

## Accuracy of Ultrasound in Detection of Cervical Lymph Node Metastasis of Oral Squamous Cell Carcinoma

**Rand Sh. Al-Ani**  
BDS., MSc., (Lec.)

**Ammar M. Mashlah**  
BDS., MSc . PhD. (Prof)

**Mohammad I. Al. Hafar**  
BDS., MSc.,PhD. (Asst. Prof)

**Department of Oral Medicine Dentistry**  
College of Dentistry, University of Damascus

**Department of Oral Medicine Dentistry**  
College of Dentistry, University of Damascus

**Department of Oral Medicine Dentistry**  
College of Dentistry, University of Damascus

### الخلاصة

**الأهداف:** تهدف الدراسة الى معرفة ما إذا كانت صدوية السرة لوحدها هي معيار جيد للكشف عن انتقالات العقد اللمفاوية العنقية الخبيثة لدى مرضى سرطان الفم ذو الخلايا الحرشفية . **المواد وطرائق العمل :** تم فحص عشرون مريضاً مشخص بإصابته بسرطان الفم ذو الخلايا الحرشفية ( 14 ذكر، 6 أنثى)، بعمر (40-90 سنة) باستخدام الأمواج فوق الصوتية، حيث تم تقييم (112) عقدة لمفاوية عنقية وكان المعيار الوحيد المستخدم للتمييز بين العقد اللمفاوية العنقية الخبيثة والحميدة هو صدوية السرة. قُيِّمت هذه العقد من ناحية (وجود السرة، العدد، والحجم، والموقع، والشكل، فضلاً على التنخر). تمت مقارنة نتائج فحص الأمواج فوق الصوتية للعقد اللمفاوية مع الفحص النسيجي باستخدام اختبار (t) ( غير المزاوج واختبار (فشر). **النتائج:** أظهرت نتائج فحص الأمواج فوق الصوتية، حساسية (84,09%) ونوعية (95,59%) ودقة (91,07%) والقيمة التنبؤية الايجابية (92,5 %) والقيمة التنبؤية السلبية (90,28 %). **الاستنتاجات:** أظهرت نتائج الفحص بالأمواج فوق الصوتية دقة عالية باستخدام صدوية السرة كمعيار وحيد في الكشف عن انتقالات العقد اللمفاوية العنقية الخبيثة لمرضى سرطان الفم ذو الخلايا الحرشفية. كلمات مفتاحية: العقد اللمفاوية العنقية، سرطان الفم ذو الخلايا الحرشفية، الأمواج فوق الصوتية .

### ABSTRACT

**AIMS:** This study was conducted to see whether the hilar echogenicity alone is a good criteria for detection of cervical lymph node metastasis in patients with oral squamous cell carcinoma (OSCC). **MATERIALS AND METHODS:** Twenty patients with OSCC (14 males and 6 females), their age 40-90 years, were examined sonographically, and the number of cervical lymph nodes studied was 112. Hilar echogenicity alone was used as a criteria to differentiate between benign and malignant cervical lymph nodes. Lymph nodes were evaluated for their echogenic hilus, number, size, site, shape, as well as for necrosis. The results of US evaluation were compared with histopathologic outcome using unpaired t-test and Fisher's exact probability test. **RESULTS:** Ultrasound examination yielded a sensitivity as 84.09%, specificity 95.59%, accuracy 91.07%, positive predictive value (PPV) 92.5%, and negative predictive value (NPV) 90.28%. **CONCLUSIONS.** Sonographic examination have a high accuracy in detecting cervical lymph node metastasis in patients with oral squamous cell carcinoma, depending on hilar echogenicity as a diagnostic criteria.

**Keywords:** Cervical lymph nodes, oral squamous cell carcinoma, ultrasound..

Al-Ani RS, Mashlah AM, Al. Hafar MI, Accuracy of Ultrasound in Detection of Cervical Lymph Node Metastasis of Oral Squamous Cell Carcinoma. *Al-Rafidain Dent J.* 2014; 14(2):236-243 .

**Received:** 11/3/2013

**Sent to Referees:** 18/3/2013

**Accepted for Publication:** 7/5/2013

### INTRODUCTION

Oral cancer is the sixth most common malignancy in the world; the majority are mucosal squamous cell carcinomas.<sup>(1)</sup> OSCC is accounting 95% of all oral malignant lesions. The most affected sites are the tongue, inferior lips and floor of the mouth.<sup>(2)</sup>

Accurate pretreatment evaluation of patients with head and neck squamous cell carcinoma (HNSCC) is fundamental

for optimal treatment planning by a thorough assessment of the primary tumor and the status of the regional (cervical) lymph node.<sup>(3)</sup> Regional metastasis is an important factor in the treatment and prognosis of oral cancer patients, because the presence of metastatic node reduces the 5-year survival rate by 50% and the presence of another metastatic node on the contralateral side further reduces the survival rate by 25%.<sup>(4-7)</sup>

Although lymph node micrometastases which cannot be observed macroscopically may be present at the cellular level, and although there may be small lesions which cannot be detected even by ultrasonography, it is very important to perform pretreatment ultrasonographic assessment of lymph nodes less than 10 mm in diameter. This suggests that ultrasonography is indispensable for metastasis evaluation.<sup>(8)</sup> The spatial resolution achieved by modern US machines, surpasses that of both multislice CT and MRI. Images are rapidly acquired, artifacts are few, and the technique is highly acceptable to most patients.<sup>(9)</sup>

Gray-scale sonography is widely used in evaluation of the number, size, site, shape, borders, matting, adjacent soft-tissue edema, and internal architectures of cervical lymph nodes.<sup>(10,11)</sup>

In this study, hilar echogenicity was selected as a diagnostic criteria to see whether it is a reliable indicator for detection of cervical lymph nodes metastasis in patient with OSCC.

The aim of the study is to assess the accuracy of US in detecting lymph node metastasis depending on hilarechogenicity.

## MATERIALS AND METHODS

This study was done in Department of Oral Medicine, Dentistry College, Damascus University. A total of 20 patients with oral SCC, 14 male and 6 female, ranging in age 40-90 years with a mean age of 65 years, were examined sonographically. All the scans were performed with Convex Scanner/Convex/Linear Ultrasonic Scanner (HS 4000 Honda Electronic CO., LTD-Japan) and 10 MHz linear-array transducer. The number of cervical lymph nodes studied was 112. These patients underwent neck dissection along with the excision of the primary tumor. Eighteen patients underwent unilateral neck dissection and two bilateral. Out of twenty cases, eight were supraomohyoid and twelve were radical neck dissection, which performed 1-2 weeks after clinical and US examination. The primary tumor sites were: thirteen of buccal mucosa, four of the tongue, three posterior trigone.

Inclusion criteria were clinical evidence and histopathologic confirmation of oral cancer with or without cervical lymphadenopathy (N-all) and surgery as primary form of treatment, neck dissection is performed at the time of first treatment and no distant metastasis at diagnosis. None of the patients had:

- Positive history of treated or untreated malignancy of any other organ or secondary elsewhere in the body.
- Previously undergone a neck dissection on the affected side or received pre-operative radiation therapy or chemotherapy.

For ultrasound examination, the distribution of the lymph nodes of the neck was studied by following the classification established by<sup>(12)</sup>, according to which the cervical lymph nodes are classified into 8 levels according to their location in the neck. Scans were obtained with the transducer placed transversely and longitudinally and measurements made in the plane that showed a maximum cross sectional area.

The US criteria used to differentiate benign from malignant lymph nodes was the presence / absence of the echogenic hilum only, as the presence of an echogenic hilum within lymph nodes was previously considered a sign of benignity.<sup>(11,13,14)</sup>

On US, the echogenic hilum appears as an hyperechoic intranodal linear structure which is continuous with the adjacent perinodal fat.<sup>(15,16)</sup> All detected lymph nodes were assessed for their site, size, numbers, shape (short-to-long-axis [S/L] ratio), as well as for the presence of an echogenic hilum, and necrosis.

During surgery, the lymph nodes were excised en bloc along with the adjacent reference structures to ascertain more easily the spatial relationship between the excised nodes and surrounding structures such as muscles, salivary glands, and veins. All specimens were dissected immediately after the removal, the size of the node was measured (short and long axis) and used for comparison with nodes studied sonographically. In groups of nodes, the node that most nearly corresponded to the detected one was selected. The neck dissection specimen was marked

so that levels could be identified by the pathologist. Although all nodes were removed from specimens and subjected to histological examination (HE), only nodes that correlated with ultrasonic observations served as materials for this study.

The lymph node specimens were sent as separate groups in separate containers for histopathology. If more than one lymph node was to be sampled from one site, the anatomic and morphologic correlation between the lymph nodes examined and excised was determined to ensure that they were from the same site. All biopsied lymph nodes were fixed, embedded in paraffin, sliced in 4 µm thickness and stained for microscopic examination by hematoxylin and eosin, and each node was pathologically determined to be metastatic or benign. Then the US findings were compared with histopathologic findings, which is the gold-standard diagnostic testing for the presence of metastatic lymph nodes<sup>(17)</sup>. The correlation between all sonographic parameters and histological diagnosis was statistically analyzed for each lymph node. An unpaired t-test was employed for comparison of long axis diameter, short axis diameter and shape index

between metastatic and benign nodes. Fisher's exact probability test was used for comparison of the pattern of internal echoes and existence of echogenic hilus. All statistical procedures were carried out using a statistical analysis software application program (SPSS 20). Difference was considered as significant if  $P \leq 0.05$ .

## RESULTS

One hundred twelve resected lymph nodes were correlated with the sonographic images. These nodes were incorporated in the drainage regions of the primary tumors. The anatomic locations of these nodes involved by metastases were as follows: 47 (42%) submandibular region, 39 (34.8%) upper cervical region, 15 (13.4%) submental region, 11 (9.8%) middle cervical region, no involvement to other regions, 45 of the 112 nodes were histologically diagnosed as metastatic and 67 node as benign. On comparing US and HE; 65 lymph nodes were true negative, 37 true positive, 7 false negative, and 3 false positive.

In this study, the hilar echogenicity shows significant difference in both US and HE as shown in Table (1), (2).

Table (1): Represent hilus echogenicity in US

Hilum	Benign n (%)	Malignant n (%)	Total n (%)	Chi-Square	P-value
Absent	4(9.3)	39(90.7)	43(100)	87.998	.000(**)
Present	67(97.1)	2(2.9)	69(100)		

n: number, US: ultrasound. (\*\*) P-value  $\leq 0.01$  significantly different

Table (2): Represent hilus echogenicity in HE

Hilum	Benign n (%)	Malignant n (%)	Total n (%)	Chi-Square	P-value
Absent	2(5.4)	35(94.5)	37(100)	75.001	.000(**)
Present	65(86.6)	10(13.3)	75(100)		

n: number, (\*\*) P-value  $\leq 0.01$  significantly different, HE: histological examination.

The mean and standard deviation of the long and short axis diameter, and shape index for malignant and benign nodes were show significant differences in both US and HE as in Tables (3),(4),(5),(6). The comparison

between size and shape of nodes in US and HE, shows no significant differences as in Table (7). The comparison between US and HE in detection of necrosis shown in Table (8).

Table (3): Represent long and short axis diameter in 112 node in US.

	<b>Benign</b> Mean ± SD	<b>Malignant</b> Mean ± SD	<b>t-test</b>	<b>P-value</b>
<b>L</b>	8.878 ±3.211	12.733 ±6.469	4.212	.000(**)
<b>S</b>	5.49 ±1.981	9.34 ±6.078	4.915	.000(**)
<b>n</b>	41	71		

n: number, SD: Standard Deviation , L:long axis , S: short axis ,US: ultrasound,  
(\*\*) P-value ≤ 0.01 significantly different

Table (4): Represent long and short axis diameter in 112 node in HE

	<b>Benign</b> Mean ± SD	<b>Malignant</b> Mean ± SD	<b>t-test</b>	<b>P-value</b>
<b>L</b>	9.14 ±3.732	13.48 ±6.126	4.657	.000(**)
<b>S</b>	5.95 ±1.89	9.78 ±5.036	5.665	.000(**)
<b>n</b>	67	45		

n: number, SD: Standard Deviation , L:long axis , S: short axis ,HE: histological examination  
(\*\*) P-value ≤ 0.01 significantly different.

Table (5): Represent the shape of 112 node in US

	<b>Benign</b>			<b>Malignant</b>		
	Mean ± SD	t-test	P-value	Mean ± SD	t-test	P-value
<b>S/L ≥0.5</b>	0.748 ±0.146	11.424	.000(**)	0.773 ±0.147	6.568	.000(**)
<b>S/L &lt; 0.5</b>	0.369±0.090			0.319 ±0.117		
<b>n: ≥0.5</b>	48 (67.6%)			36 (87.8%)		
<b>n: &lt;0.5</b>	23 (32.4%)			5 (12.2%)		
<b>Total n</b>	71			41		

n: number, SD: Standard Deviation , L:long axis , S: short axis ,US: ultrasound  
(\*\*) P-value ≤ 0.01 significantly different.

Table (6): Represent the shape of 112 node in HE

	<b>Benign</b>			<b>Malignant</b>		
	Mean ± SD	t-test	P-value	Mean ± SD	t-test	P-value
<b>S/L ≥0.5</b>	0.727 ±0.167	6.865	.000(**)	0.755 ±0.151	5.202	.000(**)
<b>S/L &lt; 0.5</b>	0.367 ±0.102			0.397 ±0.047		
<b>n: ≥0.5</b>	56 (83.5%)			40 (88.8%)		
<b>n: &lt;0.5</b>	11 (16.5%)			5 (11.2%)		
<b>Total n</b>	67			45		

n: number, SD: Standard Deviation , L:long axis, S: short axis, HE: histological examination  
(\*\*) P-value ≤ 0.01 significantly different.

	Benign Mean ± SD		t	P	Malignant Mean ± SD		t	P
	US	HE			US	HE		
<b>L</b>	8.877± 3.211	9.143± 3.732	-.449	.654	12.733± 6.469	13.482 ±6.125	-.551	.583
<b>S</b>	5.487± 1.981	5.95± 1.889	-1.40	.163	9.335± 6.077	9.777± 5.035	-.369	.713
<b>S/L&lt;0.5</b>	0.369± 0.090	0.367± 0.102	.055	.956	0.319±0 .117	0.397± 0.047	-1.393	.201
<b>S/L≥0.5</b>	0.748± 0.146	0.727± 0.167	.682	.497	0.773±0 .147	0.755± 0.151	.530	.597

Table (7): Comparison of lymph nodes size and shape between US and HE. SD: Standard Deviation , L:long axis , S: short axis ,US: ultrasound ,HE: histological examination , t:t test, P:P-value

Table (8): Comparison between US and HE in detection of necrosis.

Necrosis	US n(%)	HE n(%)
<b>Present</b>	25(61)	28(62.2)
<b>Absent</b>	16(39)	17(37.8)

n: number ,US: ultrasound ,HE: histological examination

The efficiency of US to detect malignant nodes was evaluated in term of sensitivity, specificity, accuracy, PPV, and NPV, with HE as a gold standard. US showed a sensitivity of 84.09%, specificity of 95.59% , accuracy of 91.07% , PPV of 92.50% , NPV of 90.28%.

### DISCUSSION

Many studies have reported the usefulness of US for the diagnosis of lymph node metastases depending on: size , shape , presence or absence of the hilum , echogenicity, margins , intranodal necrosis, reticulation, calcification , matting and soft tissue edema<sup>(18-24)</sup> . In these reports, ultrasound scanning had a diagnostic accuracy rate of about 90% in cervical lymph node staging<sup>(22)</sup> and was significantly better than CT<sup>(21)</sup>.

The presence of central echogenic hilum in normal and reactive nodes is due to the abutment of multiple medullar sinuses acting as interfaces<sup>(6,10,11)</sup> , which is the result of multiple fluid-filled sinuses, each of which acts as an acoustic interface, partially reflecting incident sound waves and imparting an echogenic structure, whilst fatty infiltration makes the hilum

more obvious.<sup>(15,25-27)</sup> Previously it was thought that the echogenic hilum represent intranodal fat within the lymph node<sup>(16,28,29)</sup> . It has been shown that about 90% of benign cervical nodes with a diameter above 5mm display an echogenic hilum<sup>(11,30)</sup> . Malignant nodes are, traditionally, described as having no visible hilum<sup>(6,10,11,21)</sup> . The absence of the echogenic hilum on US is due to tumor infiltration of the sinuses with distortion of the internal architecture, which no longer has multiple reflective surfaces<sup>(31)</sup>. This replacement is considered as a diagnostic criteria of abnormality and is significantly greater in malignancies than in benign lesions<sup>(32)</sup> .

In this study, the hilum was absent in 39(90.7 %) malignant lymph node out of 43(100 %) and present in 67 (97.1%) benign nodes out of 69 (100%) in US , this result is in agreement with Ahuja et al<sup>(31)</sup> who show 91.5% of 118 malignant nodes without echogenic hilum, and with Yuasa et al<sup>(33)</sup> , who detected 458 nodes in patients with N-all HNSCC, and found the echogenic hilum was missing in 90% of the metastatic nodes. In HE it was absent in 35(94.5 %) malignant node out

of 37 (100%) ,and present in 65 (86.6%) benign nodes out of 75 (100%).

Depending on this result, which shows that the echogenic hilum is a reliable indicator in detecting lymph node metastasis, other parameters such as size, shape and necrosis , was studied.

The size of metastatic nodes showed larger long and short axis diameters than benign nodes with significant differences in both US and HE. When matching the nodal size between US and HE ,it shows no significant differences , which means that , size of lymph nodes is a significant criteria in diagnosis. This result is in agreement with Dangore-Khasbage et al. (34)

The shape of cervical nodes was assessed by the ratio of short and long axis (S/L ratio). Normal lymph nodes are usually oval or elongated (S/L < 0.5), whereas metastatic nodes tend to be round (S/L  $\geq$ 0.5) (1,35-37). In this study the relationship between HE and US for the shape index (S/L) of benign and malignant lymph nodes show no significant difference , which means that the shape is a significant criteria for the diagnosis. The roundness relationship (S/L  $\geq$ 0.5) of malignant nodes shows 87.8% of 41 in US, and 88.8% of 45 in HE. In benign lymph nodes 67.6% of 71 lymph nodes were round (S/L  $\geq$ 0.5) and 32.3% were oval (< 0.5 ) in US, and 83.5% of 67 round, and 16.5% oval in HE. The roundness of benign nodes may be due to the large number of sub mandibular lymph nodes detected in this study (42%) ,which are normally round (10,11) , and because the overlapping of US findings.

In the present study, the size and shape of nodes were a significant criterion, because, in malignant nodal disease, the infiltration of the node by malignant tissue changes the shape and deforms the normal echogenic hilum. Thus, the characteristic findings of metastatic node are enlargement with a round to spherical shape and loss of hilar structure. (20) In benign reactive nodes, the diffuse nature of the process usually preserves the normal nodal shape and echogenic hilar structure. (38) All lymph nodes in this study were hypoechoic compared to neighboring muscles ,

but hypoechogenicity is not a useful diagnostic sign, because Lymphomatous , tuberculous and lymphadenitis nodes are also hypoechoic. (10,11)

Lymph nodes with intranodal necrosis, regardless of their size, are pathologic , and indicate malignancy in most instances. Intranodal necrosis can be classified into two types: cystic necrosis (also known as liquefaction necrosis) and coagulation necrosis (10,15,16,25) , Cystic necrosis appears as eccentric fluid area within the structure of the lymph node . It is more frequent in squamous carcinoma metastases , but it may appear in any type of metastasis. (10) Cystic necrosis appears as an echolucent area within the lymph nodes ,whilst coagulation necrosis is an uncommon sign and appears as an echogenic focus within the nodes. (15,16,25) In this study , cystic necrosis detected , which form 61% of malignant nodes in US, and 62.2% of malignant nodes in HE.

US showed a sensitivity of 84.09%, specificity of 95.59%, accuracy of 91.07% , PPV of 92.50%, NPV of 90.28% . High percentage of specificity is due to 35% of the sample was NO lymph node. This result is comparable with Sureshkannan et al (39) ,who showed that, US sensitivity was 85.7%, specificity 90%, accuracy 87.5% , PPV 92.3%, and NPV as 81.8%.

The present study showed that , for primary tumors the regional lymph nodes which are at highest risk for early dissemination by metastatic cancer are at submandibular and upper cervical levels, similar to that mentioned by Ahuja and Ying. (6)

From these results it is obvious that absence of hilum was found in 5.4% of benign nodes ,while 13.3% of malignant nodes still exhibit hilar echogenicity , which means that loss of fatty hilum is not a definite criterion for differentiation between malignant and benign lymph nodes, but it can gives a useful clue in the diagnosis of cervical lymph node metastasis.

## CONCLUSION

US has a high accuracy in detecting cervical lymph node metastasis depending on hilar echogenicity as the only

diagnostic criteria in patients with OSCC, but still this criteria is not a definitive one .

### REFERNCES

1. Saraswathi M C, Desai R, Reddy PB. Efficiency of ultrasonography in assessing cervical lymph node metastasis in oral carcinoma . *National Journal of Maxillofacial Surgery* .2003; 1(2) : 117-118 .
2. Dantas DD, Ramos CC, Costa AL, Souza LB, Pinto LP. Clinical- pathological parameters in squamous cell carcinoma of the tongue. *Braz Dent J* .2003;14(1):22-25.
3. Shah J.P. and Patel G. P. Head and neck surgery and oncology. 3rd ed. Mosby, New York. 2003; Pp: 175, 268 .
4. Hao SP, Ng SH. Magnetic resonance imaging versus clinical palpation in evaluating cervical metastasis from head and neck carcinoma. *Otolaryngol Head Neck Surg* . 2000;123:324-327 .
5. Ahuja A, Ying M. An overview of neck node sonography. *InvestRadiol*. 2002; 37:333-342.
6. Ahuja A, Ying M. Sonography of neck lymph nodes. part II: abnormal lymph nodes. *ClinRadiol*. 2003;58:359-366.
7. Takes RP. Staging of neck in patients with head and neck squamous cell cancer: Imaging techniques and biomarkers. *Oral Oncol*. 2004;40:656-667.
8. Furukawa MF . Furukawa M. Diagnosis of lymph node metastases of head and neck cancer and evaluation of effects of chemoradiotherapy using Ultrasonography. *Int J Clin Oncol*. 2010; 15:23–32. <http://www.ivsl.org>
9. Breeze J, AndiA,Williams MD, Howlett DC. The use of fine needle core biopsy under ultrasound guidance in the diagnosis of a parotid mass. *Br J Oral Maxillofac Surg*. 2009;47:78–79. <http://www.ivsl.org>
10. Ahuja A. Ying M. Sonographic evaluation of cervical lymph nodes. *AJR* .2005; 184:1691-1699 .
11. Ahuja A , Ying M , Ho SY, Antonio G , Lee YP, King AD, Wong KT. Ultrasound of malignant cervical lymph nodes. *Cancer Imaging*. 2008; 8(1): 48–56.
12. Hajek PC, Salomonowitz E, Turk R, Tscholakoff D, Kumpan W, Czemberek H. Lymph nodes of the neck evaluation with US. *Radiology*. 1986;158:739-742.
13. Solbiati L, Cioffi V, Ballarati E. Ultrasonography of the neck. *RadiolClin North Am*. 1992; 30: 941-954.
14. Ying M, Ahuja A, Brook F, Metreweli C. Vascularity and grayscale sonographic features of normal cervical lymph nodes: variations with nodal size. *ClinRadiol* .2001;56:416-419.
15. Evans RM, Ahuja A, Metreweli C. The linear echogenic hilus in cervical lymphadenopathy - a sign of benignity or malignancy. *ClinRadiol*. 1993; 47: 262.
16. Sakai F, Kiyono K, Sone S, Kondo Y, Oguchi M, Watanabe T, Sakai Y, Imai Y, Takeda S, Yamamoto K . Ultrasonic evaluation of cervical metastatic lymphadenopathy. *J Ultrasound Med*. 1988; 7: 305 .
17. Connor SEJ, JFC Olli JFC. Review. Imaging of malignant cervical lymphadenopathy. *Dentomaxillofac Radiol*. 2000;29:133-143.
18. Dudea SM, Lenghel M, Botar-Jid C, Vasilescu D, Duma M. Ultrasonography of superficial lymph nodes: benign vs. malignant. *Med Ultrason*. 2012; 14 (4):294-306.
19. Yuasa K, Kawazu T, Kunitake N, Uehara S, Omagari J, Yoshiura K, Nakayama E, and Kanda S. Sonography for the detection of cervical lymph node metastases among patients with tongue cancer: criteria for early detection and assessment of follow-up examination intervals. *American Journal of Neuroradiology*. 2000; 21( 6) : 1127–1132 .
20. Koischwitz D and Gritzmann N, Ultrasound of the neck. *Radiologic Clinics of North America*. 2000; 38( 5): 1029–1045.
21. Sumi M, Ohki M, and Nakamura T. Comparison of sonography and CT for differentiating benign from malignant cervical lymph nodes in patients with squamous cell carcinoma of the head and neck. *AJR Am J Roentgenol*. 2001; 176(4): 1019–1024.

22. Gritzmann N, Hollerweger A, Macheiner P, and Rettenbacher T. Sonography of soft tissue masses of the neck. *Journal of Clinical Ultrasound*. 2002; 30(6):356–373. www.ivsl.org
23. Hayashi T, Ito J, Taira S, Katsura K, Shingaki S, and Hoshina H. The clinical significance of follow-up sonography in the detection of cervical lymph node metastases in patients with stage I or II squamous cell carcinoma of the tongue. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics*. 2003; 96(1): 112–117.
24. van den Brekel MW, and Castelijns JA. What the clinician wants to know: surgical perspective and ultrasound for lymph node imaging of the neck. *Cancer Imaging*. 2005; 5: S41–S49. <http://www.ivsl.org>
25. Rubaltelli L, Proto E, Salmaso R, Bor-toletto P, Candiani F, Cagol P. Sonography of abnormal lymph nodes in vitro: correlation of sonographic and histologic findings. *AJR Am J Roentgenol*. 1990; 155:1241–1244.
26. Vassallo P, Wernecke K, Roos N, Peters PE. Differentiation of benign from malignant superficial lymphadenopathy: the role of high-resolution US. *Radiology*. 1992; 183:215–220.
27. Vassallo P, Edel G, Roos N, Naguib A, Peters PE. In-vitro high-resolution ultrasonography of benign and malignant lymph nodes. A sonographic-pathologic correlation. *Invest Radiol*. 1993;28:698-705.
28. Marchal G, Oyen R, Verschakelen J, Gelin J, Baert A L and Stessens R C. Sonographic appearance of normal lymph nodes. *J Ultrasound Med*. 1985; 4:417–419.
29. Sakai F, Kiyono K, Sone S, Kondo Y, Oguchi M, Watanabe T, Sakai Y, Imai Y, Takeda S, Yamamoto K. Ultrasonic evaluation of cervical metastatic lymphadenopathy. *J Ultrasound Med*. 1988;7:305-310.
30. Ying M, Ahuja A, Brook F. Sonographic appearances of cervical lymph nodes: Variations by age and sex. *J Clin Ultrasound*. 2002;30:1-11.
31. Ahuja A, Ying M, King A, Yuen HY. Lymph Node Hilus Gray Scale and Power Doppler Sonography of Cervical Nodes. *J Ultrasound Med*. 2001; 20: 987–992.
32. Kuna SK, Bracic I, Tesic V, Kuna K, HercegGH, DodigD. Ultrasonographic differentiation of benign from malignant neck lymphadenopathy in thyroid cancer. *J Ultrasound Med* 2006;25:1531- 1537.
33. Yuasa K, Kawazu T, Nagata T, Kanda S, Ohishi M, Shirasuna K. Computed tomography and ultrasonography of metastatic cervical lymph nodes in oral squamous cell carcinoma. *Dento-maxillofacRadiol*. 2000; 29: 238-244.
34. Dangore-Khasbage S, Degwekar SS, Bhowate RR, Banode PJ, Bhake A, Choudhary MS, and Lohe VK. Utility of color Doppler ultrasound in evaluating the status of cervical lymph nodes in oral cancer. *Oral Surg Oral Med Oral Pathol Oral RadiolEndod*. 2009;108:255-263.
35. Ying M, Ahuja A, Metreweli C. Diagnostic Accuracy of Sonographic Criteria for Evaluation of Cervical Lymphadenopathy. *J Ultrasound Med*. 1998; 17:437–445.
36. Richards PS and Peacock T.E. The role of ultrasound in the detection of cervical lymph node metastases in clinically N0 squamous cell carcinoma of the head and neck. *Cancer Imaging*. 2007; 7: 167-178.
37. Gupta A, Rahman K, Shahid M, Kumar A, Qaseem SM, Hassan SA, Siddiqui FA. Sonographic assessment of cervical lymphadenopathy: Role of high-resolution and color doppler imaging. *Head & Neck*. 2011; 33: 297–302.
38. Na DG, Lim HK, Byun HS, Kim HD, Ko YH, Baek JH. Differential diagnosis of cervical lymphadenopathy: usefulness of color doppler sonography. *AJR Am J Roentgenol*. 1997;168:1311-6.
39. Sureshkannan P, Vijayprabhu, John R. Role of ultrasound in detection of metastatic neck nodes in patients with oral cancer. *Indian Journal of Dental Research*. 2011; 22(3) : 419-42.