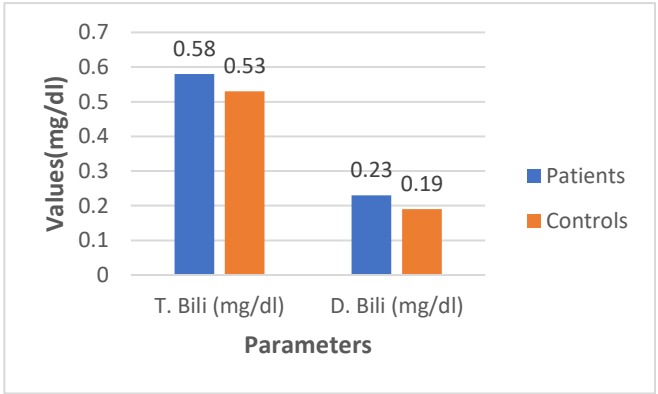


Fig: 3a Comparison of mean T. Bili and D. Bili levels between OSCC Patients and controls group.

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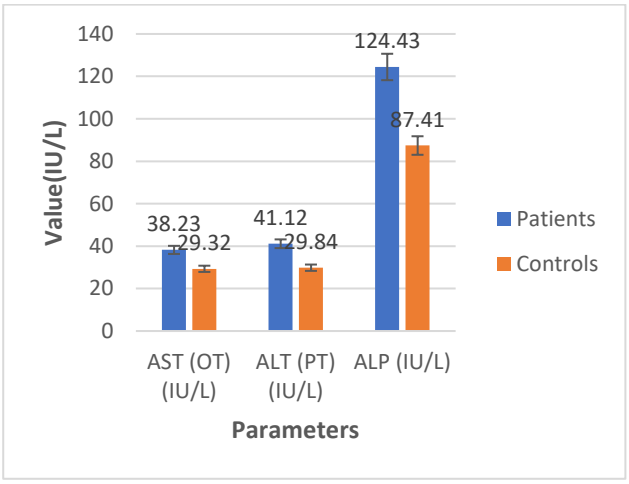

Fig: 3b Comparison of mean AST, ALT and ALP levels between OSCC Patients and controls group.

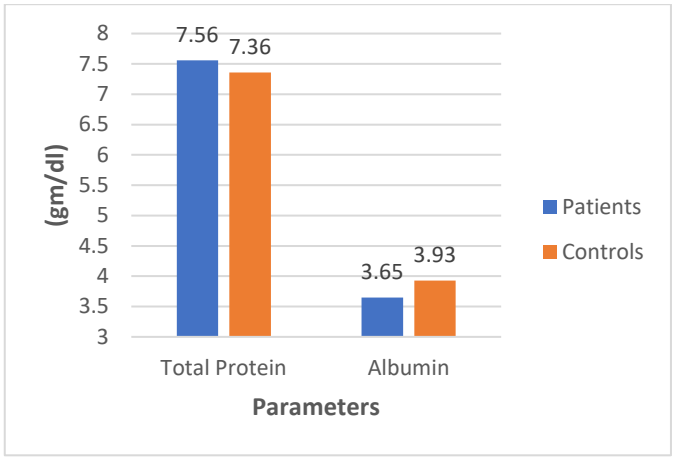

Fig: 3c Comparison of mean Total Protein and Albumin levels between OSCC Patients and controls group.

Table: 5 Comparison of mean Lipid Profile levels between OSCC Patients and controls group.

Parameter	OSCC Patients (N=63)	Controls (N=63)	P-value
Total Cholesterol	156.06 ± 33.80	186.98 ± 34.18	< 0.001 (S)
Triglycerides	109.60 ± 40.66	137.44 ± 46.49	< 0.001 (S))
HDL	35.60 ± 10.17	43.51 ± 10.32	< 0.001 (S)
LDL	98.95 ± 27.78	117.52 ± 32.14	< 0.001 (S)
VLDL	22.09 ± 8.05	27.48 ± 9.30	< 0.001 (S)

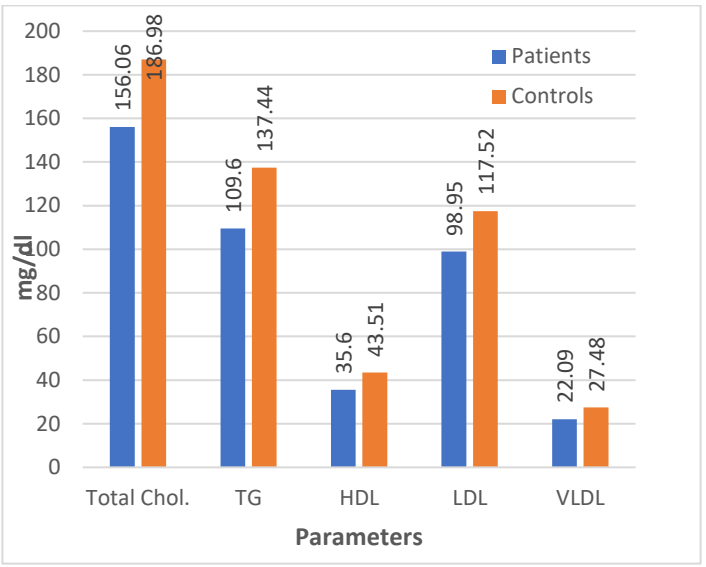

Fig: 4 Comparison of mean Lipid Profile levels between OSCC Patients and controls group.

Table: 6 Comparison of mean Copper levels between OSCC Patients and controls group.

Parameter (µg/dl)	OSCC Patients (N=63)	Controls (N=63)	P-value
Copper	167.29 ± 39.44	111.44 ±24.11	< 0.001 (S)

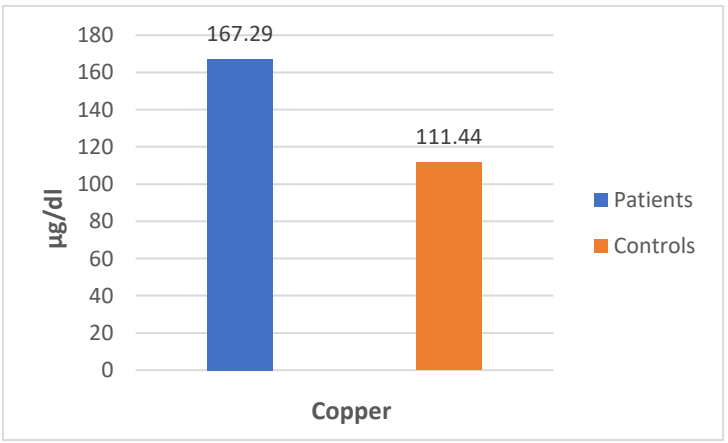

Fig: 5 Comparison of mean Copper levels between OSCC Patients and controls group.

Discussion: In OSCC patients, the evaluation of biochemical parameters is highly important for

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understanding metabolic alterations and for developing effective strategies for disease management and treatment.

In the present study, the mean age of patients with **oral squamous cell carcinoma (OSCC)** (47.7 ± 11 years) was comparable to that of the control group, indicating appropriate age matching and minimal confounding.

A distinct male predominance (50:13) was observed, consistent with established epidemiological trends.

Similar findings have been reported in previous studies. Siegel Rebecca L. et al. (2020) corroborated the overall male predominance in cancer incidence. Gupta Bhawna et al. (2016) and Rivera Carlos (2015), who demonstrated a higher prevalence among middle-aged male populations. Furthermore, Warnakulasuriya Saman (2009) reported that OSCC predominantly affects individuals above 45 years with higher incidence in males.[12-15]

The result of the present study showed that the mean fasting blood glucose level was significantly higher in OSCC patients (98.52 ± 19.51 mg/dL) compared to the control group (89.87 ± 11.87 mg/dL). This difference was statistically significant ($p = 0.001$), indicating elevated fasting blood glucose levels among patients with OSCC.

These findings align with recent metabolomic and clinical studies linking hyperglycemia to OSCC progression. Lu et al. (2025)[16] showed upregulated glucose pathways across tumor stages, while Zhong et al. (2025)[17] demonstrated high glucose enhances OSCC proliferation via O-GlcNAcylation-mediated signaling. Similarly, Chao et al. (2022)[18] evaluated hemoglobin A1c (HbA1c) and blood glucose levels in a large OSCC cohort and found that elevated HbA1c levels were significantly associated with poorer overall survival[4]. This study highlights the prognostic importance of systemic glucose dysregulation in oral carcinogenesis and tumor progression. Clinically, Gong et al. (2021),[19] in a retrospective study of 205 OSCC patients, demonstrated that elevated FBG levels were significantly associated with adverse clinicopathological parameters and poorer overall prognosis. Importantly, FBG was identified as an independent prognostic factor. These findings suggest that even modest elevations in systemic glucose may influence tumor biology and survival outcomes.

Metabolic reprogramming of tumor cells also plays an important role. Malignant cells preferentially utilize aerobic glycolysis for energy production, commonly known as the Warburg effect, resulting in increased lactate production that serves as a substrate for hepatic gluconeogenesis through the Cori cycle, thereby contributing to increased endogenous glucose production [20]. Elevated fasting serum glucose levels in OSCC patients are primarily attributed to tumor-associated insulin resistance and systemic metabolic dysregulation. Chronic inflammation mediated by pro-inflammatory cytokines such as TNF-α and IL-6 impairs insulin signaling and reduces peripheral glucose uptake [21]. Activation of the hypothalamic–pituitary–adrenal axis increases cortisol and catecholamines, thereby enhancing hepatic gluconeogenesis and glycogenolysis [22]. Hypoxia-induced activation of HIF-1α further promotes glycolysis and increases tumor glucose demand [23]. Additionally, elevated free fatty acids due to increased lipolysis exacerbate peripheral insulin resistance [24]. Collectively, these mechanisms contribute to impaired glucose homeostasis and hyperglycemia in OSCC patients.

Contrasting reports exist; Sachdev (2019)[25] found no significant glycemic differences across precancerous, OSCC, and control groups. Nonetheless, our observed fasting glucose elevation indicates tumor-associated metabolic alterations and insulin resistance.

The present study showed that the mean serum urea level was significantly lower in OSCC patients (23.02 ± 6.64 mg/dL) compared with controls (25.26 ± 5.78 mg/dL; $p = 0.03$). In contrast, the mean serum creatinine level in OSCC patients (0.80 ± 0.30 mg/dL) was slightly lower than controls (0.86 ± 0.14 mg/dL), but the difference was not statistically significant ($p = 0.24$).

Similar findings are reported in prior studies: Kapoor et al.[1] (2024)[26] observed reduced serum urea in oral cancer patients with no creatinine differences versus

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controls, while Caruntu et al.[2] (2022) [5] noted lower urea in OSCC (p=0.0344) but no changes in creatinine.

Urea, the primary metabolite from dietary and tissue protein turnover, decreases in oral squamous cell carcinoma (OSCC) due to tumor-associated metabolic reprogramming—a hallmark of cancer progression. Rapidly proliferating malignant cells ramp up amino acid uptake to fuel protein synthesis, nucleotide production, and proliferation, diverting nitrogen from hepatic urea cycle detoxification toward biosynthetic pathways. Dysregulated urea cycle enzymes like carbamoyl phosphate synthetase 1 (CPS1), ornithine transcarbamylase (OTC), and arginine succinate synthetase 1 (ASS1) further reduce urea synthesis, channeling intermediates into polyamine and pyrimidine production essential for DNA replication and tumor growth. Cancer-related inflammation and heightened protein turnover exacerbate this nitrogen metabolic shift. Meanwhile, serum creatinine remains stable in newly diagnosed OSCC patients, reflecting intact muscle creatine metabolism and renal function without overt wasting or dysfunction. These findings suggest that the reduction in serum urea is more likely related to tumor-associated metabolic alterations rather than renal dysfunction. [5,27]

However, some studies have reported contrasting findings. **Dharmana et al.[3] (2023)** observed higher serum urea levels in patients with oral cancer compared with healthy controls. [28]

The mean total protein levels were 7.56 ± 0.79 g/dL g/dL in OSCC patients and 7.36 ± 0.40 g/dL g/dL in controls, showing no significant difference. In contrast, serum albumin levels were significantly lower in OSCC patients (3.65 ± 0.52 g/dL) compared to controls (3.93 ± 0.27 g/dL; p=0.01).

Similar findings have been reported in previous studies. **Vasave et al. (2025)[29]** noted declining albumin with OSCC stage advancement; **Singh et al. (2022)[30]** found similar total protein trends with modestly lower albumin. **Suzuki et al. (2024**][31]linked low pretreatment albumin to poor OSCC prognosis.

Albumin is a major plasma protein synthesized by the liver and constitutes approximately 60% of total serum protein. In malignant neoplasms, a catabolic state is induced by multiple cytokines to meet the metabolic demands of proliferating tumor cells. Under such conditions, albumin may serve as a nutritional substrate, as it is hydrolysed to provide essential raw materials for cellular growth and division. Moreover, malignancy is associated with increased oxidative stress, and albumin may function as a sacrificial antioxidant by scavenging reactive oxygen species. This antioxidant activity may contribute to a reduction in serum albumin levels in cancer patients. [32]

The mean total bilirubin in OSCC patients was 0.58 ± 0.36 mg/dL, slightly higher than 0.53 ± 0.24 mg/dL in controls, with non-significant p-value of 0.12. Direct bilirubin was 0.23 ± 0.14 mg/dL in in OSCC patients versus 0.19 ± 0.09 mg/dL in controls ($p = 0.016$, statistically significant).

The mean SGOT in cases was 38.23 ± 25.84 U/L, higher than 29.32 ± 7.94 U/L in controls, with a statistically significant difference ($p = 0.006$). Similarly, SGPT was elevated in cases at 41.12 ± 29 U/L compared to 29.84 ± 9.98 U/L in controls ($p = 0.002$). With a statistically significant difference.

Similar finding have been reported in previous studies. By Singh et al. (2022)[33] noted the levels of Total bilirubin, direct bilirubin, glutamic – oxalacetic transaminase (SGOT) and glutamic – pyruvic transaminase (SGPT) were increased in cases as compared to controls.

Aspartate aminotransferase (AST) and alanine aminotransferase (ALT) are key enzymes involved in cellular metabolism and tumor cell proliferation. ALT participates in the glucose–alanine cycle and contributes to the regeneration of glucose from muscle tissue, whereas AST facilitates the transfer of nicotinamide adenine dinucleotide (NADH) within mitochondria, a process essential for aerobic glycolysis. These transaminase reactions are especially important in metabolically active tissues such as muscle, hepatocytes, and other rapidly proliferating cells.

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Therefore, increased tumor progression may enhance metabolic activity in cancer cells.[34,35]
The systemic impact extends far beyond the tumor site, as cancer-induced metabolic changes create a pro-inflammatory hepatic microenvironment that suppresses fatty acid metabolism enzymes and promotes fatty liver formation. The resulting hepatocyte stress and membrane damage lead to enzyme leakage, explaining elevated ALT and AST levels in cancer patients without direct hepatic involvement .[36]

The mean serum alkaline phosphatase (ALP) level was significantly higher in OSCC patients (124.43 ± 34.44 U/L) than in the control group (87.41 ± 22.65 U/L). This difference was statistically significant ($p < 0.001$), indicating that ALP levels were markedly elevated in patients with OSCC compared to healthy controls.
The present findings of significantly elevated serum ALP levels in OSCC patients are consistent with previous reports. A recent study by Bhakta Ipsita et al. (2024)[37] provides compelling evidence that serum alkaline phosphatase (ALP) levels increase significantly in patients with oral premalignant disorders (OPMDs) and oral squamous cell carcinoma (OSCC). The mean serum ALP levels were markedly elevated in OPMD patients (119.7 ± 34.1 mg/dl) and OSCC patients (175.6 ± 53.8 mg/dl) compared with healthy controls (72.7 ± 16.4 mg/dl). This progressive rise in ALP from the control group to the OPMD group, and further to the OSCC group, was statistically significant ($p = 0.001$) and suggests that serum ALP may serve as a valuable biomarker for the early detection and monitoring of disease progression in oral cancers. Acharya et al. (2017)[38] observed raised ALP in 24% of OSCC cases, with a significantly higher mean ALP level in patients than in controls.

Serum alkaline phosphatase (ALP) is a hydrolytic enzyme mainly derived from the liver and bone. In malignancy, elevated ALP levels are generally attributed to increased enzyme production and its release into the circulation as a result of rapid tumor growth, tissue destruction, and active remodeling of the tumor microenvironment. In oral squamous cell carcinoma (OSCC), increased ALP levels may also indicate local bone involvement, as tumor invasion stimulates bone resorption and subsequent osteoblastic activity. In advanced disease or in the presence of bone metastasis, elevated ALP is predominantly associated with the bone-specific isoenzyme. Inflammatory cytokines, particularly tumor necrosis factor-alpha (TNF-α), promote osteoclast activation and bone destruction, which subsequently triggers compensatory osteoblastic activity and increased ALP production. Therefore, elevated serum ALP may reflect tumor burden, bone invasion, and disease progression in OSCC.[38-42]
Not all studies have reported a significant association between serum alkaline phosphatase (ALP) levels and head and neck cancers. Banseria et al. [43](2013) found that the increase in serum ALP levels among patients with head and neck squamous cell carcinoma was not statistically significant. However, the findings of the present study demonstrated a significant increase in serum ALP levels in patients OSCC. Significant increase ALP levels in OSCC group indicates that serum ALP may be a useful biomarker for the early detection and monitoring of oral cancer progression.

The present study showed a significant reduction in all lipid profile parameters among OSCC patients compared to the control group. The mean levels of total cholesterol, triglycerides, HDL, LDL, and VLDL were lower in OSCC patients (156.06 ± 33.80 mg/dL, 109.60 ± 40.66 mg/dL, 35.60 ± 10.17 mg/dL, 98.95 ± 27.78 mg/dL, and 22.09 ± 8.05 mg/dL, respectively) than in controls (186.98 ± 34.18 mg/dL, 137.44 ± 46.49 mg/dL, 43.51 ± 10.32 mg/dL, 117.52 ± 32.14 mg/dL, and 27.48 ± 9.30 mg/dL, respectively). The differences in all lipid parameters were statistically significant ($p = 0.001$), indicating altered lipid metabolism in patients with OSCC.
The findings align with previous studies. For example, Kishor et al. (2026), Chandra et al. (2025), and Kotnoor et al. (2024), along with earlier reports by Acharya et al. (2016), and Lohe et al. (2010), have consistently shown reduced serum lipid levels in OSCC patients. [44-48]

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Lipids are the most important cell membrane parts that are required for various biological functions, such as maintaining cell integrity, cell growth, and division of normal and malignant cells**.** [10] The observed alterations in serum lipid profile in OSCC may reflect profound metabolic reprogramming within the tumor and its microenvironment**.[49,50]** Cancer cells in OSCC exhibit distinctive patterns of lipid metabolism, actively utilizing lipids for membrane biogenesis and energy production, which typically manifests as hypolipidemia in patients**.** Several mechanisms have been proposed to explain the reduced serum lipid levels observed in patients with malignancies. Fu-Chuan Chao et al. [10] suggested that hypolipidemia results from the direct lipid-lowering effect of tumor cells, as neoplastic cells actively utilize cholesterol for their metabolic and proliferative requirements. Similarly, Min-Ah Choi et al. [10] proposed that hypocholesterolemia may be secondary to diminished serum antioxidant vitamin levels, leading to excessive generation of free radicals and enhanced lipid peroxidation. S. Desai et al. [10] further explained that free cholesterol within tumor cells is preferentially esterified and stored as cholesterol esters rather than being effluxed to circulating high-density lipoprotein (HDL), irrespective of whether the cholesterol originates from endogenous synthesis or cellular uptake. This mechanism may contribute to the reduced HDL levels observed in cancer patients. Similarly, total cholesterol (TC) and low-density lipoprotein cholesterol (LDL-C) levels demonstrate a marked decrease in oral cancer patients, attributed to the enhanced utilization of lipids by cancer cells for membrane biogenesis during rapid proliferation [10]. In addition, Subbulakshmi et al. [10] reported that the decreased serum low-density lipoprotein (LDL) and very low-density lipoprotein (VLDL) levels in squamous cell carcinoma patients could be attributed to increased lipid peroxidation resulting from a decline in antioxidant defences. Collectively, these findings support the concept that altered lipid metabolism and oxidative stress play significant roles in the development of hypolipidemia associated with cancer.

Oral cancer patients exhibit distinctive alterations in their serum lipid profiles, characterized by a consistent pattern of dyslipidemia that may serve as potential diagnostic and prognostic markers. Most notably, high-density lipoprotein cholesterol (HDL-C) levels show significant reduction in oral cancer patients compared to healthy controls, a finding consistently reported across multiple studies and suggested as a potential early marker for both oral cancer and potentially malignant disorders (OPMD) [51, 52, 53].

The contrasting observations Srinivas **GV et al. (2013)** [54] reported increased VLDL and triglyceride levels in OSCC patients.

In this study, serum copper levels were significantly higher in newly diagnosed OSCC patients (167.29 ± 39.44 µg/dl) than in controls (111.44 ± 24.11 µg/dl), with a highly significant difference ($p < 0.001$).

Numerous studies have reported significantly higher serum copper levels in OSCC patients than in healthy controls. Recent evidence, including the meta-analysis by Sundar et al. (2025),[11] supports this consistent pattern across different cohorts. Similar findings have been reported by Kavle et al. (2024),[55] Samadi et al. (2024),[56] Kumar et al. (2023),[57] and Sourabh et al. (2023).[58] In addition, Samadi et al. linked elevated copper levels with disease severity and tumor progression, suggesting its potential role in OSCC detection, prognosis, and risk assessment.

Copper, an essential trace element, drives key biochemical processes including oxidation via free oxygen metabolites that induce lipid peroxidation, protein oxidation, and nucleic acid degradation, fueling cancer development and prognosis.[59,60] Elevated serum copper in OSCC reflects excessive ceruloplasmin production triggered by cancer-related inflammation or reduced ceruloplasmin catabolism.[61] Copper-dependent lysyl oxidase (LOX) promotes extracellular matrix remodeling, fibrogenesis, tumor invasion, and metastasis by upregulating collagen cross-linking and inhibiting degradation. Dysregulated copper thus aids OSCC progression through enhanced tissue remodeling and enzymatic activity. [62, 63]. Cu is essential for cell growth and functions as a co-factor for a number of enzymes. Necrosis and oxidative stress in cancer cells lead to an increase in the serum Cu level (64).

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However, contradictory findings exist: Alsanousi et al. (2019) [65] reported decreased copper in OSCC versus controls, suggesting population-specific variability in copper alterations.

The present study demonstrated a significant elevation of serum copper levels in OSCC patients compared to healthy controls, suggesting its association with oral carcinogenesis. These findings are supported by several studies, although some inconsistencies have been reported. The increase in copper levels may be attributed to its role in angiogenesis, oxidative stress, and tumor progression. Clinically, serum copper shows potential as a non-invasive biomarker for early detection and disease monitoring in OSCC.

Conclusion: The present study revealed significant alterations in serum biochemical parameters and copper levels in newly diagnosed OSCC patients compared to age- and sex-matched controls. Elevated blood glucose, liver enzyme activity, and serum copper levels, along with reduced lipid profile parameters and serum albumin, indicate metabolic disturbances, inflammation, oxidative stress, and nutritional changes associated with OSCC. These findings may aid in understanding the disease process and could serve as supportive markers for clinical evaluation and prognostic assessment of OSCC.

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