1.1INTRODUCTION

Salivary gland tumors are heterogenous group of neoplasmin the head and neck area. These tumors have complex morphologic appearance and different clinical behaviour, a fact that makes them difficultto diagnosis (Ansari, 2007). These tumors are rare lesions, represent less than 1% of all tumors and 3-6% of all head and neck neoplasms found in various reports (Ethunandun et al., 2009).

The annual incidence of salivary gland carcinomas ranges from 0.5-2 per 100000 in different countries of the world (Parkin et al., 2010). The sex distribution for salivary gland carcinomas are equal and the majority of the cases arise in the sixth decade (Licitra et al., 2003). Most of these tumors are benign and only 20% are malignant. Approximately 80% of salivary gland tumors occur in the parotid gland, of these 75-80% are benign.

Among benign salivary gland tumors 80% contributors are Pleomorphic adenoma, 10% Warthins tumor and 10% others. On the other hand, malignant tumors of salivary gland comprises Mucoepidermoid carcinoma 35%, malignant pleomorphic adenoma 20% and Acinic cell carcinoma 10-25% (Izzo et al., 2006).

Parotid gland is the largest of all salivary gland.Parotid gland masses include benign tumors, malignant tumors & chronic inflammatory diseases. Diagnosis of these benign and malignant tumors is important for management (Kim et al., 2004). Clinical presentation of parotid tumors, especially the malignant ones depends on the involvement with the facial nerve and other cranial nerves as well as the involvement of other structures outside the parotid such as masseter muscle, Sternocleidomastoid muscle, mastoid, skin, skull base. A broad spectrum of pathologies that present along with parotid swelling and extra glandular masses can also mimic parotid

lesionclinically. It is frequently difficult on clinical grounds alone to distinguish between benign and malignant parotid neoplasm.

After initial demonstration and characterization of parotid tumor by imaging FNAC is used to confirm its nature (Islam et al.,2015). There are different imaging modalities for evaluation of parotid gland lesions like ultrasonogram, Color Doppler, CT scan, MRI. CT scan leads to an accurate appraisal of parotid lesions allowing torecognize localization, sizes, margins and density, presence of intranodular calcification, invasion of surrounding tissues (Chawla et al., 2017).

Metwally Abo El Atta et al., (2016)shows multiphasic CT scan reveals 92.6% sensitivity, 96.3% specificity, 95.1% accuracy in characterization of benign and malignant parotid tumor.However the major limit for CT scan remains the radiation exposure. For patients with a history of hypersensitivity and kidney dysfunction, use of contrast agent is inappropriate (Hasebroock and Serkova, 2009).

On the contrary, MRI is a radiation free imaging modality that can achieve higher value of sensitivity and specificity for what concern the morphological and volumetric assessment, well soft tissue morphology, the lesion components, the extraglandular extension and the perineural spread.

Dynamic contrast MRI has high sensitivity of 94.4%, specificity of 97.2%, positive predictive value of 94.4%, negative predictive value of 97.2% and accuracy 96.3% in characterization of benign and malignant parotid tumors (Metwally Abo El Atta et al., 2016).

The high cost & prolonged scanning time for MRI may discourage its wide use (Liu et al., 2015).

Since sole clinical investigation lacks the necessary reliability in this respect, imaging methods arebeing applied. Due to zero invasiveness and cost effectiveness, ultrasound is now considered as an essential imaging method. Its specificity can be substantially improved by using color Doppler method mapping the blood flow in tumor supplying vessels. Color Doppler criteria are used to distinguish between benign and malignant tumors, particularly in terms of grade of intra tumor vascularity, pattern of vascular supply and flow parameter (Izzo et al., 2004). Color Doppler ultrasonogram uses PSV, PI, RI values for distinguishing benign tumors and carcinoma. Izzo et al. (2004) shows in benign tumors the peritumoral and in much lesser extent intratumoral vascularization as measured by a Color power Doppler US device with 7.5-10MHz linear prob was modest.

On the other hand carcinomas due to arteriovenous shunt massive neo vascularisation has a non homogenous pattern with scattered distribution of vessels. Some author found vascular resistance as a sign of tumor malignancy. Schick et al. (1998) reported high systolic peak flow velocity and high vascularisation raising the suspicion of malignancy (Shenoy et al., 2016).

Vascularisation has been assessed in four grades.

Grade-1: indicates no vessels visible in the mass in Color Doppler flow imaging (CDFI) low flow mode,

Grade-2: indicates a few vessel segments of not more than three blood vessels visible in the whole mass,

Grade-3: indicates upto five vessels visible in the mass and

Grade-4: indicates more than five vessels visible in the mass (Islam et al., 2015).

Color Doppler sonography evaluates microvascularity of the lesions.Usually a peripheral vascularization pattern is related to benignity, while an intra tumoral or central blood flow can be suspicious for malignancy (Wei et al., 2013). Usually different types & subtypes of microvascularization can be distinguished and the heterogenous enhancement in lesions with irregular shape and ill defined margin, vascularity grade 3-4 is associated with malignancy.

On the other side sonographic characteristics suggesting probably benign mass is round or ovoid in shape, circumscribed margin, homogenous echotexture and grade 1-2 vascularization (Islam et al., 2015).

RI value 0.8 or more, PI value 1.8 or more and PSV more than 25cm/s suggestive of malignancy. On the other hand RI value less than 0.8, PI value less than 1.8 and PSV less than 25cm/s suggestive of benignity (Strymplet al., 2014, Dibbad et al.,2018).

Bradley et al, 2000 shows the combination of real time ultrasound parameters, RI and PI in diagnosed benign cases with a sensitivity of 89.7% and specificity of 57.1%. The positive predictive value was 93.6%. No malignant lesion shows PI and RI lower than 1.8 and 0.8 respectively (Martinoli et al.,1994).

Wu et al.(2012) reported that 38.9% sensitivity, 90.1% specificity for benign parotid masses and 20% accuracy for malignant parotid mass diagnosis through sonography. Strympl et al.(2014) reported Doppler US parameter RI differentiates carcinomas from benign tumors with a sensitivity of 71.4% and specificity of 52.9%.

So this study is designed to explore valuable insight regarding role of Colour Doppler USG as a diagnostic tool to diagnose parotid tumor earlier for proper management.

1.2RATIONALE OF THE STUDY

Parotid tumor represent most common salivary gland neoplasm. A therapeutic rather a diagnostic challenge occurs when a mass is found in the parotid gland, benign neoplasm or malignant neoplasm can cause such a mass. Clinical diagnosis alone is difficult to differentiate between benign and malignant parotid tumor, so diagnosis greatly based on imaging appearance and most significant step in its diagnosis.

With the progression of time and the advancement in technology newer invention like colour Doppler USG has brought a revolution in the field of diagnostic imaging and provides significant additional diagnostic information that can confirm a tentative diagnosis based on morphological criterion. Colour Doppler imaging could reduce the rate of false negative result compared with traditional screening procedure as the decision to perform surgery depends on accurate pre operative diagnosis.

This pre-operative diagnosis of benign and malignant parotid tumor will help the concerned surgeons to make decision regarding rational approach to patient management which enhances quality of life.

1.3 RESEARCH QUESTION

Is color Doppler ultrasonography can differentiate benign and malignant parotid tumors?

1.4OBJECTIVES

General Objective:

To evaluate the color Doppler ultrasonography in the differentiation of benign and malignant parotid tumors comparing with histopathology.

Specific Objectives:

- To observe the color Doppler ultrasonographic findings of parotid tumors.
- To calculate the arterial resistive index (RI), pulsatility index (PI)of parotid tumors.
- To evaluate benign and malignant parotid tumors by colour Dopplerultrasonographic findings.
- To record the histopathological diagnosis of benign and malignant parotid tumors.
- To determine the accuracy of color Doppler ultrasonogram in the differentiation of benign and malignant parotid tumors.

2. LITERATURE REVIEW

2.1 Previous related study

Rzepakowska et al.(2017) defined the utility of ultrasound (US) in differentiating benign from malignant parotid tumors as well as pleomorphic adenomas (PA) from monomorphic adenomas (MA). Seventy-two consecutive parotid gland tumors were analysed with high-resolution ultrasonography (12 MHz) with color Doppler imagining. The histopathological diagnosis was confirmed after parotidectomy for each lesion. The sensitivity, specificity, accuracy, positive predictive value (PPV), and negative predictive value (NPV) for the US were established. The analysed material included 27 MA, 26 PA, 1 basal cell adenoma, 8 inflammatory conditions, and 10 malignant neoplasms. The sensitivity, specificity, and accuracy of US in differentiation of malignant from benign lesions in the parotid gland were 60, 95.2, and 90.3%, respectively. The predictive values were: PPV 66.8% and NPV 93.6%. Differentiating diagnoses between PA and MA with US resulted in a sensitivity of 61.5%, specificity of 81.5%, and accuracy of 73.1%. The predictive values were: PPV 50% and NPV 68.8%, respectively. For distinguishing malignant from benign tumors, the highest AUC values noted were for heterogeneity and vascularization (0.8 and 0.743, respectively). The AUC values were the highest for hypoechogenicity and vascularization in separating PA from MA (0.718 and 0.685, respectively).

Strympl et al.(2014) assessed the use of color Doppler ultrasound in the pre-histological determination of the biological features of salivary gland tumors. They studied 96 patients with major salivary gland tumors of unknown histology were examined. They were pre-operatively examined using ultrasound imaging with color

Doppler. Peak systolic velocity (PSV) was measured and pulsatility index (PI) and resistive index (RI) were calculated on the pulsed wave traces. The Doppler flow parameters were correlated with clinical stage and tumor type (benign/carcinoma) as confirmed by final histological diagnosis. The average PSV value was 22.15 cm/s for benign and 32.74 cm/s for all malignant tumors. The average RI value was 0.77 for benign and 0.86 for all malignant tumors. The average PI value for benign tumors was 2.85 and 3.14 for all malignant tumors. No significant differences between benign and malignant tumors in terms of PSV and PI values were found. The RI values for benign tumors differed significantly from those of malignant ones (P=0.021). There were no significant differences in average PSV, PI and RI values in relation to salivary gland tumor group - I, II, III. There was no confirmation of the reported applicability of PSV and PI values in differencing benign from malignant tumors. They were not able to demonstrate significant differences in Doppler flow parameters PSV and PI between benign tumors and carcinomas. Only the RI could be used to differentiate them. There were also no significant differences in PSV, PI and RI values between low (I+II) and high (III+IV) clinical tumor stage.

Dumitriu et al.(2008) assessed the role of 2D and Doppler ultrasonography in the diagnosis of salivary gland tumors. They studied 57 patients presenting with salivary gland enlargement, as the main symptom. B-mode and Color Doppler sonography (CDS) examinations were performed on each patient. The imaging features were compared with the pathology report, after surgical excision of the lesions. 51 salivary gland tumors were confirmed in 50 patients, the rest presenting other types of lesions, which created a pseudo-tumoral aspect on ultrasound. In their study group, 33 tumors were benign and 18 malignant, each category with several subtypes. Most benign

tumors (87.8%) had sharp borders, but 39.9% of malignant tumors also presented sharp borders. Lobulation of the tumor was seen most frequently in the case of pleomorphic adenomas. The internal structure of the tumor was not a relevant indicator of malignancy. The CDS examination revealed that 60.6% of benign and 55.5% of malignant tumors were poorly vascularized; the well-vascularized category included all Warthin tumors, 15% of pleomorphic adenomas and 38.8% of malignant tumors. Although ultrasound is very sensitive in identifying tumors of the salivary glands, there are no definite features to ensure a differential diagnosis between benign and malignant tumors.

El-Khateeb et al.(2011) evaluated the role of three diagnostic sonographic methods, greyscale sonography (GSS), color Doppler sonography (CDS) and spectral Doppler (SPD), in differentiating between benign and malignant salivary gland (SG) tumors. They observed 44 patients with SG masses were examined using GSS, CDS and SPD. The morphological features of each tumor were evaluated using GSS, the distribution and number of detected blood vessels were assessed using CDS, and peak systolic velocity (PSV), resistive index (RI) and pulsatility index (PI) were measured on SPD. Histopathological examination revealed that 28 of the 44 tumors were benign and 16 were malignant. GSS showed that malignant SG tumors had a significantly higher incidence of ill-defined borders and lymph node involvement than benign tumors, but there was no significant difference between benign and malignant SG tumors regarding echogenicity, homogeneity or sonographic shape. CDS demonstrated malignant tumors with significantly higher vascularity and a scattered distribution. Using SPD, malignant tumors had significantly higher PSV, RI and PI compared with benign tumors. RI values above 0.7, PI values above 1.2, PSV values above 44.3

cm.Illdefined borders, lymph node involvement, Grade 2 or 3 vascularity and hilar distribution of blood vessels should alert the clinician to suspect a malignant SG tumor. After consensus on the threshold values of PSV, RI and PI in differentiating benign from malignant SG tumors, these numbers should be incorporated into the software of ultrasound machines to guide the sonographer in his or her analysis.

The studyconducted by Jain and Jain (2018) in the Department of Radiodiagnosis, Gajra Raja Medical College and J.A. Group of Hospitals. They studied to known the reliability of USG as a diagnostic tool for the assessment of masses of major salivary gland. Major salivary gland pathologies are a significant source of morbidity in general population. The role of ultrasonography (USG) in the evaluation of salivary gland masses is become increasingly important due to the availability of high-frequency probe which permit visualization of more subtle anatomical and pathological details. According to their study, non-neoplastic pathologies 78 (62.9%) were more common than neoplastic salivary gland pathologies 46 (37.1%). Of 46 neoplastic pathologies, benign tumors 32 (69.57%) were more common than malignant 14 (30.43%). The age distribution of the patients with salivary gland neoplasm ranged from 1-80 years and Majority of belongs to the 30-70 years age group. Benign tumors were more common in 30–40 years age group. Malignant tumors were more common after 50 years of age. Malefemale ratio for malignant tumors is 6:1 and equal in benign tumors. Parotid gland was the most common site accounting for 91.30% followed by submandibular gland (8.7%) of all salivary gland tumors. On USG examination, all tumors were hypoechogenic. Most benign tumors (87.5%) had well-defined borders, but 12.5% of malignant tumors also had well-defined (sharp) borders. The internal structure of tumor was not a relevant indicator of

malignancy. According to the study, the most common tumors were pleomorphic adenoma which accounted for 60.87% of all cases followed by mucoepidermoid carcinoma (17.4%) of all cases confirmed by HPE. In their study, an excellent correlation was seen in the diagnosis of salivary. gland masses between sonography (grayscale and Color Doppler sonography [CDS]) and histopathology. Sonography (grayscale and Color Doppler together) was found to be highly sensitive and specific in the diagnosis of salivary gland masses; however, it is more sensitive for detecting benign tumors and more specific for malignant tumors.

The cross sectional study conducted by Islam et al. (2015) to find out the clinical and ultrasonographic features among patients of parotid mass for the comparison of findings of conventional FNAC and ultrasound guided FNAC. The sonographic characteristics for probably malignant masses were irregular shape, spiculated or ill defined margin, heterogenous echotexture, punctate calcification and vascularization. The sonographic features for probably benign mass were round or ovoid shape, circumscribed margin, homogenous echotexture and vascularization.

Patange N.A. et al. (2017) shows on color Doppler study the benign lesions had peripheral vascularity and the inflammatory lesions had marked vascularity within the gland. The malignant lesions showed irregular margins on ultrasonography. 13% of malignant lesions showed cystic changes and calcifications within them.Commonest site of lymph node involvement was intraparotid and the benign lesions had no lymph node involvement.

The cross-sectional study was conducted by Davachi et al.(2014) color doppler ultrasonography and MRI were performed for 22 patients with salivary gland tumor.

Demographic data as well as MRI, color Doppler ultrasonography, and surgical parameters including tumor site, signal in MRI images, ultrasound echo, tumor border, lymphadenopathy, invasion, perfusion, vascular resistance index (RI), vascular pulsatility index (PI) were analyzed. They evaluated the efficacy of magnetic resonance imaging (MRI) and color Doppler ultrasonography parameters in the diagnosis and differentiation of benign and malignant salivary gland tumors. The mean age of patients was 46.59±13.97 years (8 males and 14females). Patients with malignant tumors were older (P <0.01). The most common tumors were pleomorphic adenoma (36.4%), metastasis (36.4%), and mucoepidermoid carcinoma (9%). Nine tumors (40.9%) were benign and 13 (59.1%) were malignant. The overall accuracy of MRI and color Doppler ultrasonography in determining tumor site was 100% and 95%, respectively. No significant difference observed between RI and PI and the diagnosis of tumor. Both MRI and ultrasonography have high accuracy in the localization of tumors. Well-identified border was a sign of benign tumors. Also, invasion to adjacent structures was a predictive factor for malignancy.

Dibbad et al.,2018 shows in differentiation of benign and malignant parotid tumors by color Doppler study, total 65% were neoplastic lesions and 83% of pleomorphic adenomas occurred in parotid gland. Out of 28 benign nodules 22 (78.5%) showed grade 0/1+ vascularity and of the 18 malignant tumors 16 (88.8%) had Grade 2+/3+ vascularity. PSV was >25 cm/sec in 77.7% malignant tumors. Total 72% of malignant tumors had RI of >0.8, while only 10.7% of benign tumors showed RI of >0.8. Malignant tumors showed PI of >1.8 in 66.6%, in comparison 14.3% in benign tumors. Total 13 (72.2%) out of 18 were correctly diagnosed on grey scale USG alone,

while 16 (88.8%) were correctly diagnosed when Doppler was used along with grey scale USG and sensitivity, specificity, ppv respectively was 77.2, 89.2, 81.2.

A retrospective study conducted by Richie and Mellonie (2019) in Father Muller Medical College and Hospital. They studied to establish the existing correlation between preoperative ultra-sonogram and postoperative histopathological examination, in patients with surgically resected major salivary gland lesions. Major salivary glands display complex pathology comprising of various lesions ranging from neoplastic to inflammatory to degenerative cystic lesions. Ultrasonography plays pivotal role in choosing the appropriate treatment plan. All patients with major salivary gland lesions who have undergone preoperative ultra-sonogram and post-operative histopathological evaluated. In their study included 57 patients out of which majority of lesions were of parotid gland. There was increased incidence in 5th decade, also a male preponderance was observed. Correlation was better for benign lesions and 100% correlation was observed for pleomorphic adenoma. Overall diagnostic accuracy for ultrasonography was 85.7%. There was 100% correlation for homogeneity, vascularization and delimitation. There was correlation for size and shape for both benign and malignant lesions. Their study emphasizes the importance of ultrasound in diagnosing major salivary gland lesions. Although the sensitivity of ultrasound is not as expected, ultrasound is still a promising diagnostic tool that may be used in first line diagnosis of major salivary gland lesions.

2.2Theoretical basis of color Doppler sonography:

An Ultrasound beam insonating a blood vessel is partially reflected by red blood cells. If these are moving there is a change in the frequency of the reflected pulse: an increase in frequency if the blood flow is towards the probe and a decrease if it is away from it. This is the Doppler Effect and the changes in frequency, referred to as the Doppler shift may be calculated from the equation:

$$f_d = \frac{2 f_o \nu \cos\theta}{c}$$

The equation indicates that the Doppler frequency shift (f_d)depends on the input frequency (fo), the velocity of the blood (v) and the angle between the Ultrasound beam and the direction of the blood flow (θ). The speed of Ultrasound (c) remains constant. If the angle is known and the frequency shift measured, the blood flowvelocity may be calculated. All this is done by the instrument's computer when required, the contribution of the operator being to obtain a suitable image of the blood vessel, to place a cursor appropriately in the vessel and to mark the direction of the vessel axis. It is necessary to achieve an angle of considerably less than 90^0 between the direction of blood flow and the direction of the Ultrasound beam, as no Doppler signal results if the beam/vessel angle is 90^0= (cos 90^0= 0 in the above equation). Thus a suitable alteration in the angle of the Ultrasound beam to the vessel has to be done to obtain a satisfactory Doppler signal. This allows the scanner software, if required, to convert the frequency shift into true velocity values. The accuracy of the calculated velocities is inversely proportional to the beam/vessel angle. At an angle of 00 the error is up to 3%, at 70^0 30% and at 80° may approach 100% (Cosgrove, 2001).

The Doppler signal consists of a mixture of continually varying frequencies that, bychance, fall in the audible range. The frequency content and waveform of the signal, however, contain a wealth of information about the nature of the blood flow in the vessel and it is easier to appreciate and interpret these if a visual display is created. The visual display is derived from a 'spectrum analyzer', a device or program which determines the strength of echoes in the Doppler signal that fall into each of numerous frequency bands during a time interval of typically 5-20 ms. The resultant display represents frequency on the vertical axis and time on the horizontal axis. The brightness of the tracing at any point indicates the number of echoes having a specific frequency at each time interval and is proportional to the number of red cells in the sample volume that are moving with the relevant velocity. The outline of the spectral display gives information about the direction of the flow, the maximum Doppler frequency at any time and the nature and magnitude of any pulsations or otherperiodic changes in flow velocity. By convention, flow towards the transducer is displayed above the base line and away from the transducer below (Cosgrove, 2001).

In color Doppler systems the pulses along each scan line are divided on return to the transducer, and some are used to provide image information and the rest are used to calculate the mean Doppler shift within small pixels of the image. This mean shift information is then coded on a color scale and displayed as a color map over the gray scale image. Flow towards the transducer is customarily coded red and the flow away, blue. However, the user is able to change this or to substitute a wide range of other color maps to the velocity information (Cosgrove, 2001).

Pulsatility Measurements:

Many indices of waveform analysis have been devised but only two are in regular clinical use. These are the resistance index (RI) (also known as the Pourcelot index) and the pulsatility index (PI) (also known as the Gosling index). Because they are ratios they are independent of the beam/vessel angle (although obtaining a good quality Doppler trace from which to make the measurement does require a beam/vessel angle of $<60^0$).

Their derivations are:

$$\text{Pourcelot's Resistivity index} = \frac{\text{Peak systolic velocity-End diastolic velocity}}{\text{Peak systolic velocity}}$$

$$\text{Gosling's Pulsatility index} = \frac{\text{Peak systolic velocity-End diastolic velocity}}{\text{Temporal mean velocity}}$$

Its main disadvantage is that it requires calculation of the mean peak frequency, whereas the RI only requires the measurement of two values. The RI is particularly sensitive to changes in downstream flow resistance and was used to assess changes in diastolic flow in low-resistance vascular beds. The resistance may be increased by vascular stenosis or by disease in the organ supplied by the vessel but, as it also depends on the 'end diastolic' velocity, the RI increases as the heart rate decreases, allowing a longer duration for the diastolic flow to fall, in theory, it is possible to correct the RI for a normalized heart rate but in practice this is seldom done (Cosgrove, 2001).

2.3Normal sonographic anatomy of Parotid gland:

The normal parotid gland appears homogeneous andof increased echogenicity relative to adjacent muscle onultrasound. This increased echogenicity is due to thefatty glandular tissue composition of the gland.

Normal intraparotid nodes are frequently observedduring ultrasound examination, most commonly in apre-auricular location or in the tail of the gland. Thesenodes appear elliptical and hypoechoic with a hyperechoic,fatty, central hilum. Normal intra parotid ductsmay be visualized as highly-reflective linear structures (Howlett, 2003).

2.4Vascular resistance:

Color Doppler findings of intralesional vascularity, type and grade of vascularity, PSV, RI and PI are useful in differentiating benign from malignant tumors. Color Doppler, power Doppler and pulse wave Doppler are use to study the vascularity in the gland and the lesion. When Power Doppler Sonography (PDS) is used, the Doppler setting is optimised at high sensitivity, low wall filter, medium persistence and Pulsed Repetition Frequency (PRF) is set at 700 Hz for detecting small vessels. Color gain is increased till the artefacts or noise appears. Then it is reduce slowly till it disappears. Intra tumor vascularity seen on color Doppler sonographythen graded subjectively on a four-step analog scale.

Pattern of vascular distribution in the massis characterized as either peripheral (basket like), hilar (branching), or mixed. In the evaluation of the vascular resistance [Resistive Index (RI), Pulsatility Index (PI)] of lesions, spectral Doppler is use and the more prominent vessels are usually selected for the measurement. Peak Systolic Velocity (PSV) is measure with angle correction made at an angle of 60 or less. Grey scale USG features of the lesion are assessed and diagnosis is made.

Final USG diagnosis isprepared after assessing the Doppler characteristics of the lesion and correlating with grey scale characteristics. USG diagnosis of benign tumor is based on the lesion homogeneous or heterogeneous echopattern, well defined margins, posterior acoustic enhancement, low grade of vascularity (0/1+), PSV <25 cm/sec, RI <0.8 and PI <1.8. The diagnosis of malignant tumor is made in a lesion with heterogeneous echo pattern, ill-defined margins, extension into adjacent structures, high grade of vascularity (2+/3+), PSV >25 cm/sec, RI >0.8 and PI >1.8 (Dibbad et al., 2018).

2.5Radiopathological consideration:

Benign tumors:

Pleomorphic adenoma

The majority of parotid tumors are benign and of these85–90% of lesions are pleomorphic adenomas, which arethought to arise from myoepithelial cells.Pleomorphic adenoma typically appears rounded,well circumscribed and hypoechoic on ultrasound and hasassociated distal acoustic enhancement. UsingColor Doppler ultrasound, pleomorphic adenomas maydemonstrate a peripheral, ‘‘basket-like’’ pattern of flow .Whenpleomorphic adenomas enlarge they may develop moreatypical characteristics with internal heterogeneity andcystic changes and lesionmarginsmaybecomepoorlydefined.

Warthin’s tumor (adenolymphoma):

These are the second most common benign tumors ofthe parotid gland and arise from heterotopic parotid tissuewithin parotid lymph nodes. On ultrasound, Warthin’stumors appear rounded or lobulated, are well circumscribedand internal cystic changes with septations arecommon.

Oncocytoma:

These are rare tumors, comprising 1% of parotidneoplasms, which arise from oncocytes derived fromstriated duct cells. They present as slow growing massesusually in the superficial lobe. They have similar sonographicfeatures to pleomorphic adenoma.

Lipoma:

These are compressible, oval or elliptical masses withregular margins and a typical striped or feathered internalechotexture.

Fatty infiltration:

Fatty infiltration causes diffuse, usually bilateral andhomogeneous parotid enlargement sonographically (Howlett, 2003).

Malignant tumors:

Primary malignancy:

Mucoepidermoid carcinoma is the most common primaryparotid malignancy accounting for roughly 50 to 70 percent of cases. The smaller lesions may appear welldefined and not dissimilar to pleomorphic adenoma. Moreaggressive lesions have more typically malignant featuresappearing irregular and poorly defined with heterogeneousinternal architecture. Increased tumoral resistanceon Color Doppler ultrasound examination is indicativeof malignancy.

Carcinoma ex pleomorphic adenoma is the second most common parotid malignancy. These tumors are larger and persist for longer duration than it's benign counterpart.Adenoid cystic carcinoma comprises 25 to 30 percent parotid malignancy.These tumors, aswith mucoepidemoid carcinoma, when small often

appearcircumscribed but develop more overtly malignant ultrasoundfeaturesas theyenlarge.

Other primary parotid malignancies, including aciniccell carcinoma, adenocarcinoma andlymphoma(Stell et al., 2012).

METHODOLOGY

3.1 Study design: This was a cross sectional observational study.

3.2Place of study: This study was carried out in the Department of Radiology and Imaging, Sylhet MAG Osmani medical college and Hospital, Sylhet in collaboration with the Department of Otolaryngology and Head-Neck surgery and the Department of Pathology of the same institute.

3.3 Study duration: September 2019 to August 2021.

3.4Study population: All patients with parotid tumors referred to the Department of Radiology and Imaging for colour Doppler ultrasonogram examination from the Department of Otolaryngology and Head-Neck Surgery, SOMCH was the study population.

3.5 Sampling technique: Purposive sampling was used in this study.

3.6 Inclusion criteria:

- Clinically suspected case of parotid tumors.

3.7 Exclusion criteria:

- Post treated patient of parotid tumor.
- Patients with recurrence of parotid tumor.
- Patients having inflammatory parotid swelling.

3.8 Sample size calculation:

Sample size was determined by power analysis for a single proportion. Formula for sample size determination for single proportion.

$$n= \frac{[Z_\beta\sqrt{P(1-P)}+Z_\alpha\sqrt{P_0(1-P_0)}]^2}{(P-P_0)^2}$$

P= Proportion under alternative hypothesis (H_A) that is proposed to be detected

P_0= Proportion under null hypothesis (H_0)

We hypothesized that sensitivity of Color Doppler evaluation of parotid tumors was 71.4% or greater (Strympl et al. 2014). The sample size was calculated for a power level of 80% (where, $\underline{Z}_\beta$=0.84), an α error of 0.05 (95%) confidence level, where $\underline{Z}_\alpha$=1.96, two tail) according to Strymplet al. (2014), the accuracy of in the diagnosis of Color Doppler evaluation of parotid tumors is 58.3%.

Here,

n= Sample size

$\underline{Z}_\beta$= 0.84

$\underline{Z}_\alpha$= 1.96

P= 71.4% =0.714 (Strympl et al. 2014)

P_0= 58.3%=0.583 (Strymplet al.2014)

$$n = \frac{[0.84\sqrt{0.714(1-0.714)}+1.96\sqrt{0.583(1-0.583)}]^2}{(0.714-0.583)^2}$$

= 105.57

= 106(estimated sample size)

As parotid tumors are rare among all head and neck neoplasm and due to COVID-19 pandemic situation total 45 cases were found.

3.9 Measures of variables:

The following variables were studied:

Demographic variables:

- Age
- Sex

Colour Doppler sonography variables:

- Echogenicity (hypoechoic or hyperechoic)
- Echotexture (homogenous or heterogenous)
- Shape (oval/round, irregular)
- Margin (circumscribed,spiculated or ill defined)
- Acoustic enhancement
- Calcification
- Lymphadenopathy
- Location of vessel (central or peripheral)
- Vascularization (grade 1-4)
- Resistive index (RI)
- Pulsatility index (PI)

Histopathological variables:

- Benign
- Malignant

3.10. Diagnostic criteria:

A Ultrasonographic diagnosis regarding thecharacteristics of Parotid tumor was made based on following sonographic diagnostic criteria (Strympl et al. 2014; Islam et al. 2015; Patang N A et al. 2017; Dibbad et al., 2018)

Ultrasound criteria	**Benign**	**Malignant**
Echogenicity	Usually hypoechoic	Usually hypoechoic
Echotexture	Usually homogenous	Usually heterogeneous
Shape	Usually oval/round	Usually irregular
Margin	Usually circumscribed	Usually Spiculated, ill-defined
Calcification	Usually present	Usually absent
Lymphadenopathy	Usually absent	Usually present
Acoustic enhancement	Usually present	Usually absent
Location of vessels	Usually peripheral	Usually central
Vascularization grading	Usually grade 1,2	Usually grade 3,4
Resistive Index (RI)	Usually RI <0.8	Usually RI ≥0.8
Pulsatility Index (PI)	Usually PI <1.8	Usually ≥1.8
Peak systolic velocity (PSV)	Usually <25cm/s	Usually >25cm/s

3.11 Study procedure

Data was collected by a predesigned proforma. Informed written consent was taken from the patient or attendants after explanation of the process and purpose of the study. All patients were assessed by taking complete history and clinical examination. Patient information was obtained by using information sheet whichincludes questionnaire, clinical findings, radiological and histopathological findings.

Total 45 patients were included in this study who was selected from theDepartment of Otolaryngology and Head-Neck Surgery, Sylhet MAG Osmani Medical College and Hospital, Sylhet. Clinically suspected cases of parotid tumors were referred to the Department of Radiology and Imaging, Sylhet MAG Osmani Medical College and Hospital, Sylhet.

Then detailed study was done by colour Doppler ultrasound.

The surgical findings of each patient was compared with colour Doppler ultrasonogram findings and assessment was made regarding confirmation of histopathology with color Doppler finding.

Color Doppler Scanning Technique:

- The patient was explained about examination and verbal consent was obtained before beginning the examination.
- Color Doppler ultrasonography was performed using equipment was PHILIPS Affinity Healthcare 30 with 7.5 to 10MHz linear transducer probe.
- All parotid tumors subjected to sonomorphological evaluation followed by blood flow analysis using colour, spectral and power Doppler sonography (PDS).

- The patients were placed in supine position, with the neck turned to the contralateral side. The region of interest was scanned slowly with minimal probe pressure. Longitudinal and transverse scanning plane was used to map the colour flow signals within the parotid gland.
- Flow results was recorded as being absent or present and further characterized as normal or increased, vessel location (peripheral or central). A Doppler beam was placed in the region of interest where the colour flow was clearly noted and arterial pulsation was identified. On spectral Doppler the lowest resistive index (RI) and maximum peak systolic velocity (PSV) directed at any point in the mass was used for analysis.
- RI and PI value of the vessels was determined by the formula incorporated in the machine. Signal from various areas of the same tumor in each patient was recorded and the lowest values were obtained for the final analysis.

Histopathology technique

Formaldehyde and paraffin embedded specimens were obtained from patients. In each case, the histopathological diagnosis was established by standard light microscopic evaluation of section stained with hematoxylin and eosine.Histopathological slides were prepared, then examined and interpretated by an experienced pathologist in the Department of Pathology, Sylhet MAG Osmani Medical College Hospital.

Comparison with histopathology

Histopathology reports were collected in each case from department of pathology by researcher herself. Then collected reports were compared with color Doppler ultrasonography findings.

3.12 Data collection tool:

Data was collected by using structured questionnaire designed for the study by researcher herself which was developed by reviewing literature and by consulting with guide and experts.

3.13Statistical analysis:

Statistical analyses were carried out by using the Statistical Package for Social Sciences version 23.0 for Windows (SPSS Inc., Chicago, Illinois, USA). A descriptive analysis was performed for all data. The mean values were calculated for continuous variables. The quantitative observations were indicated by frequencies. McNemar'sChi-Square test was used to analyze the categorical variables, shown with cross tabulation.The results were presented in tables, figures & diagrams. For the validity of study outcome sensitivity, specificity, accuracy, positive predictive value and negative predictive value, positive likelihood ratio, negative likelihood ratio of color Doppler ultrasonography in the evaluation of benign and malignant parotid tumor was calculated.P values <0.05 was considered as statistically significant. ROC was analyzed and cut-off value for both RI and PI was found.

3.14Ethical consideration:

- Informed written consent was taken from each of the patients before taking information. The consent form was clearly describe the purpose and methods of the study, confidentiality of information, risk and benefits of the participating in the study, and his/her right to refuse participation or withdrawn consent at any time without prejudicing his/her further treatment.
- An approval of the study protocol was obtained from the institutional Ethical Committee of Sylhet MAG Osmani Medical College, Sylhet prior to the commencement of the study.
- All information was collected confidentially with complete respect to the patient wish and without any force or pressure.

4.RESULTS AND OBSERVATIONS

Table I: Distribution of the study patients with parotid tumor according to age (n=45)

Age group (years)	Histopathological diagnosis					
	Benign (n=28)		Malignant (n=17)		Total (n=45)	
	N	%	N	%	n	%
18-20	1	3.6	0	0.0	1	2.2
21-30	10	35.7	1	5.8	11	24.4
31-40	13	46.4	2	11.8	15	33.3
41-50	3	10.7	7	41.2	10	22.2
51-60	1	3.6	6	35.2	7	15.5
61-70	0	0.0	1	5.9	1	2.22
Mean±SD	33.4±7.7		42.9±9.3		37.0±9.4	

Table I shows that majority 13(46.4%) patients belonged to age group ≤40 years. In benign group, 10(35.7%) patients belonged to age group ≤30 years and mean age was found 33.4±7.7 years. Whereas, in malignant group maximum 7(41.2%) patients were in age group 41-50 years with mean age was found in 42.9±9.3 years.

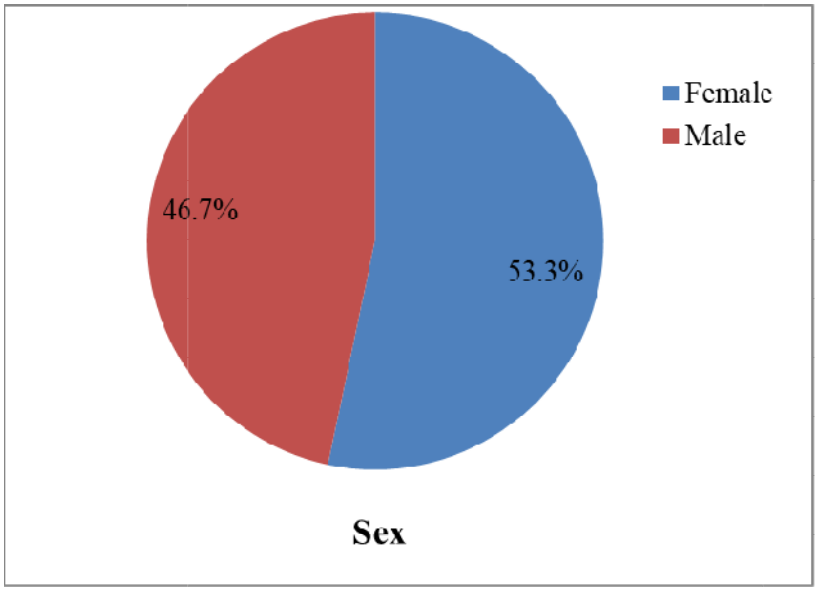

Figure 1: Distribution of the study patients by sex (n=45)

Figure 1 shows that female was found 24(53.3%) and male was 21(46.7%). Male-female ratio was 1:1.1.

Table II: Distribution of the study patients with parotid tumor according to Color Doppler USG (n=45)

Color Doppler USG	Histopathological diagnosis			
	Benign (n=28)		Malignant (n=17)	
	N	%	N	%
Echogenicity				
Hypoechoic	22	78.6	14	82.4
Hyperechoic	6	21.4	3	17.6
Ecotexture				
Heterogenous	3	10.7	13	76.5
Homogenous	25	89.3	4	23.5
Shape				
Oval/round	20	71.4	3	17.6
Irregular	8	28.6	14	82.4
Margin				
Circumscribed	17	60.7	5	29.4
Spiculated	5	17.9	0	0.0
Ill-defined	6	21.4	12	70.6
Acoustic enhancement				
Present	24	85.7	5	29.4
Absent	4	14.3	12	70.6
Calcification				
Present	3	10.7	6	35.3
Absent	25	89.3	11	64.7
Lymphadenopathy				
Present	4	14.3	6	35.3
Absent	24	85.7	11	64.7
Location of the vessel				
Peripheral	21	75.0	5	29.4
Central	7	25.0	12	70.6

Flow pattern/ Vascularization				
Grade 1 (no visible vessel)	2	7.1	0	0.0
Grade 2 (not more than 3 vessel)	24	85.7	2	11.8
Grade 3 (upto 5 vessels)	2	7.1	11	64.7
Grade 4 (more than 5 vessels)	0	0.0	4	23.5
Resistivity index				
<0.8	26	92.9	2	11.8
≥0.8	2	7.1	15	88.2
Pulsatility index				
<1.8	26	92.9	2	11.8
≥1.8	2	7.1	15	88.2

Table II shows that majority patients had hypoechoic echogenicity in both groups, that was 22(78.6%) in benign group and 14(82.4%) in malignant group. Majority 25(89.3%) patients was found homogenous echotexture in benign group and 4(23.5%) in malignant group. Almost three fourth 20(71.4%) study patients had oval/round shape mass in benign group and 3(17.6%) were in malignant group.Majority 17(60.7%) patients,circumscribed margin of mass were in benign group and 5(29.4%) in malignant group.Majority 24(85.7%) patients had acoustic enhancementof the lesionin benign group and 5(29.4%) in malignant group.Three (10.7%) patients had calcification in benign group and 6(35.3%) in malignant group.Four (14.3%) patients had lymphadenopathy in benign group and 6(35.3%) in malignant group.Majority 21(75.0%) patients, location of the vessels were found peripheral position in benign group and 5(29.4%) were in malignant group. More than half 15(53.6%) patients had grade 2 flow pattern in benign group and 4(23.5%) in malignant group. Resistivity index <0.8 were 2(11.8%) in malignant group and 26(92.9%) in benign

group.Pulsatility index <1.8 were 2(11.8%) in malignant group and 26(92.9%) in benign group.

Table III: Validity test for Color Doppler USG findings (n=45)

	Benign (n=28)			Malignant (n=17)		
	Sensitivity	**Specificity**	**Accuracy**	**Sensitivity**	**Specificity**	**Accuracy**
Echogenicity						
Hypoechoic	78.6	17.6	55.6	82.4	21.4	44.4
Hyperechoic	21.4	82.4	44.4	17.6	78.6	55.6
Echotexture						
Heterogenous	10.7	23.5	15.6	76.5	89.3	84.4
Homogenous	89.3	76.5	84.4	23.5	10.7	15.6
Shape						
Oval/round	71.4	82.4	75.6	17.6	28.6	24.4
Irregular	28.6	17.6	24.4	82.4	71.4	45.6
Margin						
Circumscribed	60.7	70.6	64.4	29.4	39.3	35.6
Spiculated	17.9	100.0	48.9	0.0	82.1	51.1
Ill-defined	21.4	29.4	24.4	70.6	78.6	75.6
Acoustic enhancement						
Present	85.7	70.6	80.0	29.4	14.3	20.0
Absent	14.3	29.4	20.0	70.6	85.7	80.0
Calcification						
Present	10.7	64.7	31.1	35.3	89.3	68.9
Absent	89.3	35.3	68.9	64.7	10.7	31.1
Lymphadenopathy						
Present	14.3	64.7	33.3	35.3	85.7	66.7
Absent	85.7	35.3	66.7	64.7	14.3	33.3

Location of the vessel						
Peripheral	75.0	70.6	73.3	29.4	25.0	26.7
Central	25.0	29.4	26.7	70.6	75.0	73.3
Flow pattern/ Vascularization						
Grade 1 (no visible vessel)	7.1	100.0	42.2	0.0	92.9	57.8
Grade 2 (not more than 3 vessel)	85.7	88.2	86.7	11.8	14.3	13.3
Grade 3 (upto 5 vessels)	7.1	35.3	17.8	64.7	92.9	82.2
Grade 4 (more than 5 vessels)	0.0	76.5	28.9	23.5	100.0	71.1
Resistivity index						
<0.8	92.9	88.2	91.1	11.8	7.1	8.9
≥0.8	7.1	11.8	8.9	88.2	92.9	91.1
Pulsatility index						
<1.8	92.9	88.2	91.1	11.8	7.1	8.9
≥1.8	7.1	11.8	8.9	88.2	92.9	91.1

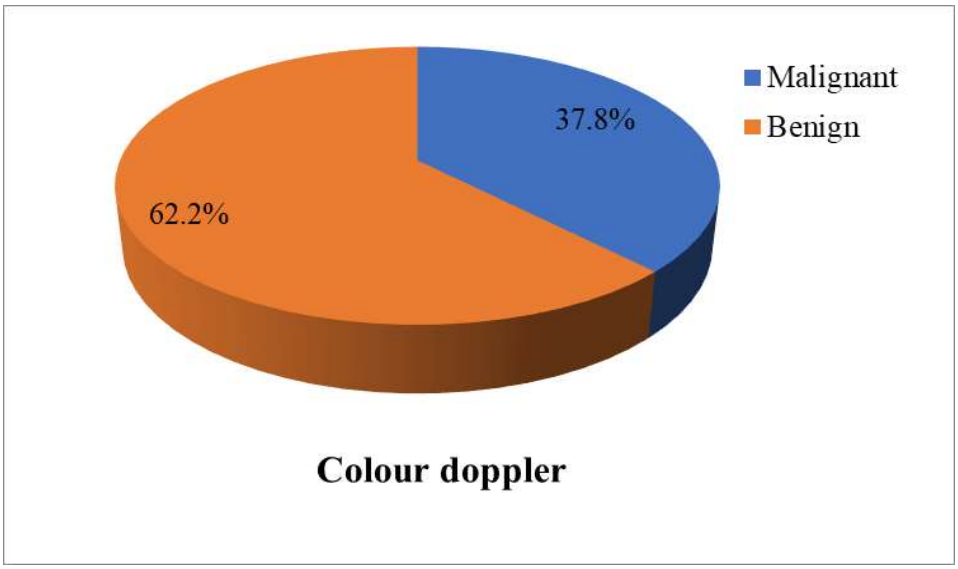

Figure 2: Pie chart showing benign and malignant parotid tumour based on Color doppler (n=45)

Figure 2 shows thatalmost two third (62.2%) patients had benign and 17(37.8%) had malignant parotid tumors diagnosed by Color doppler.

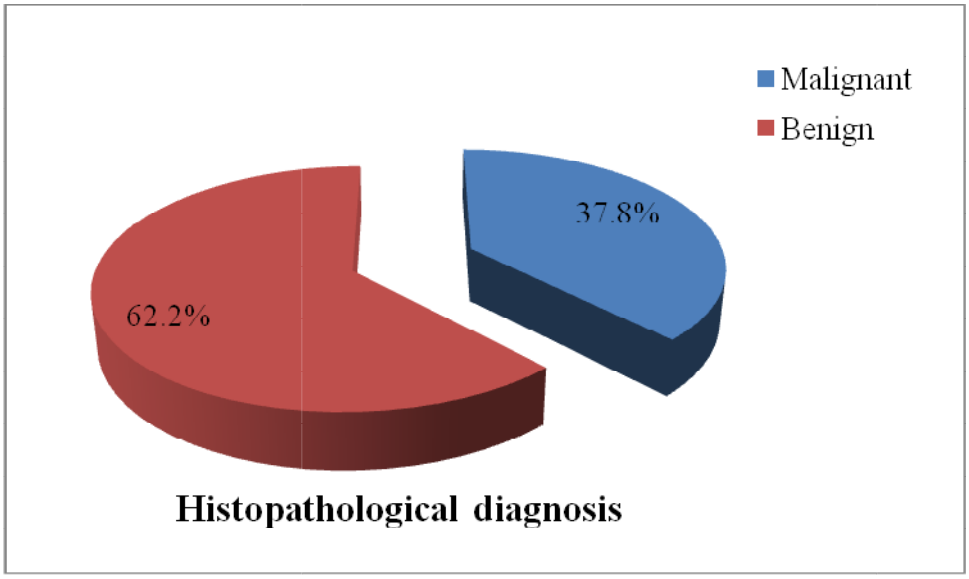

Figure 3: Pie chart showing benign and malignant parotid tumor based on histopathology (n=45)

Figure 3 shows that almost two third (62.2%) patients had benign and 17(37.8%) had malignant parotid tumors confirmed by histopathological diagnosis.

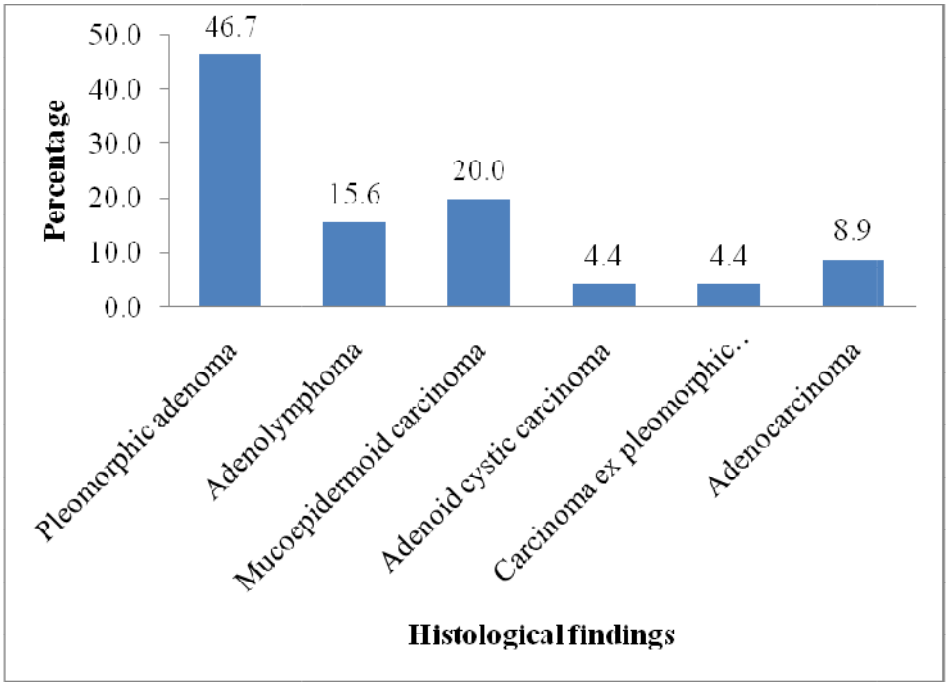

Figure 4: Bar diagram showing histopathological findings of parotid tumor (n=45)

In histopathological findings, 9(20.0%) patients was found in mucoepidermoid carcinoma followed by 2(4.4%) in adenoid cystic carcinoma, 4(8.9%) in adenocarcinoma, 2(4.4%) in carcinoma ex pleomorphic adenoma, 21(46.7%) in pleomorphic adenoma and 7(15.6%) in adenolymphoma.

Table IV: Comparison of Color Doppler ultrasonogram diagnosis with histopathological diagnosis (n=45)

Diagnosis by Color Doppler ultrasonogram	**Diagnosis by histopathology**				**P value**
	Malignant (n=17)		**Benign (n=28)**		
	N	**%**	**N**	**%**	
Malignant (n=17)	15 (Truepositive=TP)	88.2	2 (False positive= FP)	7.1	0.001^{s}
Benign (n=28)	2 (False negative =FN)	11.8	26 (True negative =TN)	92.9	
Total	17	100	28	100	

P value reached from McNemar's test

Table IV shows out of 45 cases 17 were diagnosed as malignant parotid tumors by Color Doppler ultrasonogram, among them 15(88.2%) were confirmed by histopathological diagnosis were true positive and remaining 2 were false positive. Out of 28 cases of benign parotid tumors which were diagnosed by Color Doppler ultrasonogram, 26(92.9%) were confirmed by histopathological diagnosis are true negative and remaining 2 were false negative.

Table V: Sensitivity, specificity, accuracy, positive and negative predictive values of the Color Doppler ultrasonogram in evaluation of benign and malignant parotid tumors (n=45).

Validity test	Malignant	Benign
Sensitivity	88.2	92.9
Specificity	92.9	88.2
Accuracy	91.1	91.1
Positive predictive value	88.2	92.9
Negative predictive value	92.9	88.2
Positive likelihood ratio	12.35	7.89
Negative likelihood ratio	0.13	0.08

In table V the validity of malignant parotid tumors by Color Doppler ultrasonogram were represented by calculating sensitivity was 88.2%, specificity was 92.9%, accuracy was 91.9%, PPV was 88.2% and NPV was 92.9% and the validity of benign parotid tumors were represented by calculating sensitivity was 92.9%, specificity was 88.2%, accuracy was 91.1%, PPV was 92.9% and NPV was 88.2% taken into account histopathology as gold standard.

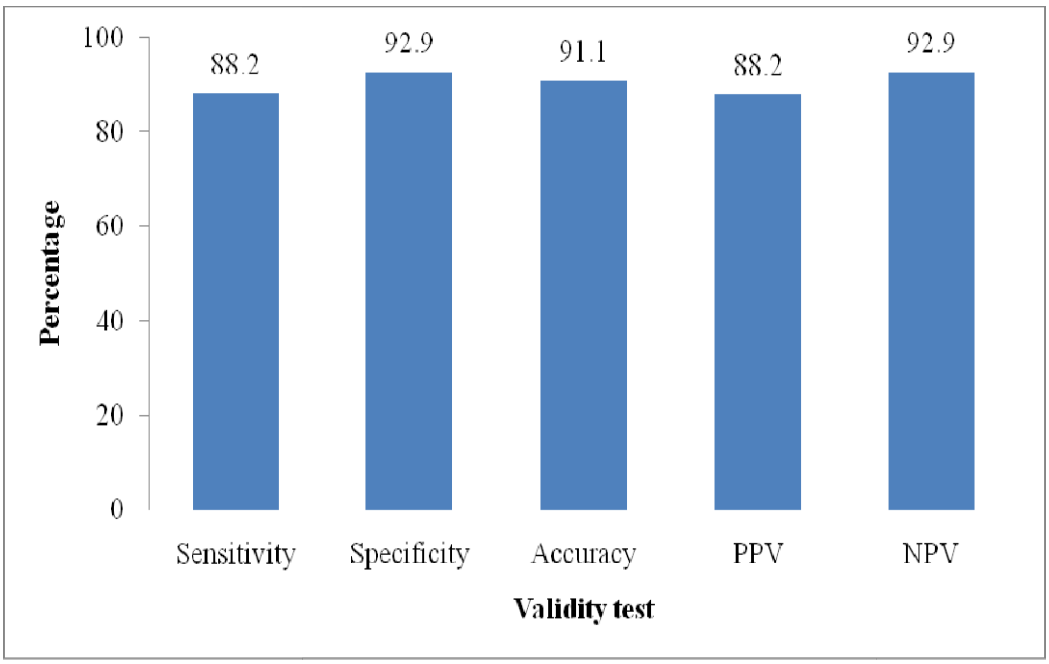

Figure 5: Bar diagram showing validity test of the Color doppler ultrasonogram diagnosis with histopathological diagnosis for the evaluation of malignantparotid tumors.

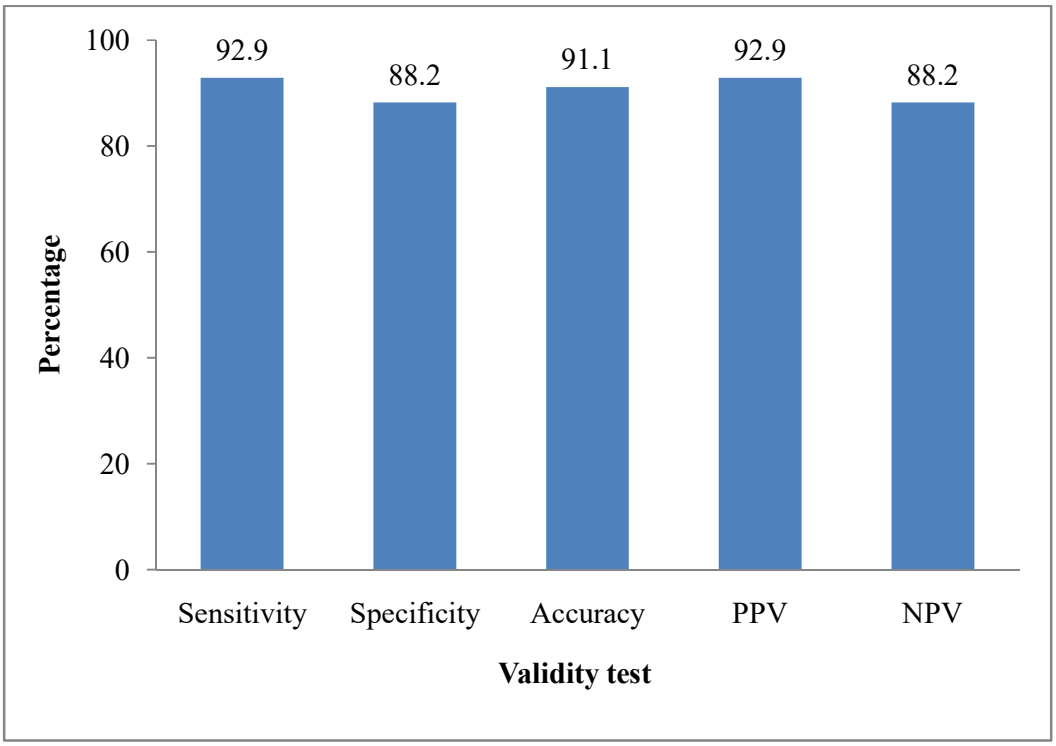

Figure 6: Bar diagram showing validity test of the Color doppler ultrasonogram diagnosis with histopathological diagnosisfor the evaluation of benign parotid tumors.

Receiver-operator characteristic (ROC) curve of RI and PI for prediction of malignant parotid tumors(n=45):

The area under the receiver-operator characteristic (ROC) curves for the malignantparotid tumors predictors was depicted in table VI. Based on the receiver-operator characteristic (ROC) curves RI had the best area under curve. Receiver-operator characteristic (ROC) were constructed using RI and PI of the patients with malignantparotid tumors, which gave a RI cut off value ≥0.75 as the value with a best combination of sensitivity and specificity for malignantparotid tumors. At this cut-off value the sensitivity and specificity of RIin diagnosing malignantparotid tumors were found to be 100.0% and 71.4%, respectively. ForPI cut off value was ≥1.52.At this cut-off value the sensitivity and specificity of PI in diagnosing malignant parotid tumors were found to be 94.1% and 60.7%, respectively.

Table VI: Receiver-operator characteristic (ROC) curve of RI and PI for prediction of malignant parotid tumors (n=45)

	Cut off value	Sensitivity	Specificity	Area under the ROC curve	95% Confidence interval (CI)	
					Lower bound	Upper bound
RI	≥0.75	100.0	71.4	0.977	0.939	1.000
PI	≥1.52	94.1	60.7	0.947	0.883	1.000

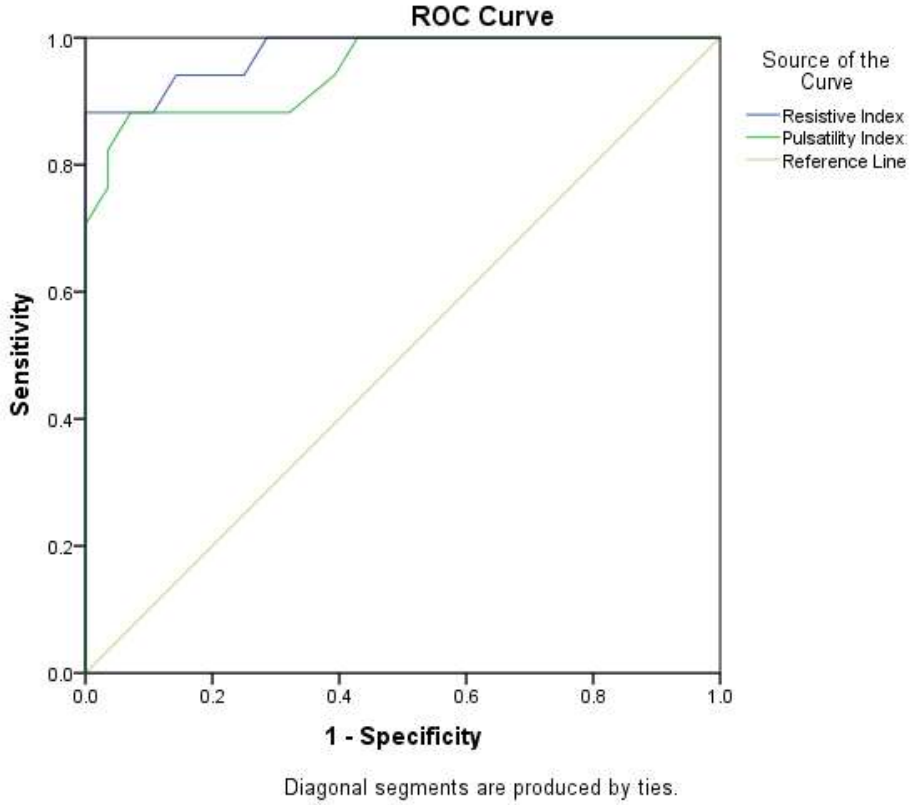

Figure 7: Receiver-operator characteristic curves of RI and PI for malignant parotid tumors.

5. DISCUSSION

This cross sectional study was carried to find out and to evaluate the overall diagnostic performance of Color Doppler ultrasonography in characterization of parotid tumors through the analysis of accuracy, sensitivity, specificity, positive predictive value, negative predictive value and comparing with histopathology as the gold standard.

A total 45 patients were included in this study after fulfillment of inclusion and exclusion criteria who were referred to the department of Radiology and Imaging of SOMCH, during September 2019 to August 2021.

In this study observed that majority 13(46.4%) patients belonged to age group ≤40 years. In benign group, 10(35.7%) patients belonged to age group ≤30 years and mean age was found 33.4±7.7 years. Whereas, in malignant group maximum 7(41.2%) patients were in age group 41-50 years with mean age was found in 42.9±9.3 years.El-Khateeb,Abou-Khalaf and Farid (2011)reported there was no significant difference between benign and malignant tumors regarding the age of the patients (P> 0.86); the mean age of patients with benign tumors was 47±14.08 years while it was 45±27.2 years for malignant tumors.Jain and Jain (2018) reported that the age distribution of the patients with salivary gland neoplasm ranged from 1-80 years and Majority of belongs to the 30-70 years age group. Benign tumors were more common in 30–40 years age group. Malignant tumors were more common after 50 years of age.

In current study observed that female was found 24(53.3%) and male was 21(46.7%). Male-female ratio was 1:1.1. Jain and Jain (2018) also observed male to female ratio

is 1.3:1. Davachi et al. (2014) also reported the majority of patients in this study were female (63.6%). Strympl et al. (2014) reported 54 women and 42 men were enrolled.

In present study showed that majority patients had hypoechoic echogenicity in both groups, that was 22(78.6%) in benign group and 14(82.4%) in malignant group. Hyperechoic was 6(21.4%) in benign group and 3(17.6%) in malignant group. Schick et al. (1998) andJain and Jain (2018) and showed that all tumors both benign and malignant were hypoechoic .

In this study observed that majority 25(89.3%) patients were found homogenous in benign group and 4(23.5%) in malignant group.Dumitriu et al. (2008) found that 51.50% benign tumor were homogenous and 48.5% were non-homogenous in echotexture. In case of malignancy, 50% were homogenous and 50% were non-homogenous. Wu et al. (2012) found 9.6% of benign tumors were homogenous and 91.2% were heterogeneous (non-homogeneous). Among malignant tumors, 16.7% were homogenous and 83.3% were heterogeneous.El-Khateeb, Abou-Khalaf and Farid (2011) observed regarding the homogeneity of the SG mass, 50% of the malignant and 42.8% of the benign tumors were inhomogeneous. This difference was not statistically significant. In Jain and Jain (2018) study, 37.5% of benign tumor had homogenous echotexture, while 62.5% had non-homogeneous echotexture. All malignant tumor had non-homogeneous echotexture.

In this study showed that almost three fourth 20(71.4%) study patients had oval/round shape mass in benign group and 14(82.4%) patients had irregular shape masses in malignant group. El-Khateeb, Abou-Khalaf and Farid (2011)observed irregular shape by GSS was present in 62.5% of malignant tumors and 42.8% of benign tumors. There was no significant difference between benign and malignant SG lesions

regarding shape of the lesion by ultrasound. The lobulated shape was present in 32.5% of benign tumors while none of the malignant tumors showed lobulations. In Jain and Jain (2018) study, most (75%) benign tumors had either lobulated or ovoid shape, while 25% benign tumor had irregular shape. Most (85.7%) malignant tumors had irregular shape. Dumitriu et al. (2008)described that most benign tumors (87.8%) had sharp borders, but 39.9% of malignant tumors also presented sharp borders. In our study, most benign tumors (87.5%) had well-defined margin, but 12.5% of malignant tumors also presented well-defined (sharp) margin. Dumitriu et al. (2008) reportedmost of the benign tumors (87.8%) and 39.9% of malignant tumors had sharp borders.

In present study showed that majority 17(60.7%) patients, margin of mass was circumscribed in benign group and 12(70.6%) patients had ill-defined in malignant group,Jain and Jain (2018) showed out of the 4 benign tumors with ill-defined margin, 2 were hemangiomas.

In this study showed that majority 24(85.7%)patients had acoustic enhancement in benign group and 5(29.4%) patients were in malignant group.Khalife etal. (2016) found that among total 28 patients 22 diagnosed benign tumor showed acoustic enhancement on ultrasonogram while 6 cases including 5 malignant and 1 benign case showed no acoustic enhancement. Reddy et al.(2018) and Paulose et al. (2018) on their study also showed benign neoplasm had acoustic enhancement.

In this study showed that in 6(35.3%) patients calcification within the parotid tumor were found in malignant group and 3(10.7%) patients were found in benign group.Khalife A et al. (2016) in their study among 28 patients of parotid tumor calcifications found in 4 benign cases and in 1 malignant case. S Wu et al. (2012) in

their study among 189 patients of parotid tumor calcifications were found in 20 benign and 3 malignant cases.

In this study showed that in 6(35.3%) patients lymphadenopathy followed by parotid tumor were found in malignant group and 4(14.3%) patients were found in benign group. Wahiduzzaman et al. (2013) showed out 45 cases of parotid tumor, lymphadenopathy was found in 5 cases of malignancy. Jain and Jain (2018) showed 71% of patients with malignant salivary gland neoplasm had cervical lymphadenopathy which was not seen in any benign cases.Shinomiya et al. (2016) found that among 72 patients of parotid gland cancer the incidence of lymph node metastasis was 22%.

In this study showed that majority 21(75.0%) patientsvessels were found peripheral position in benign group and 5(29.4%) were central in malignant group.Patange etal. (2017) found that benign lesion like pleomorphic adenoma has peripheral vascularity while malignant lesion had central vascularity.

In present study showedthat more than half 24(85.7%) patients had grade 2 flow pattern in benign group and 2(11.8%) in malignant group. Grade 3 flow pattern in 11(64.7%) in malignant group.In Jain and Jain (2018)study, 68.75% benign tumor were poorly vascularized, 25% were well vascularized, and absence of vascularization was seen in 6.25% of patient. Among malignant tumor, 10 (71.4%) were well vascularized, and 4 (28.53%) were poorly vascularized.El-Khateeb, Abou-Khalaf and Farid (2011)reported malignant tumors had higher vascularity than benign tumors. Vascularization of benign tumors was Grade 0 in 7.1% of cases, Grade 1 in 75% of cases and Grade 2 in 17.9% of cases, while no benign tumors presented with Grade 3 vascularization. However, vascularization of malignant tumors was Grade 1 in 25% of

cases, Grade 2 in 62.5% of cases and Grade 3 in 12.5% of cases and no malignant tumors presented with Grade 0 vascularization. Dumitriu et al. (2008)found that the on CDS examination 60.6% of benign and 55.5% of malignant tumors were poorly vascularized, while 30.30% of benign and 38.8% malignant tumors were well vascularized, of the 10 well vascularized benign tumors, only 3 were pleomorphic adenomas; the other 7 benign tumors were Warthin tumors and myoepitheliomas. Dibbad et al. (2018) showed that 78.5% of benign tumors showed Grade 0/1+ vascularity and only 21.5% showed 2+/3+ Grade of vascularity. Of the 18 malignant tumors, 16 (88.8%) had Grade 2+/3+ vascularity.

In present study showed that 15(88.2%) patient had resistivity index ≥0.8 in malignant group and 2(7.1%) in benign group. El-Khateeb, Abou-Khalaf and Farid (2011) reported that the range of RI in benign SG tumors was 0.5–0.78 while in malignant SG tumors it was 0.73–0.95. This difference was significant (P = 0.000). Similarly, Bradley et al. (2000) found that the range of RI in benign SG tumors was 0.6–0.9 and in malignant tumors it was 0.8–1. They also found a significant difference in the RI value between benign and malignant lesions. Schick et al. (1998) found that even though the value for RI was higher in malignant parotid tumors than in benign tumors, the difference was not statistically significant.

In this study showed that 15(88.2%) patients had pulsatility index ≥1.8 in malignant group and 2(7.1%) in benign group. Pulsatility index <1.8 were 2(11.8%) in malignant group and 26(92.9%) in benign group.Strympl et al. (2012) found that PI values at a range of 0.64 to 9.4 (mean 2.85) in benign group and a ranges of 0.7 to 13.0 (mean 3.14) in the malignant group, no statistical significant difference seen between two group. Dibbad et al. (2018) found that the mean PI values were 1.6 for

malignant tumor and 1.2 for benign group, the highest value were 2.1 for malignant and 1.9 for benign population, which was not statistically different.

In this study showed thatalmost two third (62.2%) patients had benign and 17(37.8%) had malignant parotid tumors confirmed by Color doppler.Jain and Jain (2018) observed that the Color Doppler sonography (CDS) examination revealed that 68.7% of benign and 28.7% of malignant tumors were poorly vascularized. Dumitriu et al. (2008)found that the on CDS examination 60.6% of benign and 55.5% of malignant tumors were poorly vascularized, while 30.30% of benign and 38.8% malignant tumors were well vascularized.

In this study observed that almost two third (62.2%) patients had benign and 17(37.8%) had malignant parotid tumors confirmed by histopathological diagnosis.Strympl et al.(2014) reported 66 (68%) tumors were benign and 30 (32%) were malignant evaluate by histopathology.El-Khateeb, Abou-Khalaf and Farid (2011) observed histopathological examination found that of the total number of tumours, 28 (64%) were benign and 16 (36%) were malignant.

In histopathological findings,9(20.0%) patients was found in mucoepidermoid carcinoma followed by 2(4.4%) in adenoid cystic carcinoma, 4(8.9%) in adenocarcinoma, 2(4.4%) in carcinoma ex pleomorphic adenoma, 21(46.7%) in pleomorphic adenoma and 7(15.6%) in adenolymphoma.Strympl et al. (2014) also observed pleomorphic adenoma was found in 38.1%, cystadenolymphoma 27.8%, bazocellular adenoma 2.01%, squamous cell carcinoma 6.3%, adenoid cystic carcinoma 5.2%, mucoepidermoid carcinoma 4.2%. Dumitriu et al. (2008) reported Parotid was 64.7%, Pleomorphic adenoma 60.60%, Lymphoepithelial cyst 6.06%,

Adenoid cystic carcinoma 27.80%, Squamous cell carcinoma 16.60%, Adenocarcinoma 16.60% and Acinic cell carcinoma 16.60%.

In this study showed,out of 45 cases 17 were diagnosed as malignant parotid tumors by Color Doppler ultrasonogram, among them 15(88.2%) were confirmed by histopathological diagnosis. Out of 28 cases of benign parotid tumors which were diagnosed by Color Doppler ultrasonogram, 26(92.9%) were confirmed by histopathological diagnosis.

In this study showed that the validity of Color Doppler ultrasonogram for parotid tumors correlated by calculating sensitivity 88.2%, specificity 92.9%, accuracy 91.1%, positive predictive values 88.2% and negative predictive values 92.9%.Similar observation was found different studies. In study of Rzepakowska et al.(2017) reported that the sensitivity, specificity, and accuracy of US in differentiation of malignant from benign lesions in the parotid gland were 60, 95.2, and 90.3%, respectively. The predictive values were: PPV 66.8% and NPV 93.6%. Differentiating diagnoses between PA and MA with US resulted in a sensitivity of 61.5%, specificity of 81.5%, and accuracy of 73.1%. The predictive values were: PPV 50% and NPV 68.8%, respectively. Strympl et al. (2014) observed Doppler US parameter RI differentiates carcinomas from benign tumors with a sensitivity of 71.4% and specificity of 52.9%. The sensitivity and specificity of the RI parameter in differentiating carcinomas from benign tumors were thus 71.4% and 52.9%, respectively.Jain and Jain (2018) observed study, USG showed a sensitivity of 100% and specificity of 87.5% for benign tumors and 87.5% sensitivity and 100% specificity malignant tumors. El-Khateeb, Abou-Khalaf and Farid.(2011)reported that the sensitivity and specificity of the degree of vascularity in diagnosing malignant

tumors were 75% and 83%, respectively. Mazaher et al. (2007) reported a sensitivity of 83% and a specificity of 88%. The moderate sensitivity and specificity of the degree of vascularity could be contributed to the overlap in scores between benign and malignant tumors since moderate vascularity was seen in both types.

In this study ROC curve was analyzed and cut off value for RI was ≥0.75 for malignant parotid tumor and PI value ≥1.52 was found. Area under the curve for RI was 0.977 and for PI was 0.947.

6. CONCLUSION

This study was undertaken to evaluate the usefulness of color Doppler ultrasonography in differentiation of benign and malignant parotid tumors taken histopathology as gold standard.Color Doppler ultrasonogram for parotid tumors correlated higher specificity and accuracy. Following observation of the performance of color Doppler, it can be inferred that for diagnosis and differentiation of benign and malignant parotid tumor color Doppler can be a useful tool. Color Doppler makes possible to establish the diagnosis quickly and thus start appropriate treatment early with reduction of invasive procedure.

7. LIMITATIONS

1. Samples was taken by single ultrasound machine PHILIPS Affinity Healthcare 30 with 7.5 to 10MHz probe it will be better if there were more high resolution ultrasound machine available.
2. Patients with large parotid tumor.
3. Patients with short neck.
4. Obese patient.

8. RECOMMENDATION

This current study showed that using color Doppler ultrasonography and various characteristics points of parotid tumor can differentiate benign and malignant parotid tumor.Study should be carried out with ultrasound machine having high resolution and the use of contrast enhanced color Doppler studyto find accurate parameters and cut-off values, so that we can easily differentiatebenignand malignant parotid tumor.

9. REFERENCE

Ansari, M.H. (2007). Salivary Gland Tumors in an Iranian Population: A Retrospective Study of 130 Cases. *Journal of Oral and Maxillofacial Surgery*, 65(11), pp.2187–2194.

Bialek, E.J., Jakubowski, W., Zajkowski, P., Szopinski, K.T. and Osmolski, A. (2006). US of the major salivary glands: anatomy and spatial relationships, pathologicconditions, and pitfalls. *Radiographics:* A Review Publication of the RadiologicalSociety of North America, Inc, [online] 26(3), pp.745–763.

Bradley, M.J., Durham, L.H. and Lancer, J.M. (2000). The role of colour flow Doppler in the investigation of the salivary gland tumour. *Clinical radiology*, *55*(10),pp.759-762.

Carlson, G.W. (2000). The salivary glands. Embryology, anatomy, and surgical applications. *Surg Clin North Am, 80(1),* pp.261-73.

Chawla,A.,Srinivasan, S., Lim, T.C., Pulickal, G.G., Shenoy, J. and Peh, W.C. (2017). Dual-energy CT applications in salivary gland lesions. *The British journal of radiology*, *90*(1074), p.20160859.

Cosgrove, D.O. (2001). 'Ultrasound'in Grainger and Allison's Diagnostic Radiology. A textbook of medical imaging, ed Ronald Grainzer, David Allison, Milork Dixon, Churchill Livingstone, London. 4th edition. Vol. 1, pp. 52-75.

Davachi, B., Imanimoghaddam, M., Majidi, M.R., Sahebalam, A., Johari, M., Langaroodi, A.J. and Shakeri, M.T. (2014). The efficacy of magnetic resonance

imaging and color Doppler ultrasonography in diagnosis of salivary gland tumors. *Journal of dental research, dental clinics, dental prospects*, *8*(4), pp.246-51.

Dibbad, R.B., Diwanji, N.S., Dasar, S.K. and Shastri, M.D. (2018). The role of grey scale and color doppler ultrasound in evaluation and differentiation of major salivary gland lesions. *International Journal of Anatomy, Radiology and Surgery,* 7(1), pp.RO11-RO17.

Dumitriu, D., Dudea, S., Badea, R., Botar-Jid, C., Baciuţ, G. and Baciuţ, M. (2008). B-mode and color Doppler ultrasound features of salivary gland tumors. *Medical Ultrasonography*, *10*(1), pp.31-37.

El Atta, M.M.A., Amer, T.A., Gaballa, G.M. and El-Sayed, N.T.M. (2016). Multi-phasic CT versus dynamic contrast enhanced MRI in characterization of parotid gland tumors. *The Egyptian Journal of Radiology and Nuclear Medicine*, *47*(4), pp.1361-1372.

El-Khateeb, S., Abou-Khalaf, A. and Farid, M. (2011). A prospective study of three diagnostic sonographic methods in differentiation between benign and malignant salivary gland tumours. *Dentomaxillofacial Radiology*, 40(8), pp.476–485.

Ethunandun, M., Davies, B., Pratt, C.A., Puxeddu, R. and Brennan, P.A. (2009). Primary epithelial submandibular salivary gland tumours–review of management in a district general hospital setting. *Oral oncology*, *45*(2), pp.173-176.

Hain, S.F. (2005). Positron emission tomography in cancer of the head and neck. *British Journal of Oral and Maxillofacial Surgery*, *43*(1), pp.1-6.

Hasebroock, K.M. and Serkova, N.J. (2009). Toxicity of MRI and CT contrast agents. *Expert opinion on drug metabolism & toxicology*, *5*(4), pp.403-416.

Howlett, D.C. (2003). High resolution ultrasound assessment of the parotid gland. *The British Journal of Radiology*, 76(904), pp.271–277

Islam, M.O., Sarker, M.Z., Mahmud, M., Ahmed, M.U., Bhuiyan, A.R. and Chowdhury, A.A. (2015). Comparative Study of Ultrasound Guided FNAC and Conventional FNAC in the Diagnosis of Parotid Tumour. *Bangladesh Journal of Otorhinolaryngology*, *21*(1), pp.5-16.

Izzo, L., Casullo, A., Caputo, M., Costi, U., Guerrisi, A., Stasolla, A., Basso, L., Marini, M. and De Toma, G., (2006). Space occupying lesions of parotid gland. Comparative diagnostic imaging and pathological analysis of echo color/power Doppler and of magnetic resonance imaging. *Acta otorhinolaryngologica italica*, *26*(3), pp.147-53.

Jain, S. and Jain, S.K. (2018). To Know the Diagnostic Accuracy of Ultrasonography for Major Salivary Gland Masses and Its Correlation with Histopathological Examination. *Int J Sci Stud,* 5(11), pp.138-144.

Khalife, A., Bakshaee, M., Davachi, B., Mashhadi, L. and Khazaeni K. (2016). The Diagnostic Value of B-Mode Sonography in Differentiation of Malignant and Benign Tumours of the Parotid Gland. *Iranian Journal of Otorhinolaryngology,* vol 28(5), serial no 88, p.305.

Kim, J., Kim, E.K., Park, C.S., Choi, Y.S., Kim, Y.H. and Choi, E.C. (2004). Characteristic sonographic findings of Warthin's tumor in the parotid gland. *Journal of Clinical Ultrasound*, *32*(2), pp.78-81.

Licitra, L., Grandi, C., Prott, F.J., Schornagel, J.H., Bruzzi, P. and Molinari, R., (2003). Major and minor salivary glands tumours. *Critical reviews in oncology/hematology*, *45*(2), pp.215-225.

Liu, Y., Li, J., Tan, Y.R., Xiong, P. and Zhong, L.P. (2015). Accuracy of diagnosis of salivary gland tumors with the use of ultrasonography, computed tomography, and magnetic resonance imaging: a meta-analysis. *Oral surgery, oral medicine, oral pathology and oral radiology*, *119*(2), pp.238-245.

Martinez-Madrigal, F. and Micheau, C. (1989). Histology of the major salivary glands. *The American Journal of Surgical Pathology, 13(10),* pp.879-99.

Martinoli, C., Derchi, L.E., Solbiati, L., Rizzatto, G., Silvestri, E. and Giannoni, M. (1994). Color Doppler sonography of salivary glands. *American journal of roentgenology*, *163*(4), pp.933-941.

Mazaher, H., Sharif, K.S. and Sharifian, H. (2007). Diagnostic Accuracy of Triplex Ultrasound in Malignant Parotid Tumors.. *Iran J Radiol, 4,* pp.169–174.

Parkin, D.M., Ferlay, J., Curado, M.P., Bray, F., Edwards, B., Shin, H.R. and Forman, D. (2010). Fifty years of cancer incidence: CI5 I–IX. *International journal of cancer*, *127*(12), pp.2918-2927.

Patange, N.A. and Phatak, S.V. (2016). Ultrasound and Doppler evaluation of salivary gland pathology. *International Journal of Research in Medical Sciences*, 5(1), p.79.

Paulose, S., Rangdhol, V., Kavya, L. and Dhanraj, T. (2018). An insight into ultrasonography of salivary glands: A review. *Journal of Medicine, Radiology, Pathology and Surgery*, *5*(3), pp.1-6.

Porcheri, C. and Mitsiadis, T.A. (2019). Physiology, pathology and regeneration of salivary glands. *Cells*, *8*(9), p.976.

Reddy, V., Lalawat, S. and Banda, N.R. (2018). Sonographic appearance of salivary gland pathologies: A review. *Journal of Oral Medicine, Oral Surgery, Oral Pathology and Oral Radiology,* 4(4), pp.182-185.

Richie, A.J. and Mellonie, P. (2019). Sonological evaluation of major salivary gland lesions with histopathological correlation. *International Journal of Contemporary Medicine Surgery and Radiology.* 4(2), pp.B91-B94.

Rzepakowska, A., Osuch-Wojcikiewicz, E., Sobol, M., Cruz, R., Sielska-Badurek, E. and Niemczyk, K. (2017). The differential diagnosis of parotid gland tumors with high-resolution ultrasound in otolaryngological practice. *European Archives of Oto-Rhino-Laryngology*, *274*(8), pp.3231-3240.

Schick, S., Steiner, E., Gahleitner, A., Böhm, P., Helbich, T., Ba-Ssalamah, A. and Mostbeck, G. (1998). Differentiation of benign and malignant tumors of the parotid gland: value of pulsed Doppler and color Doppler sonography. *European radiology*, *8*(8), pp.1462-1467.

Shenoy, A.S., Dinkar, A.D., Khorate, M. and Satoskar, S. (2016). Role of Ultrasonography in Salivary Gland Health and Disease–A Review. *IOSR J Dent Med Sci*, *15*, pp.43-6.

Shinomiya, H., Otsuki, N., Yamashita, D. and Nibu, K. (2016). Patterns of lymph node metastasis of parotid cancer. *Auris Nasus Larynx*, 43(4), pp.446–450.

Stell, P.M., A G D Maran, Watkinson, J.C. and Gilbert, R.W. (2012). *Stell and Maran's textbook of head and neck surgery and oncology*. London: Hodder Arnold, 5th edition, pp. 714-723.

Strympl, P., Kodaj, M., Bakaj, T., Kominek, P., Starek, I., Sisola, I., Tomaskova, H. and Matousek, P. (2014). Color Doppler Ultrasound in the pre-histological determination of the biological character of major salivary gland tumors. *Biomedical Papers*, *158*(3), pp.465-469.

Wahiduzzaman, M., Barman, N., Rahman, T., Khan, M.E.U., Islam, M.T. and Bhuiyan, M.Z.R. (2013). Major Salivary Gland Tumors: A Clinicopathological Study. *Journal of Shaheed Suhrawardy Medical College*, 5(1), pp.43–45.

Wei, X., Li, Y., Zhang, S., Li, X., Wang, H., Yong, X., Wang, X., Li, X. and Gao, M., (2013). Evaluation of microvascularization in focal salivary gland lesions by contrast-enhanced ultrasonography (CEUS) and Color Doppler sonography. *Clinical hemorheology and microcirculation*, *54*(3), pp.259-271.

Wu, S., Liu, G., Chen, R. and Guan, Y. (2012). Role of ultrasound in the assessment of benignity and malignancy of parotid masses. *Dentomaxillofacial Radiology*, *41*(2), pp.131-135.