ORIGINAL ARTICLE

Glut-1 as a prognostic biomarker in oral squamous cell carcinoma

Jyotsna M Harshani, Sivaranjani Yeluri, Venkateswara Rao Guttikonda
Department of Oral Pathology and Microbiology, Mamata Dental College, Khammam, Andhra Pradesh, India

Address for correspondence:
Dr. Venkateswara Rao Guttikonda,
Department of Oral Pathology and Microbiology,
Mamata Dental College, Khammam-507 002,
Andhra Pradesh, India.
E-mail: mamatadental@yahoo.co.in

Received: 23-08-2013
Accepted: 06-01-2015

ABSTRACT

Introduction: Glut-1 is a glucose transporter protein, the expression of which is upregulated in malignant cells which show increased glucose uptake. Alterations in expression of Glut-1 have been reported in several pre-malignant and malignant lesions. The objectives of the present study were to compare the expression of Glut-1 in normal persons and in patients with oral squamous cell carcinoma (OSCC), to correlate the expression of Glut-1 with respect to clinical staging of OSCC and to evaluate the expression of Glut-1 with respect to different histopathological grades of OSCC. **Materials and Methods:** Thirty cases of OSCC were staged clinically and graded histopathologically. Immunohistochemical method was used to detect the expression of Glut-1 in OSCC and the same was compared with the normal subjects. The scores were compared using the chi-square test. **Results:** Glut-1 expression was detected in all grades of OSCC. A significant correlation with a *P* value of 0.00004 was found in immunostaining between normal and OSCC. The expression of Glut-1 was significant when compared with different clinical stages with significant *P* value of 0.0004 and in different histopathological grades of OSCC with a *P* value of 0.00001. **Conclusion:** Higher immunohistochemical staining scores were obtained with increased clinical staging and histopathological grades of OSCC. High expression of Glut-1 may be related to poor prognosis in OSCC.
Key words: GLUT-1, oral squamous cell carcinoma, prognostic marker

INTRODUCTION

Glut-1 is a glucose transporter protein which is one of the 14 members of the mammalian facilitative glucose transporter family.[1] Glucose uptake in nearly all cells is mediated by Gluts. Glut-1 positivity in malignant cells revealed by immunohistochemistry (IHC) indicates increased proliferative activity, energy requirements and aggressive behavior.[2] The influence of Glut-1 on prognosis and its use as a biomarker may be a manifestation of tumor hypoxia and the adaptive upregulation of anaerobic glycolysis that may ultimately promote tumor cell survival,[3] suggesting that Glut-1 may be considered to be a negative biomarker of prognosis in patients with head and neck squamous cell carcinoma (HNSCC). Detection of these metabolic changes may be used to provide diagnostic, therapeutic and prognostic information.[4]

Access this article online
Quick Response Code:
Website: www.jomfp.in
DOI: 10.4103/0973-029X.151318

The aim of our study was toevaluate the expression of Glut-1 in patients with different clinical stages and histopathological grades of OSCC.

MATERIALS AND METHODS

In the present study, 30 patients of OSCC and 30 normal subjects (controls) were included. After obtaining the informed consent from the patients, the history and clinical findings of each patient was recorded. These cases were staged clinically based on Tumor Node Metastasis (TNM) classification and for histological grading Broder's grading system (1927) was followed. These cases were confirmed by corresponding Haematoxylin and Eosin sections [Figure 1]. The control group included 30 apparently normal persons who visited our Dental College for the purpose of extraction of impacted third molars. The traumatized soft tissue which was obtained along with the extracted tooth was fixed, processed and stained with routine immunohistochemical procedure using GLUT-1 primary antibody.

Immunohistochemical staining

Immunohistochemical staining was performed using Glut-1 antibody (Biogenex super sensitive detection system, USA).

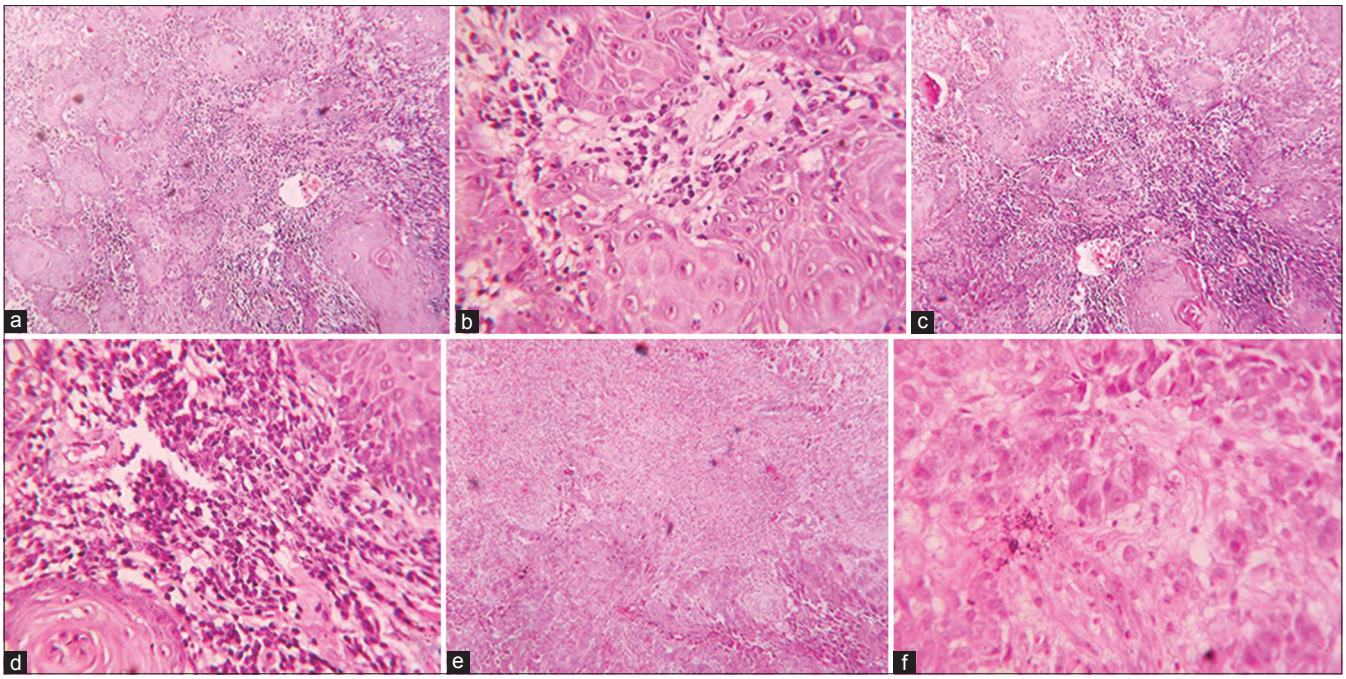

Figure 1: Photomicrographs of tissue sections of OSCC. (a) Well-differentiated carcinoma, (H&E stain, ×100). (b) Well differentiated carcinoma, (H&E stain, ×400). (c) Moderately differentiated carcinoma, (H&E stain, ×100). (d) Moderately differentiated carcinoma, (H&E stain, ×400). (e) Poorly differentiated carcinoma, (H&E stain, ×100). (f) Poorly differentiated carcinoma (H&E stain, ×400)

Three micrometer paraffin embedded sections were used for staining. The sections were dewaxed in xylene, rehydrated through decreasing concentrations of alcohol. Immunohistochemical staining for Glut-1 was done using an avidin-biotin technique. The sections were micro waved for 4 cycles of 5 minutes each in Tris-buffer, pH 9.0-9.2 for antigen retrieval. The sections were allowed to cool and endogenous peroxidase activity was blocked by immersion of slides in 3% H_2O_2 and then incubated in power block. The sections were then incubated in primary antibody Glut-1 (1:100 dilution) at 37°C for an hour. After washing with PBS buffer, the secondary antibody was applied for 30 min at 37°C. The staining for Glut-1 was visualized with DAB chromogen. Specimens were counterstained with Mayers hematoxylinthen dehydrated in increasing concentrations of alcohol and mounted with cover slip using DPX.

Esophageal squamous cell carcinoma was taken as positive control and negative controls were obtained by omitting the primary antibody [Figure 2].

Glut-1 staining was evaluated on the basis of presence or absence of staining in the cell membrane/nucleus/cytoplasm. Random fields were chosen and 300 cells were counted. The percentage of positive cells were then calculated and graded. Two observers independently evaluated the staining, their intensity and the average of the observations were taken. The intensity was graded in all the cases from 0–3, that is, with '0' to represent negative staining (less than 10% positive tumor cells), 1 (10–25% positive tumor cells), 2 (25–50% positive tumorcells) and 3 (more than 50% positive tumor cells) to represent mild, moderate and intense staining respectively depending on the percentage of tumor cells that expressed the protein. Data were analyzed statistically using the Chi-square test. A *P* value of less than 0.05 was considered to be significant.

RESULTS

Table 1 shows the clinical details of the 30 patients diagnosed histopathologically as OSCC with different clinical stages and histopathological grades.

Immunohistochemical expression of Glut-1 was studied in normal mucosal tissues ($N = 30$) and OSCC cases ($N = 30$). Normal mucosal epithelium showed undetectable or weakly detectable Glut-1 expression in supra basal layers, thus a predominant basal staining was seen. [Figure 3].

Out of the 30 normal cases, 13 were males and 17 were females. The age distribution was between 18 years and 67 years. Out of them 12 cases were less than 40 years and 18 cases were more than 40 years.

Table 2 shows a comparison of the expression of Glut 1 in normal persons and in patients with OSCC. Intensity of staining was observed to be 0 in 18 normal cases, 1 in 5 normal cases, 2 in 4 normal cases, 3 in 3 normal cases. Intensity of staining was observed to be 0 in 1 OSCC case, 1 in 10 OSCC cases, 2 in 14 OSCC cases, 3 in 5 cases of OSCC. A significant difference was observed between normal patients and in patients with OSCC patients with respect to immunohistochemistry scores (Chi-square test; $P = 0.00004$).

Table 1: Clinical details of patients

Age	Sex	Site	Provisional diagnosis	Tnm staging	Hp grading
60	M	Right mandible	Ameloblastoma	Stage II	Grade I
70	F	Buccal mucosa	Chronic non healing ulcer of Buccal Mucosa	Stage I	Grade I
75	M	Tongue	Carcinoma	Stage II	Grade II
65	F	Right alveolus	Chronic non healing ulcer	Stage I	Grade I
85	M	Left alveolus	Chronic non healing ulcer	Stage III	Grade I
32	M	Buccal mucosa	Carcinoma of left buccal mucosa	Stage III	Grade II
30	M	Floor of mouth	Carcinoma left alveolus and floor of mouth	Stage III	Grade II
65	M	Right alveolus	Carcinoma of right alveolus	Stage III	Grade II
55	M	Left alveolus	Carcinoma of left alveolus	Stage III	Grade II
30	M	Tongue	Chronic non healing ulcer	Stage IV	Grade III
30	M	Left alveolar ridge	Chronic non healing ulcer of alveolar ridge	Stage I	Grade I
50	M	Buccal mucosa	Leukoplakia	Stage I	Grade I
30	M	tongue	Carcinoma of tongue	Stage IV	Grade II
60	F	Right alveolus	Carcinoma of right lower alveolus	Stage III	Grade III
45	M	Right alveolus	Carcinoma of right alveolus	Stage III	Grade II
60	M	Mandible	Osteomyeilitis	Stage III	Grade III
55	M	Left retromolar region	Chronic non healing ulcer in left retromolar region	Stage III	Grade II
60	M	Palate	Carcinoma of palate	Stage III	Grade II
75	M	Left retromolar region	Carcinoma–retromolar area	Stage I	Grade I
45	M	Right mandible	Radicular cyst	Stage III	Grade III
70	F	Left alveolus	Carcinoma of alveolus	Stage I	Grade I
40	F	Tongue	Chronic nonhealing ulcer	Stage I	Grade I
46	F	Buccal mucosa	Traumatic ulcer	Stage II	Grade II
51	M	Tongue	Chronic non healing ulcer	Stage I	Grade I
60	M	Buccal mucosa	Leukoplakia	Stage III	Grade I
56	F	Left alveolus	Chronic non healing ulcer	Stage II	Grade II
44	M	Tongue	Carcinoma	Stage II	Grade II
50	F	Right alveolus	Chronic non healing ulcer	Stage I	Grade I
58	M	Mandible	Chronic non healing ulcer	Stage II	Grade I
75	F	Left alveolus	Chronic non healing ulcer	Stage I	Grade I

Out of 30 cases of OSCC; 29 cases expressed cytoplasmic staining with predominant membrane staining pattern whereas only one case expressed nuclear staining.

Table 3 shows the comparison of expression of Glut-1 with respect to clinical staging of OSCC. Out of the 10 cases with stage I, intensity of staining was observed to be 0 in 1 case, 1 in 8 cases, 2 in 1 case. Out of 6 cases with stage II, intensity of staining was 1 in 1 case, 2 in 5 cases. Out of 12 cases with stage III, intensity of staining was 1 in 1 case, 2 in 8 cases and 3 in 3 cases. Out of 2 cases with stage IV, intensity of staining was 3 in 2 cases. A significant difference was observed between clinical staging with respect to immunohistochemistry scores. (Chi-square test; $P = 0.0004$).

Table 4 shows the comparison of expression of Glut-1 with respect to histopathological grades of OSCC. Out of the 14 cases with grade I, intensity of staining was observed to be 0 in 1 case, 1 in 9 cases, 2 in 4 cases. Out of 12 cases with grade II, intensity of staining was 1 in 1 case, 2 in 10 cases, and 3 in 1 case. Out of 4 cases with grade III, intensity of staining was 3 in 4 cases. A significant difference was observed between histological grades with respect to immunohistochemistry scores. (Chi-square test; $P = 0.00001$).

Table 2: Comparison of expression of Glut-1 in normal persons and in patients with Oral Squamous Cell Carcinoma

IHC scores	Normal	%	OSCC	%	Total
Score 0	18	60.00	1	3.33	19
Score 1	5	16.67	10	33.33	15
Score 2	4	13.33	14	46.67	18
Score 3	3	10.00	5	16.67	8
Total	30	100.00	30	100.00	60

Chi-square test=22.9332, df=3, P=0.00004, Chi-square test; P=0.00004, Significant, OSCC: Oral Squamous Cell Carcinoma

Grade I OSCC cases showed predominant basal Glut-1 staining with score 1 and Grade II OSCC cases showed basal and supra basal staining with score 2. Whereas, Grade III OSCC cases showed staining extending up to all the layers of the epithelium with score 3 [Figure 4].

DISCUSSION

Presently TNM classification and histological typing, considered as prognostic markers are not sufficient for exact prediction of prognosis in OSCC. Glut-1 expression is seen

in patients with HNSCC; however the prognostic value of this parameter has not been analyzed systematically for this tumor type. The current study reveals that Glut-1 can be used as a prognostic marker or as a negative biomarker in OSCC.

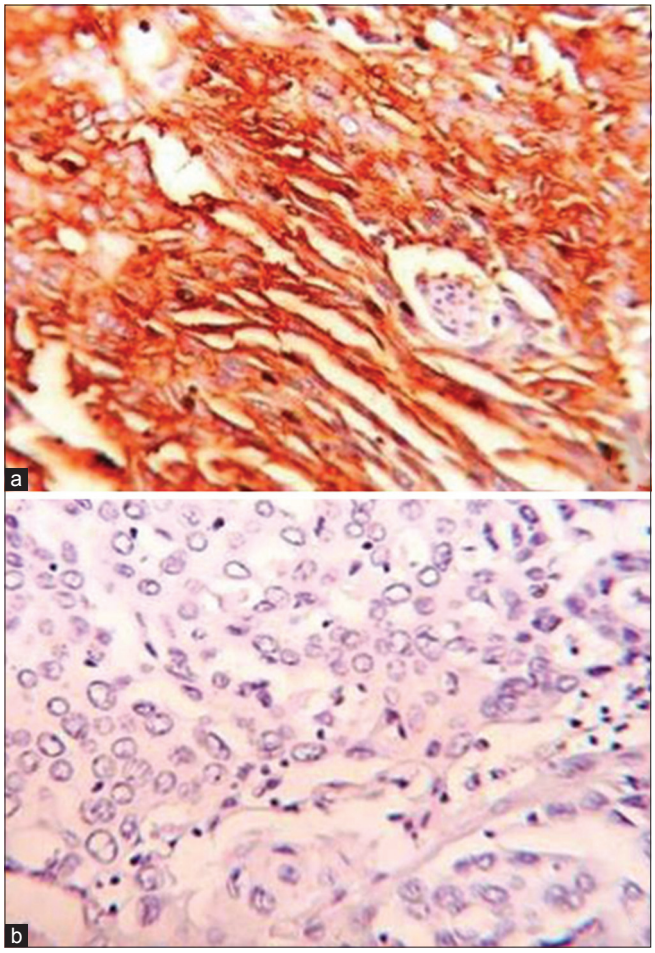

Figure 2: (a) Photomicrograph of esophageal carcinoma used as positive control for Glut 1, (IHC stain, ×400) (b) Negative control for Glut 1 expression on esophageal carcinoma on omitting the primary antibody (IHC stain, x400)

Glucose transporters which are membrane proteins active in the transport of hexoses such as glucose and fructose across plasma membranes are divided into two families: Facilitative glucose transporters (Glut family) and Na + coupled glucose transporters (SGLT family). Glut-1 is also called as erythrocyte, brain or Hep G2-type glucose transporter.[5]

Glut-1 is aglucose transporter protein with high affinity and clear potential to provide cellular growth advantages.[6] Over expression may play a role in survival of tumor cells by providing adequate energy supply which supports their high metabolic rate and fast growth in an environment that often is less than ideal from a physiologic stand point or not natural.[7] Direct link is seen between Glut-1 over expression and malignant transformation process.[8] Enhancement of glucose utilization, especially of glycolytic (anaerobic) metabolism is widespread characteristic of malignant cells.[9] Function and expression of Glut-1 is regulated by number of physiological and patho-physiological conditions.[10]

Altered expression of glucose transporter protein has been described in different tissues under various conditions such as cells undergoing transformation by oncogenes, hypoxia and exposure to insulin. It is a potential endogenous marker of hypoxia.[11] Expression of Glut-1 transporter protein is induced by certain oncogenes such as ras and src and regulated by growth factors such as platelet-derived growth factor and epidermal growth factor.[6,11] Changes in Glut-1 expression and rates of glucose transport are affected by growth rates, transformation and malignancy.[12]

The glycogen content in both normal mucosa and pre neoplastic lesions was always inversely correlated with Glut-1

Table 3:Comparison of expression of Glut-1 with respect to clinical staging of Oral Squamous Cell Carcinoma

IHC scores	Stage I	%	Stage II	%	Stage III	%	Stage IV	%	Total	%
Score 0	1	100.00	0	0.00	0	0.00	0	0.00	1	3.33
Score 1	8	80.00	1	10.00	1	10.00	0	0.00	10	33.33
Score 2	1	7.14	5	35.71	8	57.14	0	0.00	14	46.67
Score 3	0	0.00	0	0.00	3	60.00	2	40.00	5	16.67
Total	10	33.33	6	20.00	12	40.00	2	6.67	30	100.00

Chi-square=30.0213, df=9, *P*=0.0004, Chi-square test, *P*=0.0004, Significant

Table 4:Comparison of expression of Glut-1 with respect to different histopathological grades of Oral Squamous Cell Carcinoma

IHC score	Grade I	%	Grade II	%	Grade III	%	Total	%
Score 0	1	100.00	0	0.00	0	0.00	1	3.33
Score 1	9	90.00	1	10.00	0	0.00	10	33.33
Score 2	4	28.57	10	71.43	0	0.00	14	46.67
Score 3	0	0.00	1	20.00	4	80.00	5	16.67
Total	14	46.67	12	40.00	4	13.33	30	100.00

Chi-square=34.5563, df=6, *P*=0.00001, Chi-square test; *P*=0.00001, Significant

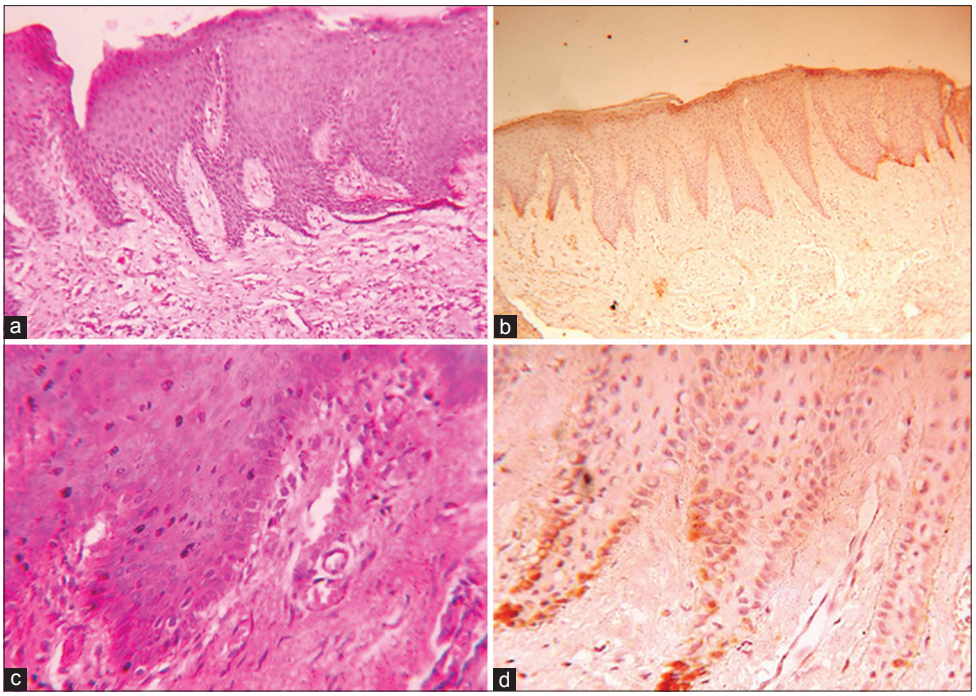

Figure 3: (a) Photomicrograph of H&E stained normal tissue section, (x100) (b) Photomicrograph of immunoexpression of Glut 1 in normal tissue sections showing predominant staining in the basal cell layer. (IHC stain, x40) (c) Photomicrograph of H&E stained normal tissue sections, (x400) (d) Photomicrograph of Glut 1 expression in normal tissue section, (IHC stain, x400)

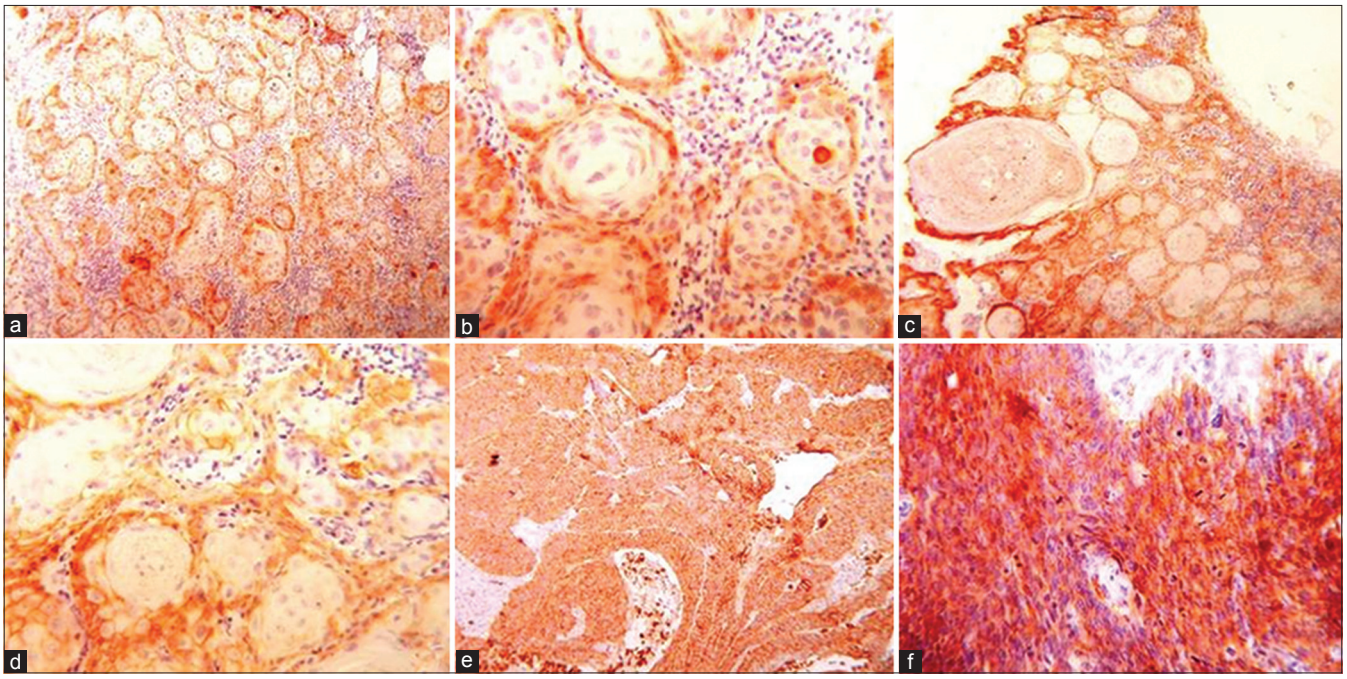

Figure 4: Immunoexpression of Glut 1 in OSCC. (a) Glut 1 expression in well differentiated (Grade I) OSCC, (IHC stain, ×100) (b) Glut 1 expression in well-differentiated OSCC showing predominant basal cell staining and loss of Glut 1 expression with keratinization at the core of the tumor nest, (IHC stain, ×400). (c) and (d) Glut 1 immunoexpressionin in moderately differentiated (Grade II) OSCC, (IHC stain, ×100 and ×400 respectively. (e) and (f) Glut 1 immunoexpression in poorly differentiated (Grade III) OSCC showing diffuse immunopositivity (IHC stain, ×100 and x400 respectively)

expression; exhibiting intense glycogen storage in normal and reduced glycogen storage in cells with different degrees of dysplasia associated with increased Glut-1 expression. Such localization pattern of glycogen was inversely correlated with the extension of proliferating compartment showing an association between glycogen storage and tumor cell differentiation in SCC.[13]

This study was done to evaluate the expression of Glut-1 in normal and OSCC cases with different clinical stages and

histopathological grades to determine the role of Glut-1 as a prognostic marker.

A study was conducted by Burstein DE *et al*., to evaluate the expression of Glut-1 in head and neck squamous intraepithelial neoplasia. Results showed negative or weak expression of Glut-1 in normal epithelium, and Glut-1 immunostaining was detected in cell layers above parabasal layer and that expression increased with the increased grading of squamous intraepithelial neoplasia.[14]

A study was done by Ayala FR *et al*., to investigate expression of Glut-1 in OSCC in which results showed that 50.3% cases showed membrane staining pattern and 49.7% showed nuclear expression.[15] In the present study only 1 case showed nuclear staining whereas the rest showed membrane staining pattern.

In the same study Ayala FR *et al*., investigated Glut-1 expression in OSCC. They compared the results with normal adjacent hyperplastic epithelium and the results showed that Glut-1 staining in non-neoplastic squamous epithelium was undetectable or weakly detected in suprabasal layers and predominant basal staining was seen.[15] Similar results were seen in our study where only 13 normal cases showed positive staining and a predominant basal staining was seen.

Study was conducted by Ohba S *et al*., on Glut-1 expression in invasive front to associate with depth of OSCC and prognosis; correlation with clinical characteristics showed that there was no positive correlation of Glut-1 expression with Tumor status or Node status.[1] In contrast our study showed positive correlation between Glut-1 expression and TNM staging with *P* value of 0.0004 in Chi-square test.

Study was done by Tian M *et al*., to investigate expression of Glut-1 in OSCC, results showed that there was no correlation between staining pattern and tumor differentiation or T grade classification.[16] Similar finding were seen in another study conducted byAirley *et al*., where Glut-1 immunohistochemical staining was carried out in many tumors and normal tissue types and the results showed no correlation between Glut-1 and grade of differentiation, which contrasts with the previous studies, where Glut-1 appears to correlate with histological differentiation of OSCC.[3] In our study we found correlation of Glut-1 staining with histological grades that was statistically significant with a *P* value of 0.00001 in Chi-square test.

The present study showed a significant statistical difference with *P* value of 0.00004 in Chi-square test between expression of Glut-1 in normal and OSCC cases. Our results coincided with the findings of a previous study done by Reisser C *et al*., to evaluate expression of Glut-1 in normal, pre neoplastic, neoplastic mucosal lesions of head and neck, where they observed weak expression of Glut-1 in normal mucosa and strong expression in HNSCC.[13]

A study was conducted by Mellanen P *et al*., on immunoexpression of glucose transporters 1–4 in head and neck tumors. The results showed that Glut-1 mediated facilitative glucose transport is involved in increased glucose metabolism of head and neck cancer.[17] Another study was done to determine expression of Glut-1 in association with increased glucose metabolism and prognosis in patients with OSCC by Kunkel M *et al*. The study supported that the significance of Glut-1 over expression which was associated with shorter survival and it was concluded that Glut-1 can be used as predictive marker or negative biomarker of prognosis in patients with OSCC.[18] This finding was further supported by other studies by Schutter HD *et al*., where they stated that Glut-1 can be correlated independently with prognosis.

Eckert AW *et al*., carried a study to determine expression of staining in comparison with clinico-pathological data. Results showed increased detection of Glut-1 in OSCC and suggested that Glut-1 expression is an independent marker for routine assessment of OSCC.[19] Recent study carried out to estimate prognostic value of Glut-1 by Ayala FR *et al.,* in OSCC showed that Glut-1 can be used as an indicator of poor prognosis in OSCC cases.[15]

The present study shows that the intensity of staining of Glut 1 varied with different clinical staging and histopathological grades of OSCC with severe intensity in Stage IV and poorly differentiated OSCC. Statistical significant results with respect to the intensity of staining were observed between clinical stages and histopathological grades of OSCC.

CONCLUSION

The present study shows that increased expression of Glut-1 is an early event in development of OSCC and that it can be used as an prognostic marker. There was a statistically significant increase in Glut-1 staining as the clinical staging progressed from stage 1 to –4 and as the histopathological grading progressed from grade I to grade III. The enhanced expression of this protein indicated increased glycolytic activity of the tumor cells with an increase in the stage or grade of thetumor. Hence, Glut-1 expression may be used as a prognostic biomarker in OSCC. However, studies of Glut-1 expression in larger samples need to be conducted for more conclusive results.

REFERENCES

1. Ohba S, Fujii H, Ito S, Fujimaki M, Matsumoto F, Furukawa M, *et al*.Overexpression of GLUT-1 in the invasion front is associated with depth of oral squamous cell carcinoma and prognosis.J Oral Pathol Med 2010;39:74-8.
2. Carvalho KC, Cunha IW, Rocha RM, Ayala FR, Cajaíba MM, Begnami MD, *et al*.GLUT1 expression in malignant tumors and its use as an immunodiagnostic marker. Clinics (Sao Paulo) 2011;66:965-72.
3. Airley R, Evans A, Mobasheri A, Hewitt SM. Glucose transporter Glut-1 is detectable in peri-necrotic regions in many

human tumor types but not normal tissues: Study using tissue microarrays. Ann Anat 2010;192:133-8.
4. Oliver RJ, Woodwards RT, Sloan P, Thakker NS, Stratford IJ, Airley RE. Prognostic value of facilitative glucose transporter Glut-1 in oral squamous cell carcinomas treated by surgical resection; results of EORTC Translational Research Fund studies. Eur J Cancer2004;40:503-7.
5. Mueckler M. Facilitative glucose transporters. Eur J Biochem 1994;219:713-25.
6. North PE, Waner M, Mizeracki A, Mihm MC. GLUT1: A newly discovered immunohistochemical marker for juvenile hemangiomas. Hum Pathol 2000;31:11-22.
7. Kawamura T, Kusakabe T, Sugino T, Watanabe K, Fukuda T, Nashimoto A, *et al*.Expression of glucose transporter-1 in human gastric carcinoma: Association with tumor aggressiveness, metastasis, and patient survival. Cancer 2001;92:634-41.
8. Mori Y, Tsukinoki K, Yasuda M, Miyazawa M, Kaneko A, Watanabe Y. Glucose transporter type-1 expression are associated with poor prognosis in patients with salivary gland tumors. Oral Oncol 2007;43:563-9.
9. Haber RS, Rathan A, Weiser KR, Pritsker A, Itzkowitz SH, Bodian C, *et al*.GLUT1 glucose transporter expression in colorectal carcinoma: A marker for poor prognosis. Cancer 1998;83:34-40.
10. Cooper R, Sarioglu S, Sokmen S, Fuzun M, Kupelioglu A, Valentine H, *et al*.Glucose transporter-1 (GLUT-1): Apotential marker of prognosis in rectal carcinoma? Br J Cancer2003;89:870-6.
11. Rudlowski C, Becker AJ, Schroder W, Rath W, Buttner R, Moser M. GLUT1 Messenger RNA and Protein induction relates to the malignant transformation of cervical cancer. Am J ClinPathol 2003;120:691-8.
12. Brown RS, Wahl RL.Overexpression of Glut-1 glucose transporter in human breast cancer. An immunohistochemical study. Cancer1993;72:2979-85.
13. Reisser C, Eichhorn K, Herold-Mende C, Born AI, Bannasch P. Expression of facilitative glucose transport proteins during development of squamous cell carcinomas of the head and neck. Int J Cancer 1999;80:194-8.
14. Burstein DE, Nagi C, Kohtz DS, Lumerman H, Wang BY. Immunohistochemical detection of GLUT1, p63 and phosphorylated histone H1 in head and neck squamous intraepithelial neoplasia: Evidence for aberrations in hypoxia-related, cell cycle- and stem-cell-regulatory pathways. Histopathology 2006;48:708-16.
15. Ayala FR, Rocha RM, Carvalho KC, Carvalho AL, da Cunha IW, Lourenço SV, *et al*.Glut1 and Glut3 as potential prognostic markers for oral squamous cell carcinoma.Molecules 2010;15:2374-87.
16. Tian M, Zhang H, Nakasone Y, Mogi K, Endo K. Expression of Glut-1 and Glut-3 in untreated oral squamous cell carcinoma compared with FDG accumulation in a PET study. Eur J Nucl Med Mol Imaging 2004;31:5-12.
17. Mellanen P, Minn H, Grenman R, Harkonen P. Expression of glucose transporters in head-and-neck tumors. Int J Cancer 1994;56:622-9.
18. Kunkel M, Reichert TE, Benz P, Lehr HA, Jeong JH, Wieand S, *et al*. Overexpression of Glut-1 and increased glucose metabolism in tumors are associated with a poor prognosis in patients with oral squamous cell carcinoma. Cancer 2003;97:1015-24.
19. Eckert AW, Lautner MH, Taubert H, Schubert J, Bilkenroth U. Expression of Glut1 is a prognostic marker for oral squamous cell carcinoma patients. Oncol Rep 2008;20:1381-5.

How to cite this article: Harshani JM, Yeluri S, Guttikonda VR. Glut-1 as a prognostic biomarker in oral squamous cell carcinoma. J Oral Maxillofac Pathol 2014;18:372-8.

Source of Support: Nil. **Conflict of Interest:** None declared.