Review Article

# Color-Doppler Ultrasound in the Diagnosis of Oral Vascular Anomalies

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## Abstract

In last few years, thanks to laser technology with minimally invasive approach, there was a growing need for treatment of oral vascular malformations inside the dental offices. Generally, the diagnosis of oral vascular malformations is based on clinical history, clinical examination and imaging exams. In the present paper, we review, researching by PubMed, the technical aspects, clinical indications, potentialities and limitations of color-Doppler ultrasound in the work-up of oral vascular malformations. Different imaging modalities are encountered for the diagnosis and follow-up of these lesions such as computed tomography, magnetic resonance imaging, color-Doppler ultrasound and angiography. To date, color-Doppler ultrasound is considered the first-line imaging approach since it provides a non-invasive, cost effective, real time evaluation of oral vascular anomalies. It provides both morphological and vascular information, which are useful to determine the best therapeutic options. Ultrasonography, for these reasons, could be considered as a valuable diagnostic tool in the preliminary assessment of oral vascular anomalies.

**Keywords:** Color-Doppler ultrasound, hemangiomas, oral cavity, vascular malformations

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## Introduction

A vascular lesion is an all-encompassing term used to describe a wide range of conditions consisting of an abnormal number, structure, or position of blood vessels. Many classifications have been proposed,[1-3] but to date a very basic classification system has been adopted by the International Society for the Study of Vascular Anomalies (ISSVA). This classification distinguishes two main types of vascular anomalies: Vascular tumors and vascular malformations.[4]

Vascular tumors were differentiated from vascular malformations by their clinical appearance, radiological and pathological features,[5] and biological behavior.

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Vascular tumors rise from cellular (mainly endothelial) hyperplasia. On the other side, vascular malformations are formed by a quiescent endothelium and they are considered localized defects in vascular morphogenesis. Vascular tumors can regress or persist depending on their type. These lesions are often present at birth, although, they may not be clinically manifested until later in life. Vascular malformations instead persist throughout life[6] and their diagnosis and treatment are different according to the specific subtype;[5,7] are usually asymptomatic, but sometimes prolonged and intermitted bleeding caused by recurrent trauma can occur.[8]

There are differences even in the management of the lesions, according to the type (tumors or malformations). Previously, the diagnosis was only clinical and histological, but recently imaging modalities such as ultrasound demonstrated to be useful in the diagnosis of skin and oral cavity diseases.[9-12] Various treating methods were proposed including primary surgical resection, cryotherapy, embolization, sclerotherapy, laser treatment and steroids.[13-20] Excision, although effective, is not widely used because of the complications of scarring and bleeding,[21] whereas cryotherapy is prone

to cause unsightly scarring.[22] Over the last 15 years, laser treatment of vascular lesions has been showing good results.[23-29] Lasers with a wavelength raging between 400 nm and 1100 nm (diode, Nd: YAG and KTP) are better absorbed by the hemoglobin chromophore, and penetrates deeply into the tissues and emits heat determining coagulation down to the depth of about 2–10 mm (it depends from the laser wavelengths), with approach called photocoagulation. The minimally invasive approach to vascular malformations with laser technology has led to an increase in the treatment of such malformations in the outpatients.

The aim of this study is to emphasize that the color-Doppler ultrasound may be an important way of acquisition of diagnostic images able to differentiate the vascular malformations located in the oral cavity.

## Imaging modalities

Several imaging modalities are available for the assessment of oral vascular lesions such as: Computed tomography (CT), magnetic resonance imaging (MRI), angiography and ultrasonography (US). The CT and MRI are standard imaging modalities in oral and maxillofacial surgical fields. The extent of the lesions may be determined by all the imaging modalities such as CT, MRI and US, but the velocity of blood flow may be better determined by contrast-enhanced MRI and color-Doppler US. MRI with gadolinium may determine the presence of contrast-enhancement. Peripheral enhancement without progression throughout the mass suggests a lesion that is probably not primarily a vascular entity. If a lesion is identified historically and clinically as a vascular mass, peripheral-enhancement progressing to the center (low flow) is typical of venous malformation, whereas rapid enhancement throughout the mass characterizes an arterial malformation and, if accompanied by flow voids, an arteriovenous malformation.[30]

Angiography is useful to investigate complex vascular lesions in bone and soft tissue. It does not assess quantitatively the vascularization but may show rapid or slow flow, although it can show rapid flow through (into and from) an arteriovenous malformation.

In recent years, the consideration of sonography in the dermatologic field increased;[31] at the same time, ultrasound imaging plays an important role to study lesions in the oral regions such as tongue, oral cavity and lips. However, although a number of reports on baseline US and fewer on Doppler appeared in the oral and maxillofacial surgical literature in the past 20 years, the investigative and diagnostic potentials of these modalities continue to be explored.[30] US has excellent intrinsic resolution, it is ionizing radiation free, and provides Doppler information, but it cannot penetrate the interstices of bone.

## Color-Doppler US features

The development of new high-resolution ultrasound equipment with higher and variable frequencies supporting compact linear design-type probes, improved evaluation of these superficial vascular variants. The linear high frequency probes (7-15 MHz) permit to follow and analyze a vascular structure changing the focal point of vision from the external vermillion or internal lip surface to the maxilla bone cortical margin without moving the patient or probe.

The compact linear probe takes the shape of a hockey stick and its small size permits a closer view of the lesion directly from the oral cavity, which can be useful to acquire a complete three- dimensional evaluation of the course of the vessel. Then it can permit the examination of the anatomy of the lips either from the external vermillion aspect or from the vestibular aspect of the oral cavity.[32]

High resolution and high frequency color-Doppler US is a reliable non-invasive imaging tool that may avoid unnecessary biopsy or surgical procedures, and therefore may help to decrease the risk of complications. It may help in the differential diagnosis of vascular and nonvascular causes of nodular lesions in the oral cavity and it can also provide a clearer definition and spatial resolution of the cutaneous, muscular, and mucosal layers, using its high resolution sonographic equipment. US provides information about size, localization, echogenicity, margins and tendency of the lesion to invade the surrounding structure.

In detail, the focal lesions may be measured in three-orthogonal dimensions using on screen calipers.[30] Lesions echogenicity is described in comparison to adjacent muscle as it follows: Hyperechoic (brighter than muscle), isoechoic (equal to muscle), hypoechoic (darker than muscle), anechoic (no internal echoes), or mixed. In addition, the lesions appear soft or strong because of the capability of size reduction due to the probe compression or thanking to the new software of elastography already tested in other fields.[33-35]

Color-Doppler evaluation was done in order to identify the presence, quantity and type of Doppler flow, and to identify feeding and draining vessels. In addition, Color-Doppler spectral curve analysis of a blood vessel determines the arterial or venous nature of the flow, as well as its velocity (cm/s) [Figures 1a-c and 2a-c].

All gray-scale US are usually performed using the probe at higher resolution frequency, which provides

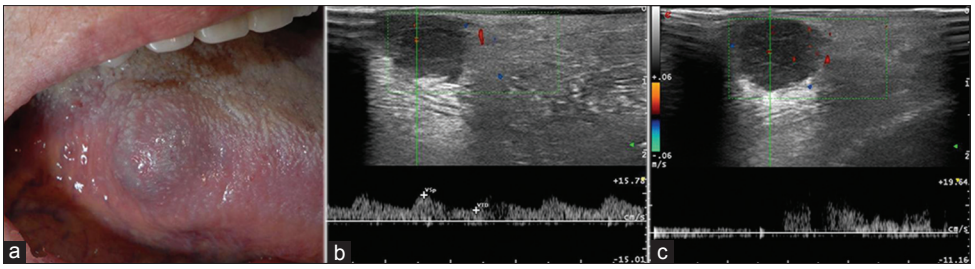


**Figure 1:** (a) Clinical aspect arteriovenous malformation of the tongue. (b) Color-Doppler US image shows an hypoechoic lesion with lobulated margins with some color-flow signal within it with spectral features compatible with arterial flow. (c) Color-Doppler US with spectral analysis reveals a venous waveform in a different vessel

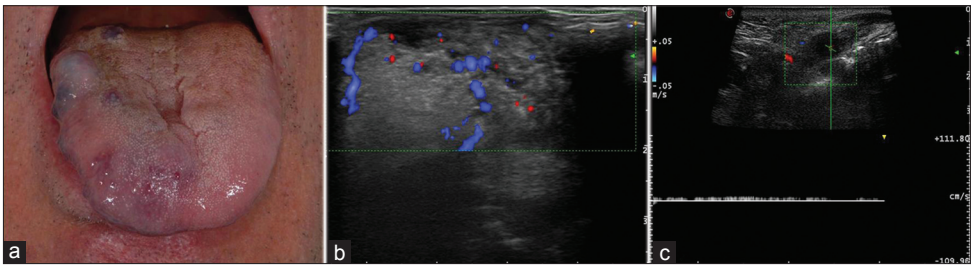


**Figure 2:** (a) Clinical image arteriovenous malformations of the tongue. (b) Color-Doppler US image (longitudinal plane), with a hypoechoic lesion presented diffuse vascular signals within the lesion. (c) Arterial feeding vessels were easily depicted

better spatial resolution, whereas color-Doppler was usually performed at 6 Mhz.[30] Color Doppler depicts an anatomic view and shows the type of vascularization and mean velocity and direction of blood flow in the region of interest. When flow is detected, its nature such as arterial and/or venous was confirmed with a spectral waveform that plotted Doppler frequency shift on the Y-axis and time on the X-axis. Power-Doppler could be a useful adjunct especially to detect very slow-flows. A copious amount of gel was used to link the vermillion and the vestibular aspect of oral cavity.

Vascular anomalies can be divided into two major categories: Vascular tumors and vascular malformations. Tumours of blood and lymphatic vessels form a heterogeneous group ranging from infantile hemangiomas and congenital hemangiomas, both benign neoplasms of capillary endothelium, at intermediate lesions that are locally aggressive but rarely metastasize and which Kaposiform hemangioendotheliomas and Spindle-cell hemangioendotheliomas, at the rarer forms are malignant as the epithelioid hemangioendotheliomas, composite and retiform hemangioendotheliomas and angiosarcomas. Most of these tumours originates from the differentiation of endothelial cells; other, instead, are derived from the cells that support and/or lining the blood vessels.

Hemangiomas are the most common soft-tissue tumors of of childhood and consist of small blood vessels of capillary morphology and size. They usually appear within a few weeks after birth have a phase of intense proliferation in the following months and then undergo a gradual spontaneous involution in subsequent years commonly around 5–6 years. Hemangioma at examination, usually appear as a large, erythematous, soft, protuberant lesion. At color-Doppler Ultrasound, hemangiomas are usually poorly defined solid masses that may show different echogenicity and vascularization depending on their phase.[31,35]

Vascular malformations are congenital anomalies of different morphogenic vessels that can occur at any age. They are divided into two categories: Low and high flow. The low-flow malformations contain combinations of components capillary, venous, and lymphatic systems. The high flow malformations instead contain arterial, arteriovenous fistula and arteriovenous malformations. They are usually present at birth, grow simultaneously to the child, and they never regress.[35]

When at US/Doppler a homogeneous mass with diffuse internal echoes producing a smooth erosion of the palate and a small component that invaded the nasal floor is showed, a differential diagnosis includes carcinoma, neurofibroma, and inflammatory mass.

Low-flow venous malformations are generally compressible and have a hypoechoic, heterogeneous appearance with multiple anechoic sinusoidal spaces on US images [36,37] [Figure 3a-c]. They are usually characterized by compressible ducts by the US probe with venous flow on spectral analysis. Usually at color-Doppler no evidence of arterial flow is depicted.

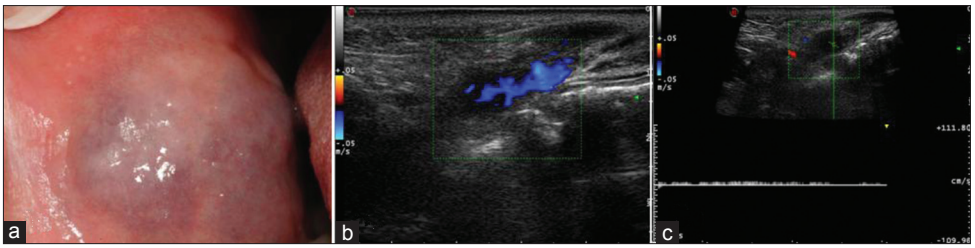


**Figure 3:** (a) Clinical appearance venous malformation of the right cheek. (b) At color-Doppler US image, the lesion appeared heterogeneously hypoechoic with multiple anechoic sinusoidal spaces (longitudinal plane) with mild vascularization. (c) At spectral analysis monophasic venous flow was detected

Sometimes some phleboliths may be encountered within the lesions.[36] When encountered they appear as hyperechoic foci with posterior acoustic shadowing. The slow flow is often undetectable at power Doppler imaging and conventional angiography.

Lymphatic malformations (lymphangiomas), of which cystic hygromas are the most common, usually manifest as transpatial cystic masses within the first two years of life. They may be macrocystic, microcystic or combined.[38] Macrocystic lymphangiomas appear as large, anechoic cavity separated by septa at US.[39] Microcystic lymphangiomas, because it is made up by multiple microscopic cavities, may appear hyperechoic.[39] Usually they are avascular, except for the septa, although a mixed type of vascular flow both venous and arterial sometimes may be depicted.[39]

High-flow arteriovenous malformations are rare lesions that are usually present at birth but may manifest clinically at any age. Their clinical manifestation often follows a period of rapid growth. Color-Doppler US usually reveals a mass composed entirely of vascular spaces with aberrant arterial and venous vessels within the mass.[37,40] US has been proposed not only for diagnostic aims in the oral cavity vascular lesions but for treatment guidance as well.[41,42]

## Discussions and Conclusions

Color-Doppler US is a useful imaging modality that provides both morphological and vascular information. However, a multidisciplinary approach and strict cooperation between imaging specialists and clinicians promote better diagnosis and management.

Kurabayashi *et al.*[43] underlined that CT and MRI were an important adjuvant to permit the location, the measurement of lesions in the oral cavity and are useful in demonstrating the characterization between the different vascular lesions.

Some authors[30,44] suggest that enhanced MRI could be substituted with unenhanced MRI associated at color-Doppler US to provide more diagnostic information at lower cost. US may be useful for both diagnosing and guiding the treatment of vascular lesions. Laser induced changes can be identified by US as increase of echo level, so some authors [26,45] used US for guiding laser-fiber insertion safely. Therefore, US guidance makes Laser therapy more effective and less invasive for the patients, because it converts the blind operation into visual operation.[42] Moreover, the US echo probe slightly compresses and reduces the lesion, allowing laser light to penetrate more easily into the whole layer. However, the operator should be quite skilled because one should be able to hold the probe and the fiber in each hand, and so a training period is warranted. The oral pathology specialist is more frequently involved in the treatment of vascular malformations; in addition, he should be aware of the potentialities and limitation of imaging modalities.

The ultrasound, thanks to its advantages (easy, quick and cost-effective) is indicated for studying superficial structure, quite small vascular malformations and to program the best technique for the pre-operative evaluation.

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