Ultrasonographic evaluation of mandibular ameloblastoma: a preliminary observation

Linguo Lu, MD,[a] Jie Yang, DDS, MMS, MS, DMD,[b] Ji-Bin Liu, MD,[c] Qiang Yu, DDS,[d] and Qiuhua Xu, MD,[e] Shanghai, China, and Philadelphia, PA
SHANGHAI JIAO TONG UNIVERSITY AND TEMPLE UNIVERSITY KORNBERG SCHOOL OF DENTISTRY

Objective. The purpose of this study was to demonstrate ultrasonographic characteristics of mandibular ameloblastoma and assess the value of ultrasonography in diagnosis of the tumor.
Study design. Nineteen subjects with ameloblastomas in the mandibles were examined with ultrasonography. Locations, sizes, internal echoes, boundaries, and blood flow of the tumors were observed and documented. Ultrasonographic appearances of the tumors were compared with histopathological findings. Sensitivity and specificity of Doppler flow signals for prediction of active tumor proliferations were calculated.
Results. The main sonographic features of the tumor appeared as a complex cystic mass with solid contents. Most tumors (15/19, 79%) showed no or minimal flow signals on color Doppler flow imaging (CDFI), whereas the remaining 4 lesions demonstrated abundant flow signals. The sensitivity and specificity of the Doppler flow signals for prediction of active tumor proliferations were 100% and 94%, respectively. The ultrasonographic appearances could be classified into 4 types: multilocular (10/19, 53%), honeycomb (4/19, 21%), unilocular (3/19, 16%), and local severe destructive (2/19, 10%).
Conclusion. Ultrasonography can be used as an effective supplementary diagnostic method for mandibular ameloblastomas. CDFI of tumor vascularity could be used to predict active tumor proliferations. **(Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009;108:e32-e38)**

Ultrasonography (US) is commonly used for evaluation of soft tissue lesions in the head and neck. However, ultrasound studies of bony tissues are rare, especially for tumors of the mandible.[1] Ameloblastoma is the most common odontogenic tumor in the mandible. Based on an online literature search of PubMed from 1961 to 2008, there was no report regarding ultrasonographic study of ameloblastoma in the mandible.

Although conventional radiography, computed tomography (CT), and magnetic resonance imaging (MRI) have been predominantly used for evaluation of the mandibular lesions,[2,3] US may have potential advantages over these imaging modalities including providing real-time blood flow information of the tumor and distinguishing cystic and solid components. In addition, US is noninvasive, relatively low cost, and easy to use.[4,5]

The purpose of this study was to demonstrate the ultrasonographic characteristics of mandibular ameloblastomas and evaluate the value and potential role of US in diagnosis of the tumor.

MATERIAL AND METHODS

The study was approved by the institutional research ethics committee. All patients were fully informed of the procedure, including the techniques and any potential benefits or risks, and signed consent. From October 1999 to September 2007, 19 patients with mandibular ameloblastoma confirmed by surgery and histopathological examination were retrospectively enrolled in this study. The subjects included 10 males and 9 females with mean age of 37.8 years (range from 15 to 61). The distribution of the lesions is listed in Table I.

Ultrasonographic examinations were performed with a digital ultrasound unit with an approximately 10- to 13-MHz broadband transducer (LOGIQ 700, GE Healthcare, Milwaukee, WI). When it was necessary, an approximately 3.5- to 7.5-MHz frequency probe was used for large tumors to improve the penetration of the imaging.

[a]Attending Doctor, Department of Ultrasonography, Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai, PR China, and Visiting Scholar, Division of Oral and Maxillofacial Radiology, Temple University, Kornberg School of Dentistry.
[b]Associate Professor and Director, Division of Oral and Maxillofacial Radiology, Kornberg School of Dentistry, and Associate Professor of Radiology, School of Medicine, Temple University.
[c]Research Professor of Radiology, Division of Diagnostic Ultrasound, Department of Radiology, Thomas Jefferson University.
[d]Professor and Chief Doctor, Department of Radiology, Ninth People's Hospital, School of Medicine, Shanghai Jiao Tong University, Shanghai, PR China.
[e]Associate Professor and Director, Department of Ultrasonography, Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai, PR China.
Received for publication Jan 14, 2009; returned for revision Mar 10, 2009; accepted for publication Mar 31, 2009.
1079-2104/$ - see front matter

doi:10.1016/j.tripleo.2009.03.046

Table I. Distribution, location, and ultrasonographic and histopathologic findings of 19 mandibular ameloblastomas

Subject no./ sex/age/ right or left	*Site*	*Inner echo*	*CDFI*	*Boundary*	*Maximum dimension, cm*	*Cortical bone*	*Type*	*Active tumor proliferation*
1/M/15/L	M	Mixed*	No signal	Clear	6.5	T,C	ML	−
2/F/19/R	R	Mixed	No signal	Clear	5.8	T,C	ML	−
3/M/28/R	B	Cystic	No signal	Partially unclear	4.1	Local unclear	ML	−
4/M/35/L	R	Mixed*	No signal	Clear	5.3	T,C	ML	−
5/F/42/R	M	Mixed*	No signal	Clear	5.5	T,C	ML	−
6/M/43/L	M	Mixed*	No signal	Clear	4.6	T,C	ML	−
7/M/45/R	B	Cystic	No signal	Clear	5.1	T,C	ML	−
8/F/52	IR	Mixed	Few signal	Clear	6.2	T,C	ML	−
9/F/55	IR	Solid	Few signal	Partially unclear	2.8	Local unclear	ML	−
10/M/61/L	B	Mixed	Abundant	Clear	8.5	T,C	ML	−
11/F/38/L	M	Mixed	No signal	Clear	4.6	T,C	HC	−
12/F/39/R	R	Mixed	Few signal	Clear	5.7	T,C	HC	−
13/F/43/R	M	Mixed	Few signal	Clear	4.3	T,C	HC	−
14/M/51/L	R	Mixed	Abundant	Partially unclear	2.6	Local unclear	HC	+
15/F/27/R	M	Cystic	No signal	Clear	8.9	T,C	UL	−
16/F/29/R	M	Cystic	No signal	Clear	5.9	T,C	UL	−
17/M/36/L	M	Solid	Few signal	Clear	5.1	T,C	UL	−
18/M/25/L	M	Mixed	Abundant	Partially unclear	4.5	LSD	LSD	+
19/M/36/R	M	Solid	Abundant	Unclear	7.2	LSD	LSD	+

CDFI, color Doppler flow imaging; *M,* molar area; *R,* ramus of mandible; *B,* body of mandible; *IR,* incisor region of mandible; *Mixed**, major in cystic contend; *T,C,* thinning, continuous; *ML,* multilocular; *HC,* honeycomb; *UL,* unilocular; *LSD,* local severe destructive; −, non-active proliferation; +, active proliferation.

Patients were placed in the supine position with a pillow under the neck, to raise the jaw to expose the lesion and submaxillary region. Each lesion was scanned by use of multiple imaging sections (eg, longitudinal, transverse, and oblique) over the entire mass. The maximum dimension of the lesion was measured on the longitudinal plane. Gray-scale imaging was used to evaluate the tumor's location, size, boundary, bony septa, and internal echotexture (cystic or solid component). In addition, color Doppler flow imaging (CDFI) was used to assess the vascularity of the tumor and its surrounding tissues. Owing to the nature of the color Doppler imaging technique, blood flow signals were subjectively determined to be no, minimal, moderate, or abundant.[6] Within the sample area, in general, less than 3 pixels containing flow was considered minimal flow. If several small vessels were visualized, the blood flow was judged to be moderate. When 5 or more vessels were visualized it was classified as abundant.

The tumors were classified into 4 types as follows based on bony septa, compartment, and destruction features on sonogram and in reference to previous radiology literature[7,8]:

- Type 1: Multilocular, had many strong echo bands, and the compartments sizes varied. The compartments usually presented with elliptical shape, and ranged in cluster and superposition.
- Type 2: Honeycomb, had small compartments but similar in size with irregular bony septa. If small and large compartments coexisted and the small ones were in the majority, the tumors belonged to honeycomb type, otherwise they were classified into the multilocular type.
- Type 3: Unilocular, had no bony septum echo band inside and a clear boundary was observed.
- Type 4: Local severe destructive, showed local invasion of the bony matrix with uneven internal echoes, with unclear boundaries.

All 19 subjects underwent surgical intervention for tumor resections. The ultrasonographic results and features were compared with histopathological findings. The tumor infiltration and local destruction indicating active tumor proliferation and high recurrences of the tumor were observed in the pathologic examination. The histological findings of "active tumor proliferation" included active karyokinesis, nuclear staining deepened, but without malignant karyokinesis. The sensitivity and specificity of the Doppler flow imaging for prediction of active tumor proliferations were analyzed. In addition, the sensitivity and specificity of the destruction of cortical bones on ultrasonogram for prediction of active tumor proliferations were also calculated.

RESULTS

All the mandibular ameloblastomas were clearly depicted using ultrasonography. The ultrasonographic findings are listed in Table I. There were 9 tumors located in the right side, 8 in the left side, and 2 in the

Table II. The sensitivity and specificity of the Doppler flow signal on CDFI for prediction of active tumor proliferations in histopathology

	Active proliferation	*Non-active proliferation*
Abundant flow signal on CDFI	3	1
No or few flow signal on CDFI	0	15
Total	3	16
Sensitivity (%)	3/3 (100)	
Specificity (%)	15/16 (94)	

CDFI, color Doppler flow imaging.

Table III. The sensitivity and specificity of the destruction of cortical bone on ultrasonogram for prediction of active tumor proliferations in histopathology

	Active proliferation	*Non-active proliferation*
Destruction of cortical bone	3	2
Continuity of cortical bone	0	14
Total	3	16
Sensitivity (%)	3/3 (100)	
Specificity (%)	14/16 (88)	

incisor region of the mandible. Among them, 12 (63%) lesions located in the molar areas and the rami of the mandibles. There were 4 (21%) cystic, 3 (16%) solid, and 12 (63%) mixed tumors. The mean maximum dimension of these tumors was 5.4 cm and the values ranged from 2.6 to 8.9 cm.

CDFI showed that 15 (79%) ameloblastomas had no or minimal blood flow signals, whereas the remaining 4 lesions demonstrated abundant flow signals, in which 2 were shown on US with local severe destruction and 3 were confirmed histopathologically with active tumor proliferations. The sensitivity and specificity of the Doppler flow signals for prediction of active tumor proliferations were 100% and 94%, respectively (Table II).

Ultrasound imaging demonstrated ameloblastomas with continuous thin mandibular cortices in 14 patients (74%). Ten of 14 appeared as eggshell structures. In the remaining 5 (26%) lesions with destruction of cortical bone, 2 were observed with severe local bony destruction and 3 with active tumor proliferation on pathologic findings. The sensitivity and specificity of the destruction of cortical bone for prediction of active tumor proliferation were 100% and 88%, respectively (Table III).

The multilocular type is the most common in this series (Fig. 1, *A*). It accounted for 10 subjects (53%), whereas the honeycomb type accounted for 4 tumors (21%) (Fig. 2, *A*). Three tumors (16%) were the unilocular type without septa inside and clear boundaries (Fig. 3, *A*). Those features showed on US were similar with the panoramic characteristics (Fig. 1, *B*, Fig. 2, *B*, and Fig. 3, *B*). Two tumors (10%) belonged to the local severe destructive type, which appeared with unclear boundaries and heterogeneous internal echoes (Fig. 4, *A*); active tumor proliferation was confirmed by histopathological findings (Fig. 4, *B*).

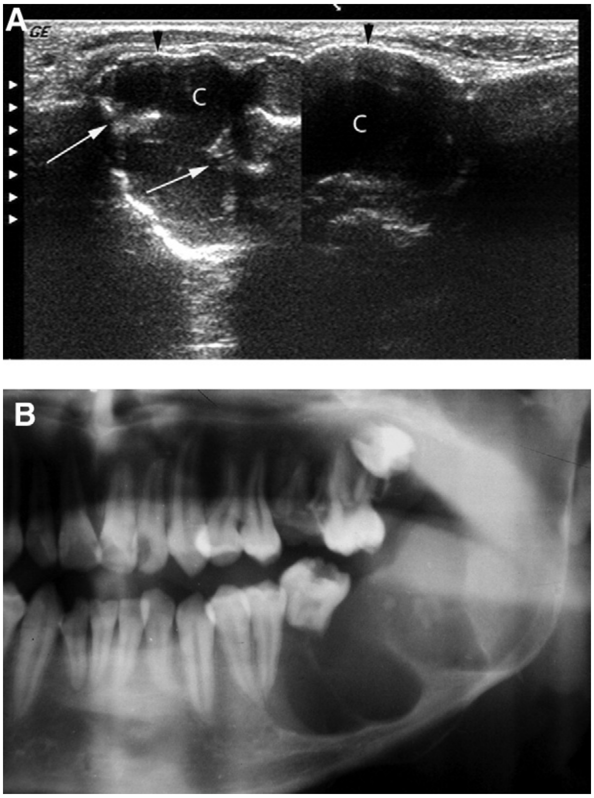

Fig. 1. Subject 1: Multilocular. US (**A**) showed internal bony septa (*arrows*), visualized as strong echo bands; the size of compartments (C) is big and different; the bone cortex appeared as thinning eggshells (*arrowheads*). Panoramic radiography (**B**) showed it was multilocular and the boundary was clear.

DISCUSSION

Ultrasonic imaging of bone is usually limited to show bone surfaces and contours, rather than internal structures. The reason is ultrasound waves in the diagnostic frequency range are often reflected on the normal bony surfaces. Therefore, the ultrasonic examinations for bony structures did not attract clinical attention before. However, when a neoplasm occurs, the mandible is compressed and the cortical bone thins, and the ultrasound beams are then able to penetrate the mandible. In the current study all ameloblastomas in the mandible were clearly depicted on US, which indicated that US might be useful in diagnosing mandibular le-

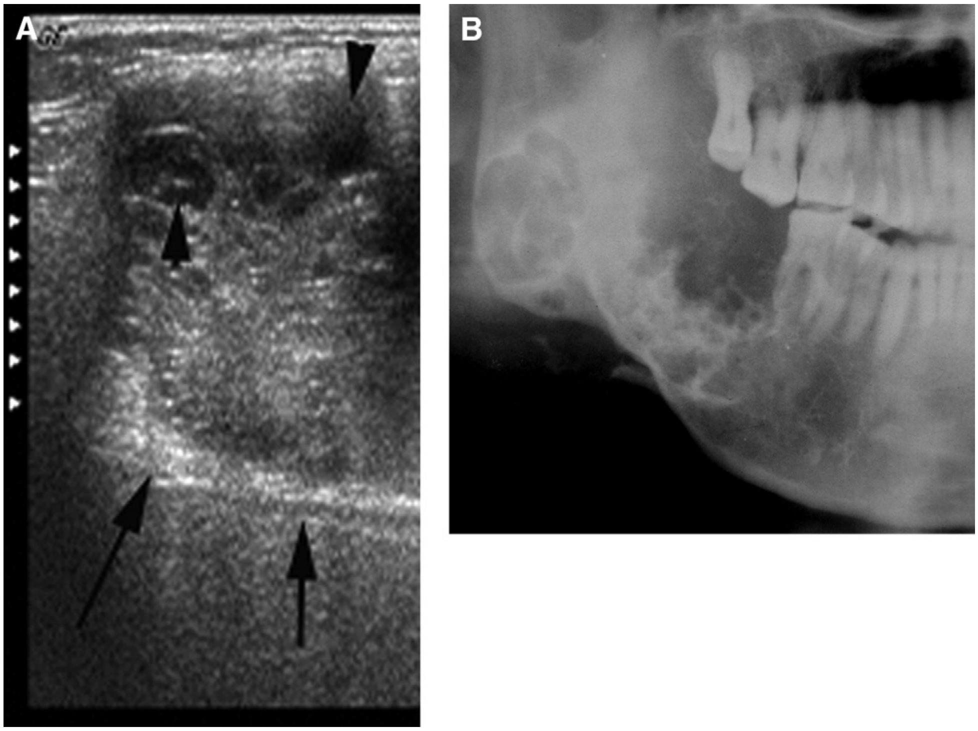

Fig. 2. Subject 12: Honeycomb. US (**A**) showed the compartments (*arrowheads*) of the tumor were small and nearly similar in size and honeycomblike; the boundary (*arrows*) of the tumor is clear. Panoramic radiography (**B**) showed the compartments were honeycomblike as well.

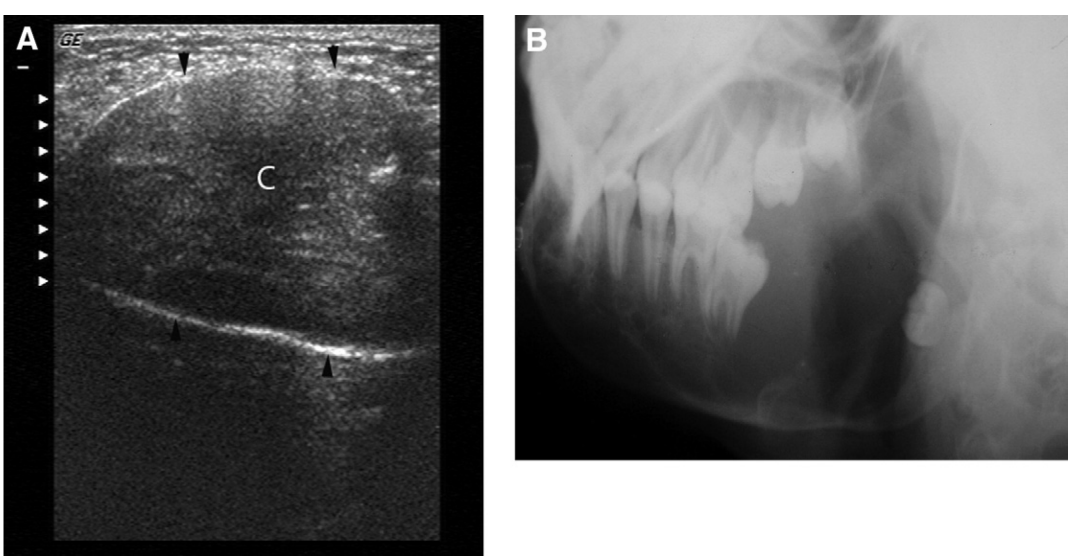

Fig. 3. Subject 17: Unilocular. US (**A**) showed internal echo of the tumor, which showed mainly on solid content; there is no obviously bony septa inside the compartment; the boundary of the tumor is clear (*arrowheads*). The unilocular was observed with panoramic radiography and the lesion's boundary is clear (**B**).

sions, especially those common odontogenic tumors, such as ameloblastomas.

In this study, the mandibular ameloblastomas were all single lesions (19/19, 100%), often located in the molar and ramus areas (12/19, 63%). The tumors had thinning but continuous cortices (14/19, 74%). These features were similar to clinical and other imaging modality (radiography, CT, or MRI) findings in the

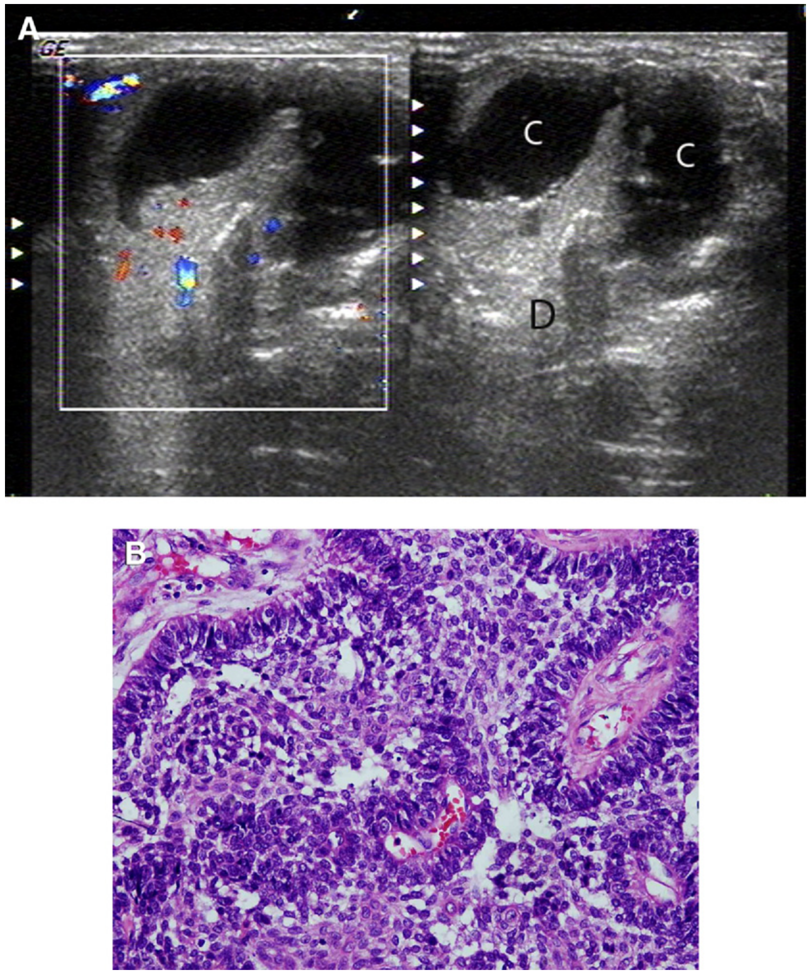

Fig. 4. Subject 18: Local severe destructive. US (**A**) showed the mandible is severely destroyed in the depths of the tumor (D area). In this area, the boundary is not clear and the color Doppler flow signals are abundant on CDFI. The microscopic evaluation (**B**) showed active karyokinesis, nuclear staining deepened, but without malignant karyokinesis (hematoxylin-eosin stain; ×400).

previous literature.[2,3,7-9] However, unlike the other imaging modalities, US is able to distinguish cystic and solid tumors. Most of the tumors in this series had mixed cystic and solid contents (16/19, 84%), and 4 of them were completely cystic. Histologically these tumors usually contain numerous follicular cells.

Although ameloblastomas are benign tumors, some of them have a trend toward malignancy with a high rate of recurrence, possibly with distant metastasis if not treated adequately.[10-15] Therefore, it is crucial to know the tumor proliferation activities or invasive potentials before surgery. In this study, it was found that the blood flow signals detected on CDFI were related to the tumor proliferations in histopathology. Three lesions (3/3, 100%) with active tumor proliferations in biopsy demonstrated abundant blood flow signals on CDFI. In the lesions of local severe destructive type, CDFI showed that the blood flow signals were strong in the areas with bony matrix destruction. However, this US characteristic did not show on most subjects without active proliferation (Fig. 5). The sensitivity and specificity of the CDFI in predicting active tumor proliferation were 100% and 94%, respectively. This shows a unique value of US in terms of diagnosis of benign tumors in the mandible when compared with other imaging modalities. In addition, the destruction of cortical bones could also predict active tumor proliferation. The sensitivity and specificity in the series were 100% and 88%, respectively.

According to the bony septum, compartment size, and destruction features, 4 different types of ultrasonic appearances of the tumors were classified in this study: multilocular, honeycomb, unilocular, and local severe destructive. The occurrences of these types were 53%, 21%, 16%, and 10%, respectively. The ratio of the unilocular ameloblastoma in this study was lower than

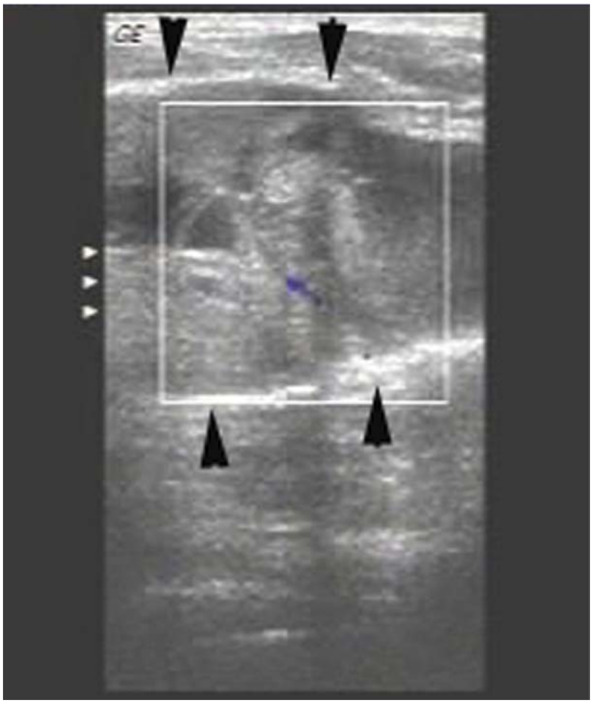

Fig. 5. Subject 8: Minimal color Doppler flow signal. CDFI showed minimal color Doppler flow signal within the sample area. The boundary of the tumor is clear (*arrowheads*).

those studies conducted among non-Asian populations[7,8,16]; however, it is close to other Asian population studies.[2,17] Therefore, different races may have slightly different appearances of ameloblastomas.

Previous literature suggests that tumors with unilocular appearance should be treated more conservatively (ie, with enucleation, curettage, or both) than other types of ameloblastomas.[7,8,18] So these classifications with US may aid surgeons in properly approaching lesions. When compared with histopathological findings, all lesions in the local severe destruction type (2/2, 100%) were found with active tumor proliferations, with one invading the buccal mucous membrane. Therefore, if the local severe destruction appearances were observed on US, especially with abundant blood flow signals on CDFI, a more aggressive surgical approach should be performed.

Panoramic radiography, CT, and MRI are the existing imaging modalities for assessment of mandibular ameloblastomas; however, none show the real-time blood flow information within the tumor. US, as a noninvasive imaging modality, has no ionizing radiation, and can easily be repeated. It shows the real-time blood flow signals on CDFI, which can be used to determine the active proliferation of the tumor. US can also distinguish cystic from solid contents in the tumor. US has its limitations, however. If the tumor is too small and the cortex of bone is not thinning, it will be hard to detect. If the tumor is too large, it cannot be observed all-around by high-frequency (10 MHz) ultrasound and the size of the tumor could be measured smaller than it actually is. At times a lower frequency (3.5 MHz) US probe might be needed to examine the tumor.

CONCLUSION

This preliminary study showed ameloblastomas could be depicted with US. Blood flow signals on CDFI might be used to predict activities of tumor proliferation. The local severe destruction type of ameloblastomas with abundant blood flow signals on CDFI indicates active tumor proliferation and should be treated more aggressively. US has the potential to be an effective supplementary diagnostic method for mandibular odontogenic tumors.

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Reprint requests:

Jie Yang, DDS, MMS, MS, DMD
Division of Oral and Maxillofacial Radiology
Department of Oral and Maxillofacial Pathology, Medicine, and Surgery
Temple University Kornberg School of Dentistry
3223 N. Broad Street
Philadelphia, PA 19140
jyang@dental.temple.edu