ORIGINAL RESEARCH

Evaluation of the Efficiency of Ultrasonography and Color Doppler in Diagnosis of Intraosseous Jaw Lesions: An *In Vivo* Study

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Abstract

Aim: The current *in vivo* investigation aimed to evaluate the accuracy of ultrasonography and color Doppler performed in the diagnosis of intraosseous jaw lesions.

Materials and methods: A total of 30 patients with intraosseous jaw lesions between the ages of 12 and 60 were selected for the present study. For every jaw lesion, a preliminary diagnosis was done using preoperative conventional radiographs. A sonologist evaluated the preoperative ultrasound examination and color Doppler images to determine the lesion's content, vascular supply, and preliminary classification was made as either a cyst or a tumor. The tissue was curetted during the surgical procedure to facilitate the histological examination. Every measurement and result were compared, and a statistical analysis was performed.

Results: On ultrasound and color Doppler examination out of 8 solid lesions, 2 (25%) were non-vascular and 6 (75%) were vascular.11 (64.7%) out of 17 cystic lesions were non-vascular and 6 (35.3%) were vascular. About 2 (66.7%) out of 3 complex lesions were non-vascular and 1 (33.3%) was vascular. And out of 2 Inconclusive lesions 1 (50%) was vascular and another 1 (50%) was non-vascular. There was a statistically significant difference found between color Doppler and ultrasound characteristics (0.001). Histopathological examination determined that 8 (100%) solids were diagnosed as the tumor. And 8 (47.1%) out of 17 cystic lesions were diagnosed as the tumor and 9 (52.9%) as cysts on histopathological examination. Out of 3 complex lesions 2 (66.7%) lesions were diagnosed as the tumor and 1(33.3%) as cysts. And 2 cases which were inconclusive were diagnosed as cysts and 1 tumor each. There was no statistically significant difference found between histopathological characteristics and ultrasound characteristics ($p = 0.081$).

Conclusion: The current investigation came to the conclusion that ultrasound can reliably distinguish between a cyst and a tumor and provide correct information about the pathological nature of a jaw lesion.

Clinical significance: Ultrasound has been a crucial diagnostic tool for numerous medical specialties. It is simple to use and can provide a detailed representation of soft tissues. Furthermore, it facilitates the accurate localization of samples when necessary and the evaluation of the solid and cystic components of lesions.

Keywords: Color Doppler, Conventional radiography, Histopathology, Jaw lesions, Ultrasonography.

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Introduction

The jaw is a common anatomical location for the occurrence of odontogenic and non-odontogenic diseases. The diagnosis of these lesions is complicated due to the vast range of variability in their clinical and radiological appearance.[1] Clinical examination, imaging, laboratory testing, histological analysis, etc. are used to achieve a conclusive diagnosis of any disease or pathology.[2] Histopathological analysis of tissues is required to make the final confirmatory diagnosis, which is impractical in circumstances where the patient is not receiving surgical therapy. Radiographs are the most often used diagnostic adjunct. The radiograph has a vague appearance with all of the shadows.[3]

There are currently a lot of advanced imaging methods accessible in addition to the commonly practiced conventional radiography. Among these are radionuclide imaging, magnetic resonance imaging, cone beam computed tomography, and ultrasound. Using intraoral periapical, occlusal, and panoramic radiographs, radiologists can analyze and screen pathologic abnormalities of the jaws, particularly if they are the result of an endodontic infection.[4]

Ultrasonography has been a vital diagnostic technique for many years in a variety of medical specialties. This approach has

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the following benefits: it is inexpensive, noninvasive, non-ionizing, fast to execute, easily repeatable, and causes no discomfort to the patient. It is easily accessible and has the ability to depict soft tissues in great detail. Additionally, it aids in assessing the solid and cystic components of lesions and, if necessary, directs the precise location of biopsies.[5]

The integration of color Doppler ultrasound with echography provides an opportunity to assess and ascertain the existence, orientation, and speed of blood flow within the ultrasound image of the tissue under investigation. A color-coded representation of the Doppler signals and their temporal modification is provided by a color-power Doppler. Since it has been around for so long, this real-time imaging modality has only been used sparingly and mostly for soft tissue applications in dentistry.[6] Hence, the current investigation was carried out to evaluate the accuracy of ultrasonography and color Doppler performed in the diagnosis of intraosseous jaw lesions.

Materials and Methods

The present study was conducted in the Department of Oral Medicine and Radiology, Kothiwal Dental College and Research Center, Moradabad, India, during the year of 2010–2012. Ethical approval was obtained from the ethical committee under MJP Rohilkhand University, Bareilly. Thirty patients between the ages of 11 and 60 were considered in the study group. These 30 patients were divided into groups according to the age. For the study, patients with provisional diagnoses of intraosseous jaw lesions based on clinical signs and symptoms confirmed by conventional and periapical radiographs were chosen.

Patients having primary intraosseous lesions in the maxilla or mandible, lesions which were big enough to produce expansion and thinning of cortical plates, and patients aged between 11 and 60 years group were included in the present study. Pregnant women and those were not provided the consent were excluded from the present study.

A specific patient record sheet was created to document the following: a thorough history of the patient; a clinical examination involving all diagnostic techniques, including pulp vitality testing as needed; conventional radiography; an ultrasound examination utilizing a color Doppler; and a histological investigation. Prior to undergoing the ultrasonographic examination, all thirty of the patients who volunteered to participate in the study were asked to sign an informed consent form. The observers included a histopathologist, an oral radiologist, and an ultrasonographer.

Clinical Examination (Figs 1 to 4)

For the clinical assessment, the individuals were made to sit comfortably on a physiologic dental chair with artificial lighting. A test for pulp viability was conducted in the necessary situations. The proforma included pertinent data. Afterward, the subjects underwent radiographic procedures in the radiologic division.

Conventional Plain Film Radiography Examination

A preoperative periapical and panoramic radiograph was taken for each of the thirty patients. It was determined that intraosseous jaw lesions were present based on clinical and radiographic evidence. The oral radiologist examined each lesion's images. A preliminary diagnosis was established.

Fig. 1: Extraoral photograph showing the diffuse swelling on the right body of the mandible

Fig. 2: Orthopantomograph showing radiolucent lesion in the right mandibular molar region with well-defined border and with no internal areas of calcification displacing the inferior alveolar canal inferiorly

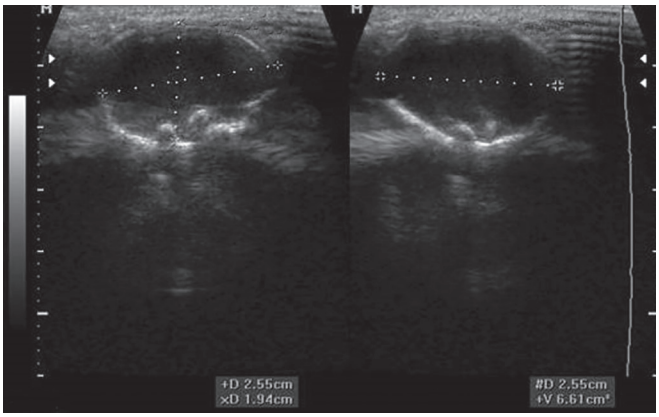

Fig. 3: Ultrasonogram showing well-defined cystic, hypoechoic lesion with low level of internal echo with mild-to-moderate posterior acoustic enhancement is seen

Ultrasound with Color Doppler Examination

After that, a diagnostic ultrasound examination was carried out utilizing the Medison Sonoace 8000 Live machine, which included

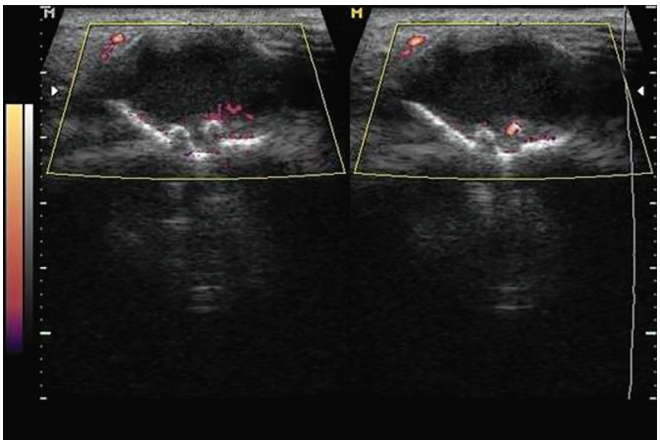

Fig. 4: Ultrasonogram showing no vascularity on color Doppler flow imaging (CDFI) and power Doppler imaging (PDI)

a high-definition, linear, regular-size, multifrequency ultrasound probe at a frequency of 7–11 Mhz. It also had color and power Doppler functions. First, to prevent infection, a layer of ultrasound gel was applied to the ultrasound probe after a disposable insulating latex glove had been replaced. On the skin covering the intraosseous lesion, the probe was positioned externally to the mouth. To get a sufficient number of transverse scans (axial scan) to characterize the bone defect, the probe position was adjusted numerous times. Additionally, sagittal plane longitudinal images were acquired. In instances where it was feasible, an intraoral ultrasound probe was also placed in the buccal or labial sulcus above the jaw lesion, and longitudinal and transverse scans were taken.

The thin anterior buccal bone and potential fenestration made it possible to get ultrasound images in every instance and identify the jaw lesions' echo characteristics. Every lesion was measured in three different planes: mesiodistal, superoinferior, and anteroposterior, and the dimensions were noted. After that, a color Doppler and a power Doppler were used on each examination to find blood flow. Three-dimensional ultrasonography pictures were also acquired for certain lesions. A thermal printer was utilized to produce hard-copy images.

An experienced ultrasonographer analyzed each lesion's image. Based on the following concepts, a diagnosis was determined. A cystic lesion is a well-defined, hypoechoic hollow with strengthened bone walls that is filled with fluid and shows no signs of internal vasculature when examined with a color power Doppler. Tumor: – On a color power Doppler examination, a poorly defined lesion may be openly corpusculated (hyperechoic or echogenic) and display both corpusculated and hypoechoic patches demonstrating a rich vascular supply.

Surgery and Histopathological Examination

All patients were treated with surgery and curettage in the department of oral surgery at Kothiwal Dental College and Research Center, Moradabad. Following periapical surgery, biopsy samples from each of the 30 patients were preserved in 10% buffered formalin and forwarded for standard histological analysis.

Following the fixation in 10% buffered formalin, the samples underwent standard processing, including a graded phase of dehydration and paraffin infiltration. The paraffin was then removed by sectioning and mounting the sections on glass slides, which were then kept at 36°C for an hour and then run through a descending concentration of alcohol. After that, the sections were examined under a microscope after being stained with hematoxylin and eosin. The histological sections were evaluated in a blind fashion. The lesion's histology was then compared with the findings of color Doppler ultrasonography.

Table 1: Age and sex-wise distribution of subjects

Age-range	*No.of males*	*No. of females*	*No. of patients*	*Percentage (%)*
11–20	5	5	10	33.3
21–30	4	3	7	23.3
31–40	3	3	6	20
41–50	1	3	4	13.4
51–60	2	1	3	10
Total	15	15	30	100

Table 2: The comparison of radiographic characteristics and ultrasound

Type of examination	*Characteristics*	*N (%)*
Radiological examination	Cyst	16 (53.3)
	Tumor	14 (46.7)
Ultrasound examination	Solid lesions	8 (26.7)
	Cystic lesions	17 (56.7)
	Complex lesions	3 (10)
	Inconclusive	2 (6.6)

Chi-squared value: 5.318, *p*-value 0.002

Statistical Analysis

Following tabulation of the data in an Excel sheet, the data were transferred to SPSS Statistics for Windows, version 20, for analysis. Mean ± SD and Number (%) were used to represent the values. Data analysis was done using the Chi-squared test. A statistically significant *p*-value was defined to be less than 0.05.

Results

The 30 subjects were divided into groups according to the age. There were 10 (33.3 %) subjects between 11–20 years (5 males and 5 females), 7 (23.3%) subjects between 21 and 30 years (4 males and 3 females), between 31 and 40 years, there were 6 (30%) subjects (3 male and 3 females), between 41 and 50 years, there were 4 (13.4%) subjects (1 male and 3 females), between 51 and 60 years, there were 3 (10%) subjects (2 males and 1 female) (Table 1).

On radiological examination out of 30, 16 cases were diagnosed as cyst and 14 cases as tumor. While on USG examination, 17 cases had cystic appearance, 8 solids, 3 were complex, and 2 were inconclusive. The comparison in the distribution of radiographic and ultrasound characteristics was found to be statistically significant (p-value < 0.05), that is, ($p = 0.002$) (Table 2).

On clinical examination 16 (30) cases were diagnosed as cysts and 14 (30) cases as tumor. While on USG examination 17 (30) cases had the cystic appearance, 11 (solid) and 2 (30) were inconclusive. Thus, the comparison in the distribution of radiographic and ultrasound characteristics was found to be statistically significant (p-value < 0.05), that is, ($p = 0.002$) (Table 3).

Table 3: The comparison of clinical characteristic and ultrasound

Type of examination	*Characteristics*	*N (%)*
Clinical examination	Cyst	16 (53.3)
	Tumor	14 (46.7)
Ultrasound examination	Solid lesions	8 (26.7)
	Cystic lesions	17 (56.7)
	Complex lesions	3 (10)
	Inconclusive	2 (6.6)

Chi-squared value: 5.318, *p*-value 0.002

Table 4: The comparison in the distribution of color Doppler and ultrasound characteristics

Lesions	*Characteristics*	*N (%)*
Solid lesions	Non-vascular	2 (25)
	vascular	6 (75)
Cystic lesions	Non-vascular	11 (64.7)
	vascular	6 (35.3)
Complex lesions	Non-vascular	2 (66.7)
	vascular	1 (33.3)
Inconclusive	Non-vascular	1 (50)
	vascular	1 (50)

Chi-squared value- 6.412, *p*-value- 0.001

On ultrasound and color Doppler examination out of 8 solid lesions, 2 (25%) were non-vascular, and 6 (75%) were vascular. And 11 (64.7%) out of 17 cystic lesions were non-vascular and 6 (35.3%) were vascular. About 2 (66.7%) out of 3 complex lesions were non-vascular and 1 (33.3%) was vascular. And out of 2 inconclusive lesion, 1 (50%) was vascular and another 1 (50%) was non-vascular. The comparison in the distribution of color Doppler and ultrasound characteristics was done using the Chi-squared test. The difference was found to be statistically significant (p-value < 0.05) that is, (0.001) (Table 4).

Histopathological examination determined that 8 (100%) solids were diagnosed as tumor. And 8 (47.1%) out of 17 cystic lesions were diagnosed as tumors and 9 (52.9%) as cysts on histopathological examination. Out of 3 complex lesions, 2 (66.7%) lesions were diagnosed as tumors and 1 (33.3%) as a cyst. About 2 cases which were inconclusive were diagnosed as cysts and 1 tumor each. Thus, the comparison in the distribution of histopathological characteristics and ultrasound characteristics was found to be statistically not significant (p-value > 0.05), that is, $p = 0.081$) (Table 5).

The inference of the present study indicated that the ultrasound provides accurate information on the pathological nature of the jaw lesion and can accurately differentiate a cyst from a tumor. Ultrasound can even evaluate cystic content (clear or debris), thus differentiating an infected and non-infected cyst. Color Doppler can evaluate the vascularity within the lesion which can determine whether the lesion is a cyst or tumor or secondarily inflamed.

Table 5: The comparison of histopathological and ultrasound characteristics

Lesions	*Characteristics*	*N (%)*
Solid lesions	Cyst	0
	Tumor	8 (100)
Cystic lesions	Cyst	9 (52.9)
	Tumor	8 (47.1)
Complex lesions	Cyst	1 (33.3)
	Tumor	2 (66.7)
Inconclusive	Cyst	1 (50)
	Tumor	1 (50)

Chi-squared value- 7.084, *p*-value 0.081

Discussion

Radiographs have been used extensively in dentistry over the years to diagnose a variety of jaw abnormalities. However, they have various limitations, and one of them being the inability to differentiate cystic and solid lesions, as both appear radiolucent. Knowing the content of the lesion would enable the clinician to decide whether to perform an incisional biopsy as the next step or to undertake the complete surgical treatment of the patient.[7] The development of modern imaging methods like CBCT and MRI has allowed for the collection of additional information beyond what a radiograph can provide, such as the nature of the lesion. The patient is exposed to ionizing radiation when using CBCT, and routine use of these imaging modalities is restricted due to their expensive cost and limited availability.[8,9]

It is commonly known that ultrasonography can be used to identify different soft tissue lesions of the head and neck. This approach has the following benefits: it is inexpensive, noninvasive, non-ionizing, fast to execute, easily repeatable, and causes no discomfort to the patient.[10] There are two reports of trials where ultrasonography was used to differentiate periapical lesions and only one study where ultrasonography was examined for its use as a complementary diagnostic method for intraosseous jaw lesions.[11,12]

Of the 30 lesions included in this study, 9 (53.6%) had a correct histological diagnosis, and 17 were classified as cystic lesions. However, during a histological analysis, eight cystic lesions were identified as tumors, most likely as a result of lesion modifications. The findings of this investigation were inconsistent with those of Cotti E et al.[7] who correctly identified periapical granulomas from periapical cysts in each of the 11 cases they examined. Dib LL et al.[5] found that of 72 intraosseous lesions of the jaw, only 17 out of 23 cystic lesions could be reliably identified, which is in contrast to the findings of the current investigation. This may be the result of solid portions inside the cystic lesion, thick cortical bone covering the lesion, and the existence of infected cysts.

In the present study, the cystic lesions on the ultrasound imaging appeared as an anechoic or hypoechoic lesion in 17 cases. The internal echoes were present in cases of an infected cyst and in cases of keratocystic odontogenic tumor, and could have been produced by the dense particles (cholesterol clefts in infected cysts) in the cystic fluid and by keratin in cases of keratocystic odontogenic tumor.

These results are consistent with those of histological results of Cotti E et al.,[7] Rajendran N and Sundaresan B[13] and Vinod VS et al.,[14] who reported that a periapical cyst was diagnosed as having substantial secretary content after it displayed small, scattered echoes that appeared to be a fluid with dense particles.

In one of the cases, a calcifying odontogenic cyst was not clearly visible despite the histological analysis leading to the identification of a cyst. The dense cortical bone covering it was most likely the cause of this. A similar histological finding was reported by Dib LL et al.[5] and Celia C et al.,[15] who noted that the thick cortical bone plate had led to the wrong diagnosis in five cases. Six patients in this study's 17 cyst cases had Doppler examinations that showed blood flow. This result did not support the observation stated by Cotti E et al.[6]

When ultrasonography and conventional radiography data were compared, it was found that ultrasonography could detect septae or calcifications even when they were not visible on radiographs. The presence of thick vestibular cortical bone, the formation of infected cysts, and solid areas within cystic lesions are among the potential pitfalls in the interpretation of ultrasonography. The majority of the respondents in this study were able to accurately determine whether the lesion was cystic, solid, or mixed based on Ultrasound/Ultrasonography (US) examination results. A strong correlation of 100% was observed between the US and histological findings for lesions with solid substance, while 66.6% was found for complicated lesions.[16]

Ultrasonography will help differentiate between solid and cystic lesions, even though it might not provide the final diagnosis. When diagnosing intraosseous lesions of the jaws, ultrasound is frequently suggested as a complementary technique.

A limitation of the present study is the smaller sample size used. Although the results of our investigation are highly encouraging, further research using larger samples and a variety of pathologies may be necessary to confirm ultrasonography's diagnostic potential.

Conclusion

Within its limitations, the current investigation found that an ultrasound can reliably distinguish between a cyst and a tumor and provide correct information about the pathological nature of a jaw lesion. It can even distinguish between an infected and non-infected cyst by evaluating the cystic content (debris or clear). Additionally, color Doppler provides the ability to view blood flow direction and presence, which can be used to identify vascularization in an intraosseous jaw lesion.

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