Review paper

Cite as: Delantoni A, Sarafopoulos A, Giannouli N, Rafailidis V: Maxillofacial inflammations visualized with ultrasonography. Description of the imaging features and literature review based on a characteristic case series. J Ultrason 2023; 23: e80–e89. doi: 10.15557/JoU.2023.0015.

Submitted: 13.12.2022
Accepted: 12.01.2023
Published: 28.04.2023

Maxillofacial inflammations visualized with ultrasonography. Description of the imaging features and literature review based on a characteristic case series

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DOI: 10.15557/JoU.2023.0015

Keywords

maxillofacial ultrasound; maxillofacial inflammation; facial ultrasonography

Abstract

Objectives: Inflammations of the maxillofacial regions are a frequent occurrence. They areusually of odontogenic origin, but maxillofacial swelling could also have non-odontogenic causes. Their clinical presentation is worrisome for the patient, presenting as swellings of the region with rapid and significant expansion to adjacent areas due to the thin and delicate nature of the regional soft tissues. **Materials and methods:** The characteristic features are discussed upon the presentation of a case series of the most common types of inflammation seen in the region. **Results:** In most hospital emergency departments, ultrasound scanning is readily accessible, and typically constitutes the first-line imaging modality for this entity. Nevertheless, the role of ultrasound imaging is limited in cases with deep extension of the inflammation, where cross-sectional imaging with CT or MRI will be the modality of choice. This manuscript aims to present the characteristic features of various inflammatory conditions of the maxillofacial area seen on ultrasonography. **Conclusions:** Even though maxillofacial inflammations are often treated without imaging in their initial phase, ultrasound can provide aninexpensive, easy-to-use, and readily available alternative that best visualizes the characteristics and expansion patterns of the lesions, based on their origin and area of initial presentation.

Introduction

Maxillofacial infections represent a significant proportion of daily dental problems. Typically, inflammatory dental conditions are limited to the osseous structures of the jaws. However, a significant number of infections may also expand to the adjacent soft tissues of the region[1]. The differential diagnosis of a soft tissue infection and the determination on whether it is an abscess (fluctuance) or cellulitis may be difficult clinically, but it is very important, as the conditions require different treatments[2–4]. Swelling spreading through the adjacent soft tissue and dissecting tissue spaces along adjacent fascial planes is considered to be diffuse swelling or cellulitis[5]. Frequently, the two conditions coexist, as an abscess often begins as cellulitis. Accurate diagnosis may be difficult, and may lead to missed abscesses and/or unnecessary invasive procedures. In the literature, there have been numerous papers on the differentiation of both conditions with the use of ultrasonography, however there are few reports on the inflammation expansion pattern. The aim of this study is to review the literature on the applications of ultrasonography in the assessment and differential diagnosis of odontogenic infections and their ultrasound imaging characteristics in the facial region. The topicis of high significance, since in many cases odontogenic infections spread to facial structures and tissues, and can be easily misdiagnosed by doctors of many specialties.

Materials and methods

Within a two-year timeframe, various cases of maxillofacial infections and abscesses were retrospectively collected from the Department'sdatabase, to review and analyze their imaging characteristics and expansion patterns with ultrasonography (US). Even though many were of odontogenic origin (27 in number), there were additional 14 cases that originated fromsalivary gland inflammation.

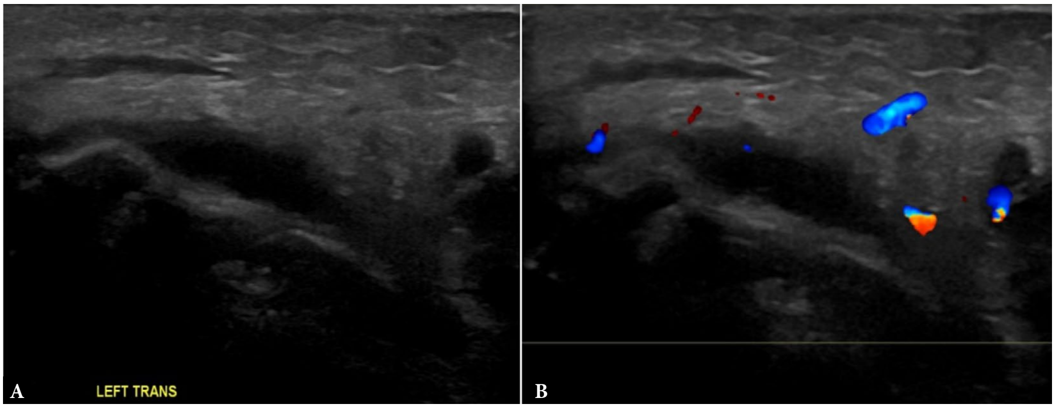


Fig. 1. *Periapical abscess. B-mode (**A**) Transverse view of the left buccal region shows a well-defined anechoic cavity with thickened hypoechoic wall of ill-defined borders, adjacent to the mandible. Color Doppler (**B**) No internal blood flow within the cavity, with vascularity of the surrounding tissue*

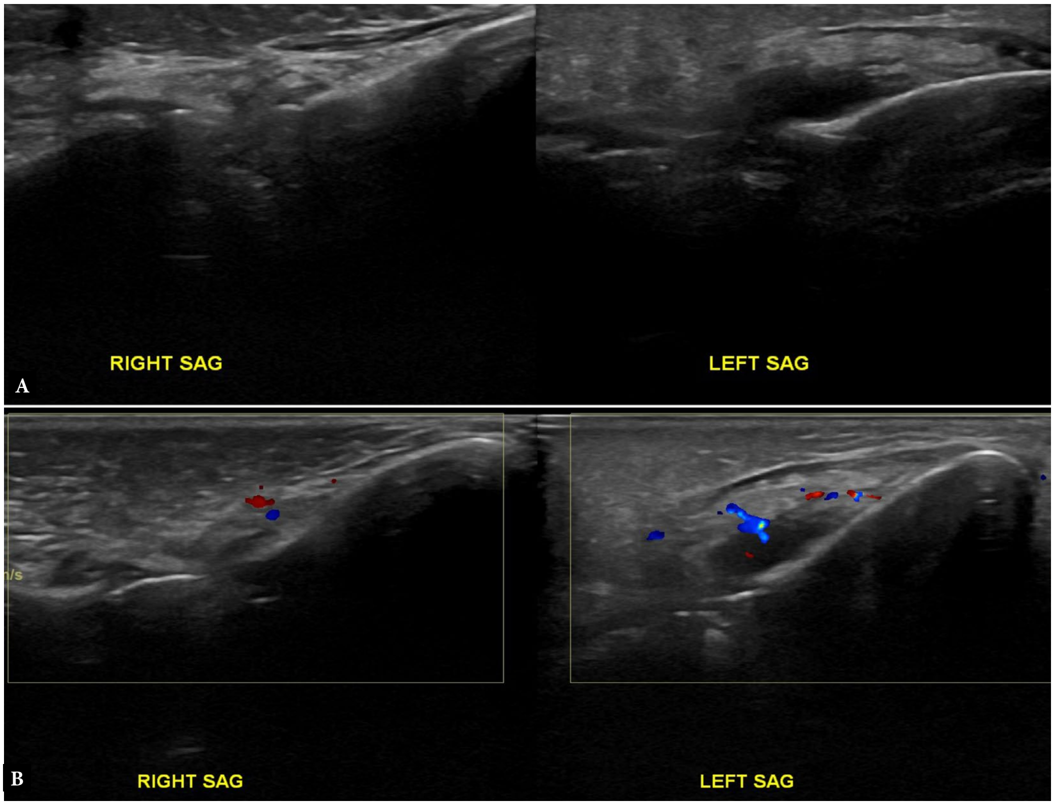


Fig. 2. *Comparison with the normal contralateral side. B-mode (**A**) Sagittal scans of the same area on both sides demonstrating aperiapical abscess on the left. Color Doppler (**B**) Increased vascularity of the surrounding inflammatory tissue. Note the appearance of adjacent subcutaneous tissues, which are more hyperechoic, and the loss of differentiation on the left due to edema from associated cellulitis*

This can be easily differentiated with US, and the various imaging features of odontogenic and non-odontogenic infections of the maxillofacial region are analyzed based on a number of characteristic cases.

Case 1. Odontogenic abscess

Case 1 shows a characteristic clearly seen in odontogenic infections which, if not treated properly, can spread into the surrounding tissues. More specifically, through the periradicular tissues it can extend to the fascial spaces, which can be classified as primary maxillary spaces, primary mandibular spaces, and secondary fascial spaces. As the inflammatory infiltration spreads, it can lead to cellulitis and ultimately progress to the formation of an abscess. In this particular case, the infection spread to the buccal vestibular space, one of the primary mandibular spaces, and resulted in the formation of an abscess (Fig. 1, Fig. 2). The presence of the abscess cavity and the thickening-distortion of the subcutaneous tissues, which are indicative of cellulitis, suggests that they may represent different stages of infection, but their coexistence should be expected.

Case 2. Intraparotid abscess

Case 2 shows an infection of the parotid gland which most frequently arises from ascending infection via Stensen's duct, or from bacteremia or viremia. The most common pathogen associated with acute bacterial parotitis and head and neck abscesses is *Staphylococcus aureus*, both in adults and pediatrics patients. In most cases, sonography is considered the first-line imaging technique for the evaluation of the parotid gland. This is because, thanks to its superficial position, most parts are easily accessible, and only a little portion of the parotid gland may be hidden by the acoustic shadow of the mandible. If combined with color Doppler, sonography is important not only in the diagnostic work-up, but also in the evaluation of therapeutic efficacy and as a guide to the aspiration and drainage of abscesses (Fig. 3, Fig. 4). In many cases wherethe inflammation expands to adjacent tissues, the lymph nodes of the adjacent area might be affected, as seen in the case shown in Fig. 5.

Case 3. Cervical abscess

This is a patient with inflammation spreading to the neck, with cellulitis of the region. Soft tissue infection is a common clinical problem, and US is a low-cost imaging modality that can guide therapeutic decisions. Cellulitis can be effectively treated with antibiotics, but the formation of an abscess may require drainage, either surgical or image-guided. On US, early in the process of cellulitis, the skin and subcutaneous tissue appear thickened and hyperechoic because of the inflammatory infiltration. Also, the differentiation of the subcutaneous tissue is lost, and the normal hypoechoic regions with the hyperechoic septations of the adipose tissue cannot be visualized. At a later stage, there may be interdigitating reticular strands of hypoechogenicity representing interstitial inflammatory exudate, also known as the "cobblestone" pattern. As the inflammatory process evolves, there may be a transitional stage where the tissues become mixed in echogenicity (hypoechoic and hyperechoic), indicating the end of the cellulitis and the onset of abscess formation, though the two conditions coexist in many cases, This is clearly seen in this case (Fig. 6) where there is a clear multilobulated anechoic lesion with relatively well defined borders, viscous content, internal debris and acoustic enhancement. The development of an associated abscess, as in this case, is an important finding to diagnose. Abscesses can have a variable appearance on ultrasound. An abscess border may be either well-defined or ill-defined and infiltrative. There may also be a surrounding rim of hyperemic, thickened soft tissue. The internal liquefied material may demonstrate an anechoic, hypoechoic, or complex echogenic appearance, with internal septations and low-level echoes. Foci of echogenic gas, with associated ill-defined shadowing and reverberation artifacts, may be present within the abscess. Dynamic compression of the abscess induces swirling of the echogenic debris.

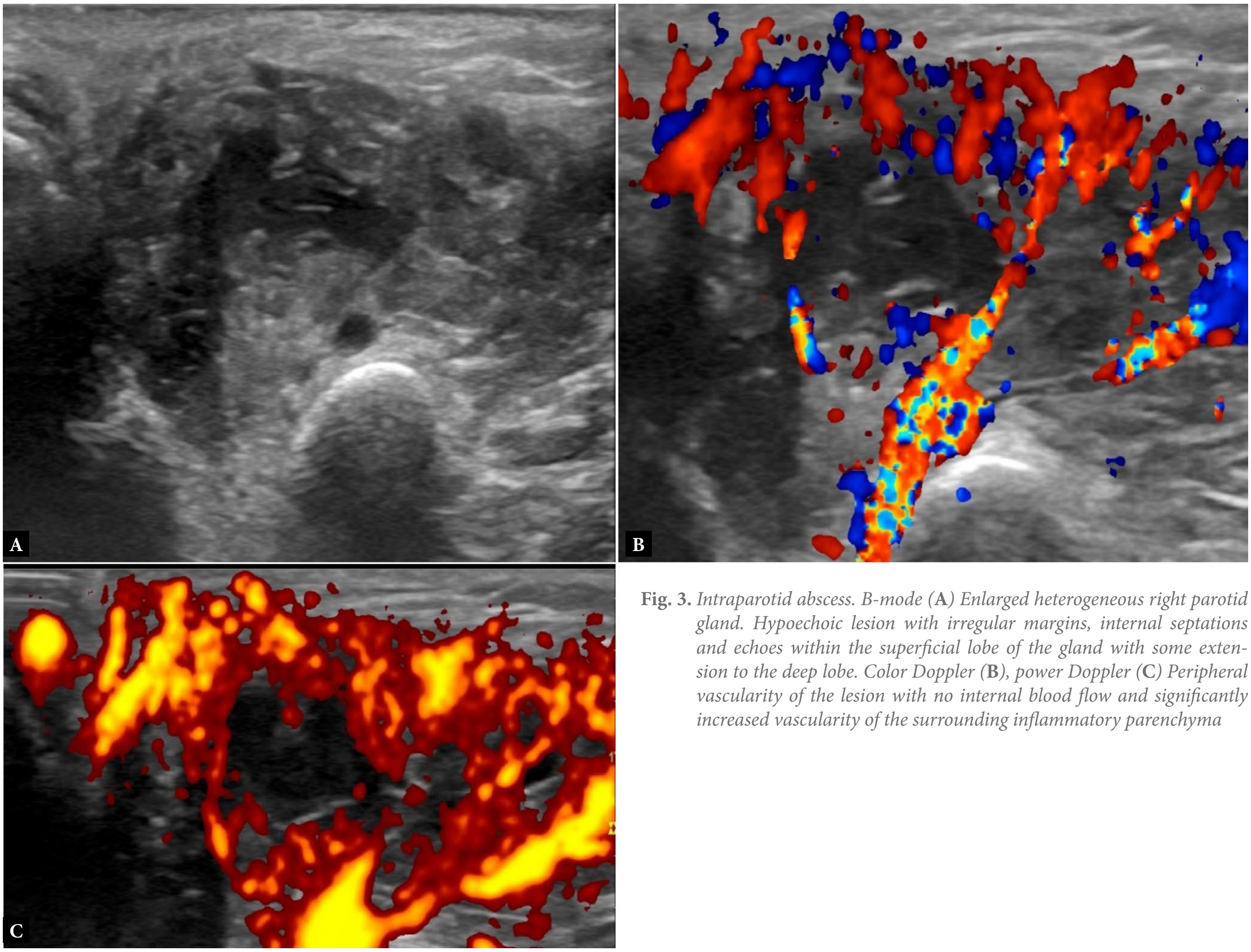


Fig. 3. *Intraparotid abscess. B-mode (***A***) Enlarged heterogeneous right parotid gland. Hypoechoic lesion with irregular margins, internal septations and echoes within the superficial lobe of the gland with some extension to the deep lobe. Color Doppler (***B***), power Doppler (***C***) Peripheral vascularity of the lesion with no internal blood flow and significantly increased vascularity of the surrounding inflammatory parenchyma*

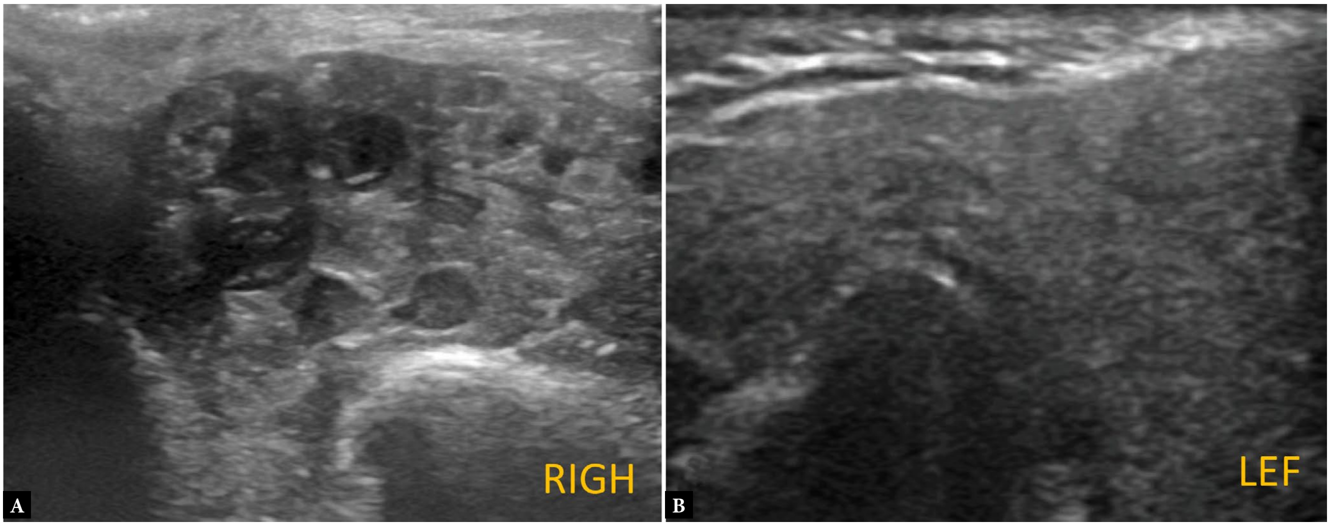


Fig. 4. *Comparison with the normal contralateral side. B-mode (***A***) Right parotid gland with intraparotid abscess. B-mode (***B***) Left normal parotid gland. Note the heterogeneity and increased size of the right parotid gland in comparison with the left, but also the thickening and distortion of the surrounding subcutaneous tissue. On the left side, the subcutaneous tissues are more hypoechoic, with normal hyperechoic septations within the adipose tissue*

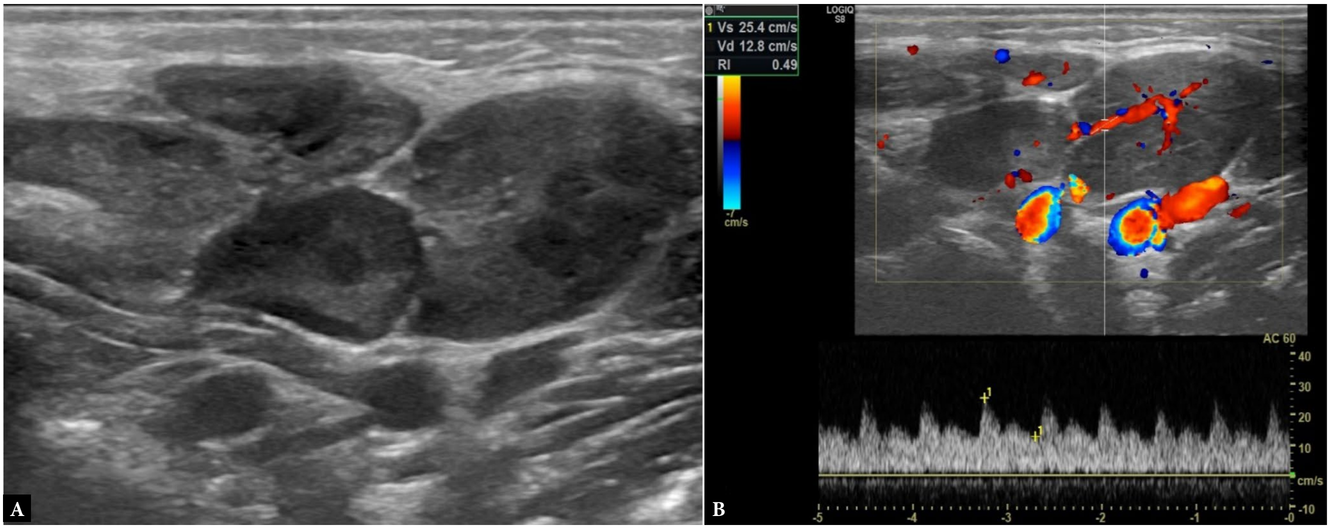


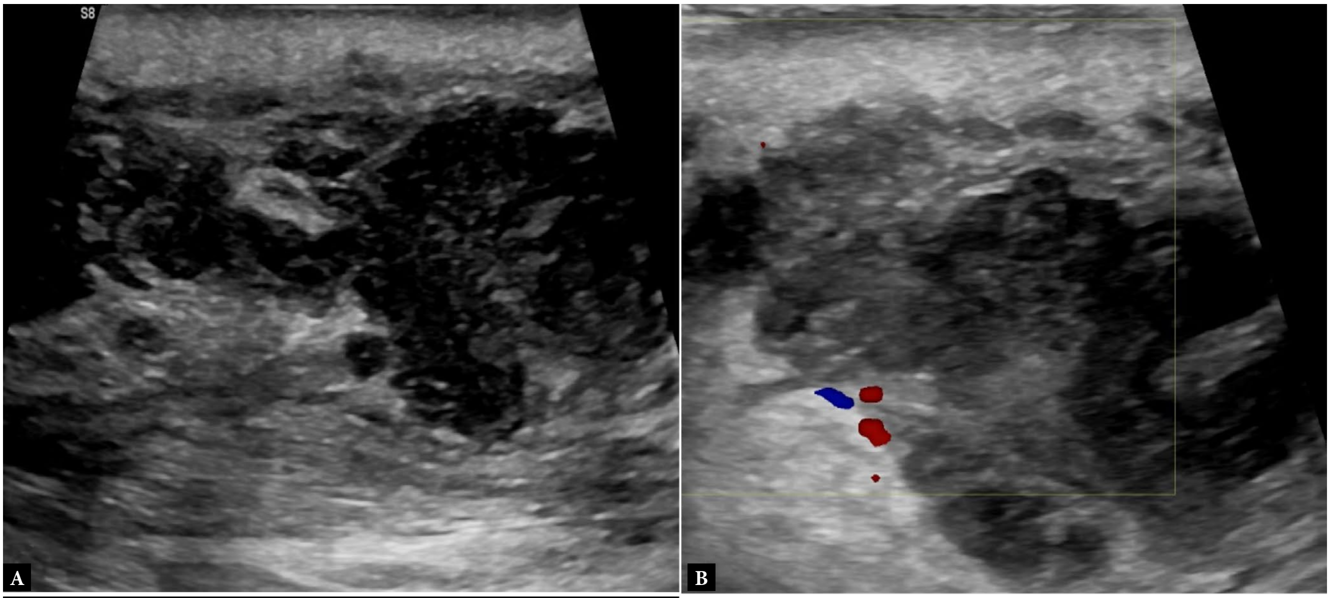
Fig. 5. *Adjacent cervical lymphadenopathy. B-mode (***A***) Enlarged hypoechoic lymph nodes with oval shape and an echogenic hilus. Spectral Doppler (***B***) These reactive lymph nodes show hilar vascularity with low resistance index (RI) of 0.49*

Case 4. Odontogenic abscess in submandibular region

Odontogenic abscess in the submandibular region presenting as a hypoechoic heterogeneous lesion without a clear content and with ill-defined/infiltrative borders. The lesion extends from the surface of the mandible to the surface of skin. Color Doppler in the second image shows no blood flow within the lesion, but an increased vascularity of the surrounding tissues and two reactive lymph nodes next to it (level IB) as seen in Fig. 7 and Fig. 8. Looking at Fig. 8, it should be noted that the hypoechoic lesion is in direct contact with the cortex of the mandible, causing small bony deficits and a characteristic cobblestone pattern.

Case 5. Intraparotid abscess

An intraparotid abscess which presents as an anechoic lesion with an irregular shape, as expected in inflammatory conditions. The lesion shows varying internal echoes and echogenicity within the right parotid gland. Note the heterogeneity of the gland and the hyperechoic adjacent subcutaneous tissue (Fig. 9). The abscess appears as a characteristically anechoic cavity with internal debris, as seen in Fig. 10, while the use of color Doppler (Fig. 10B) revealsno internal blood flow and peripheral hyperemia. The same lesion shows the adjacent lymph nodes which, with the use of spectral Doppler, demonstrate vascularity with a low resistance index (RI) of 0.5 (Fig. 10, Fig. 11).



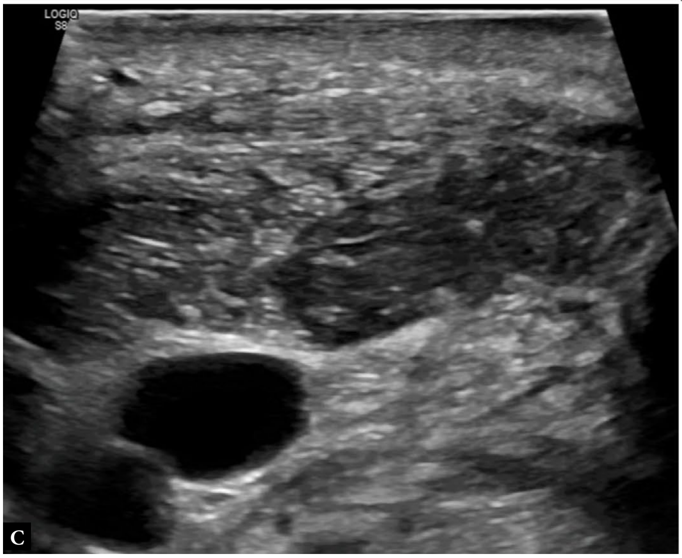


Fig. 6. *Cervical abscess. B-mode (***A***) Multilobulated anechoic lesion with relatively well-defined borders, viscous content, internal debris and acoustic enhancement. Hypoechoic appearance of the circumjacent tissue. Color Doppler (***B***) No internal blood flow within the abscess cavity. B-mode (***C***) Heterogeneous appearance and thickening of the muscles, representing myositis. Hyperechoic subcutaneous tissue with hypoechoic striations, indicating adjacent cellulitis*

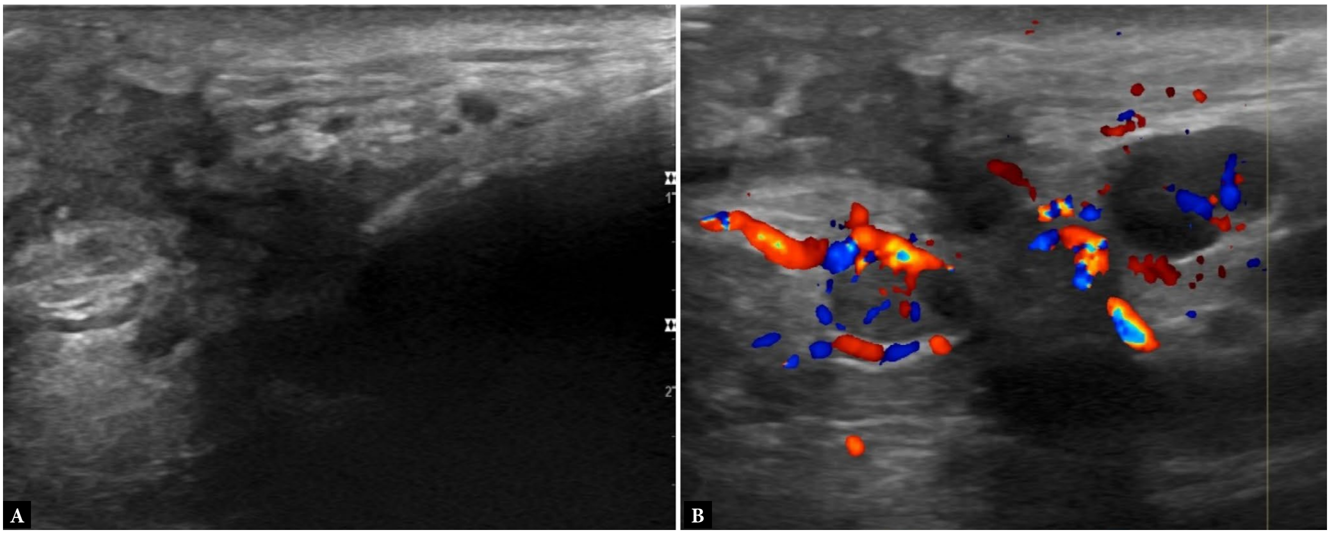


Fig. 7. *Odontogenic abscess in the submandibular region. B-mode (***A***) Hypoechoic heterogeneous lesion with ill-defined/infiltrative borders. The lesion extends from the surface of the mandible to the surface of skin. Color Doppler (***B***) No blood flow within the lesion, increased vascularity of the surrounding tissue and two reactive lymph nodes next to it (level IB)*

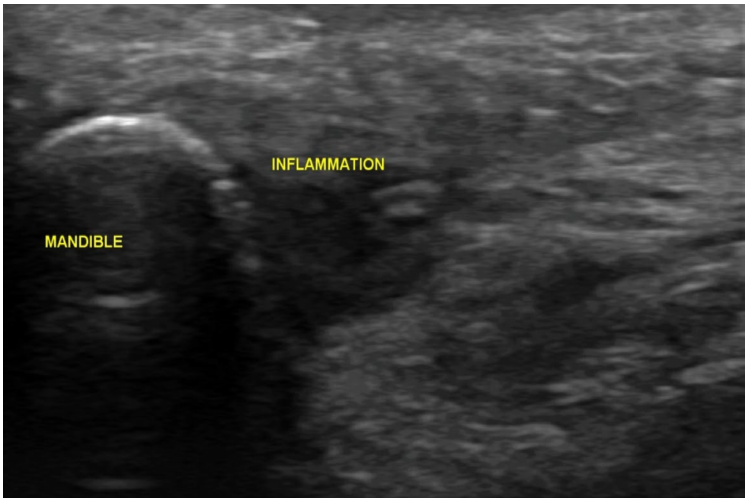


Fig. 8. *Bone involvement. The hypoechoic lesion is in direct contact with the cortex of the mandible, forming small bony deficits*

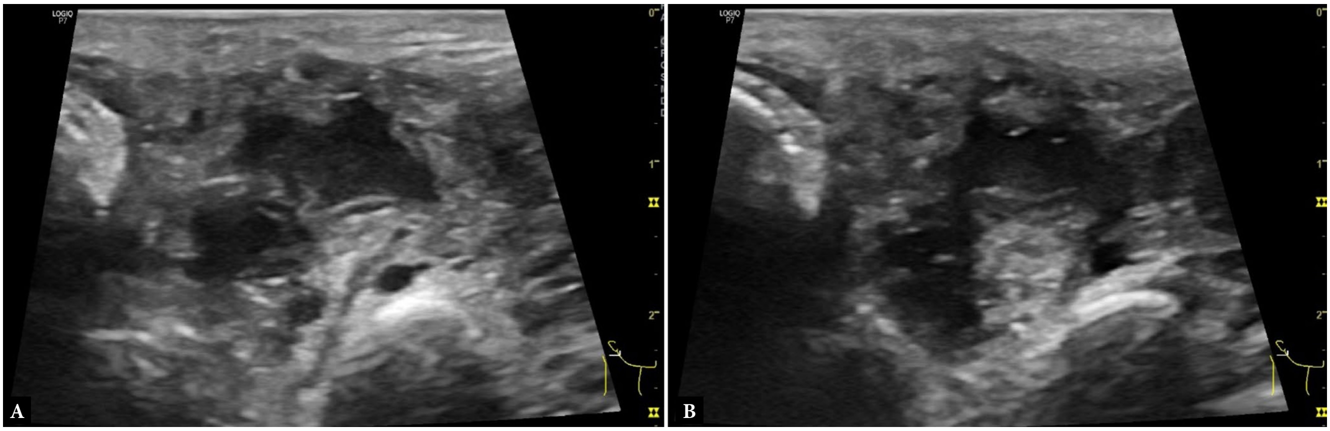


Fig. 9. *Intraparotid abscess. B-mode (**A**, **B**) Anechoic lesion with irregular shape, ill-defined borders and internal echoes within the right parotid gland. Note the heterogeneity of the gland and the hyperechoic subcutaneous tissue*

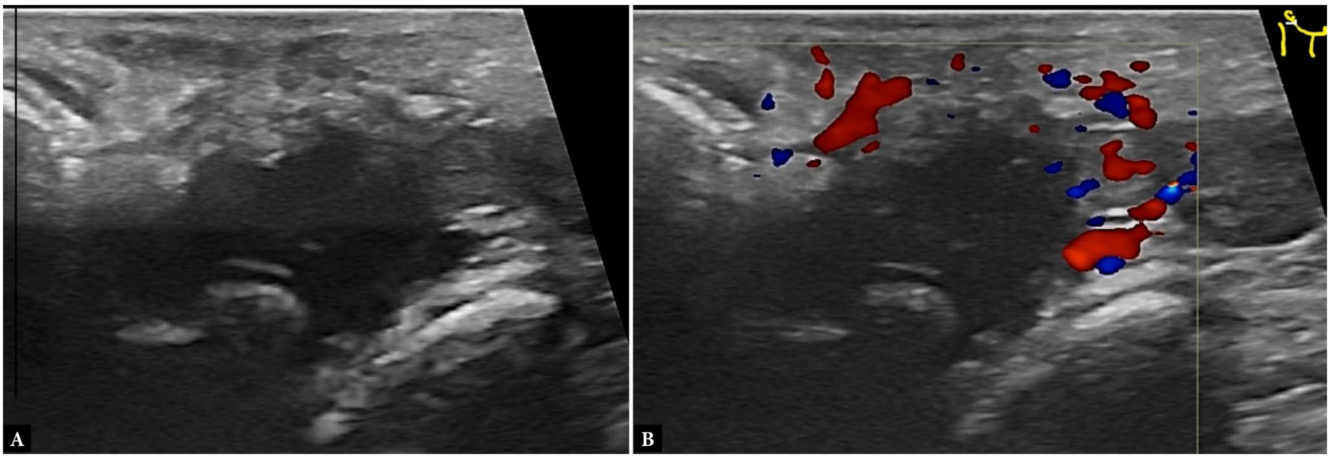


Fig. 10. *Intraparotid abscess. B-mode (**A**) Anechoic cavity with internal debris represents the abscess. Color Doppler (**B**) No internal blood flow and peripheral hyperemia*

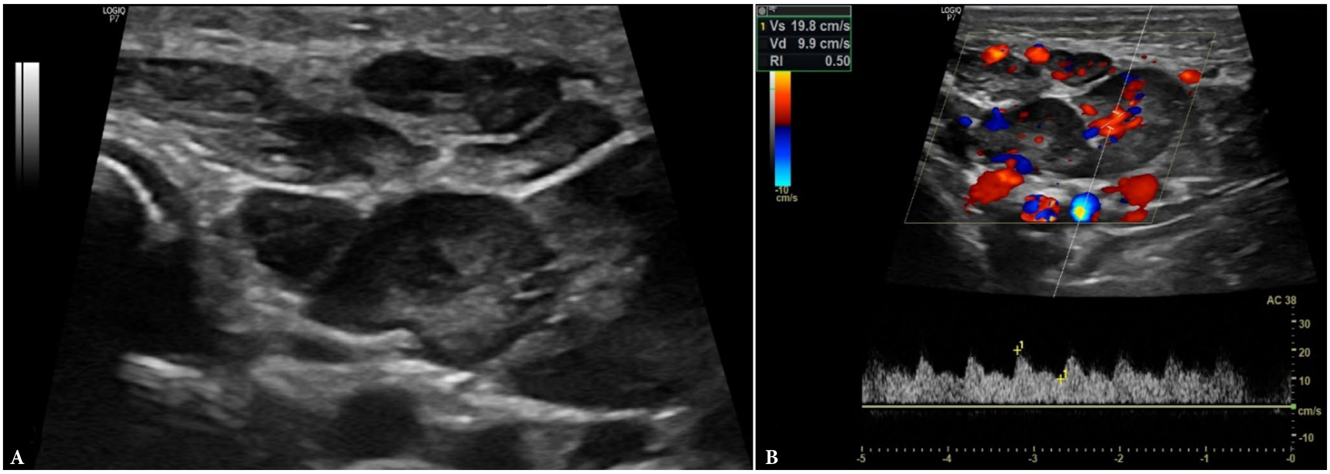


Fig. 11. *Adjacent cervical lymphadenopathy. B-mode (***A***) Multiple hypoechoic lymph nodes ipsilateral to the intraparotid abscess. Spectral Doppler (***B***) These reactive lymph nodes have oval shape and hilar vascularity with low resistance index (RI) of 0.5*

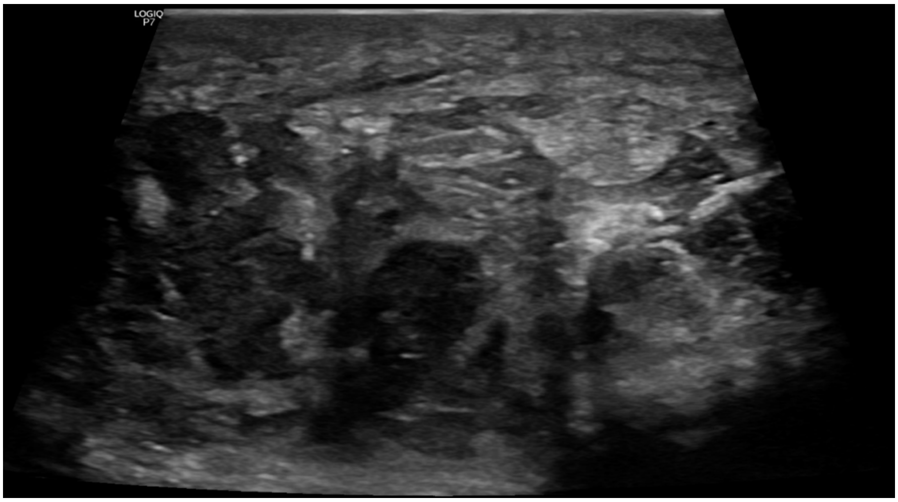


Fig. 12. *Maxillary abscess. B-modeshows a large hypoechoic multiloculated mass with viscous content and internal debris. The inflammation extends to the surrounding soft tissues, causing a distorted echotexture. Hyperechoic appearance and hypoechoic striations seen in the subcutaneous tissues, indicating cellulitis*

Case 6. Maxillary abscess

Case 6 presents a case of maxillary abscess, appearing on B-mode ultrasound as a large hypoechoic multiloculated mass with viscous content and internal debris. The inflammation extends to the surrounding soft tissues with distorted echotexture. Hyperechoic appearance and hypoechoic striations in the subcutaneous tissues, indicative of cellulitis, are characteristic features. In these cases, US was used to identify and characterize the infection of soft tissues. B-mode imaging modality can show the extent, maturity, and structural features such as loculations (potential internal chambers) and internal content. Color and power Doppler can establish the presence of blood flow in the lesion and surrounding tissues. New techniques are also being studied for their potential contribution to the accurate diagnosisof the stage of soft-tissue infections. Contrast-enhanced ultrasound (CEUS) has been used to distinguish between inflammatory tissue that may represent early infection (phlegmons), and fully developed mature abscesses by measuring the level of enhancement within the infected tissue. Full enhancement within the tissue signifies a phlegmon (cellulitis), while the lack of internal enhancement is a sign of a mature abscess containing potentiallydrainable fluid. Elastography has also been reported as a potential modality to diagnose and characterize abscesses (Fig. 12, Fig. 13)[6,7].

Case 7. Intraparotid abscess with sialolithiasis

Case 7 demonstrates the final type of characteristic inflammation of the maxillofacial region, namely the intraparotid abscess with sialolithiasis. In such cases, the use of B-flow US shows a hypoechoic heterogeneous intraparotid mass located in the deep lobe of the right parotid gland, with poorly defined margins, thick internal echoes and hyperechoic foci representing small stones (microlithiasis). In the present case, there is an enlarged right parotid gland with moderately dilated ducts and edematous appearance of Stensen's duct (Fig. 14 and Fig. 15).

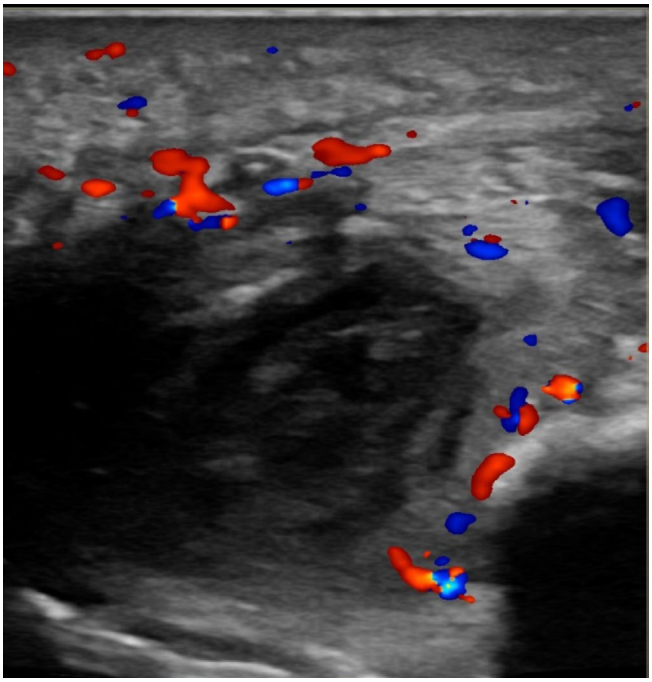


Fig. 13. *Maxillary abscess. Color Doppler shows no internal blood flow with increased vascularity of the surrounding tissue*

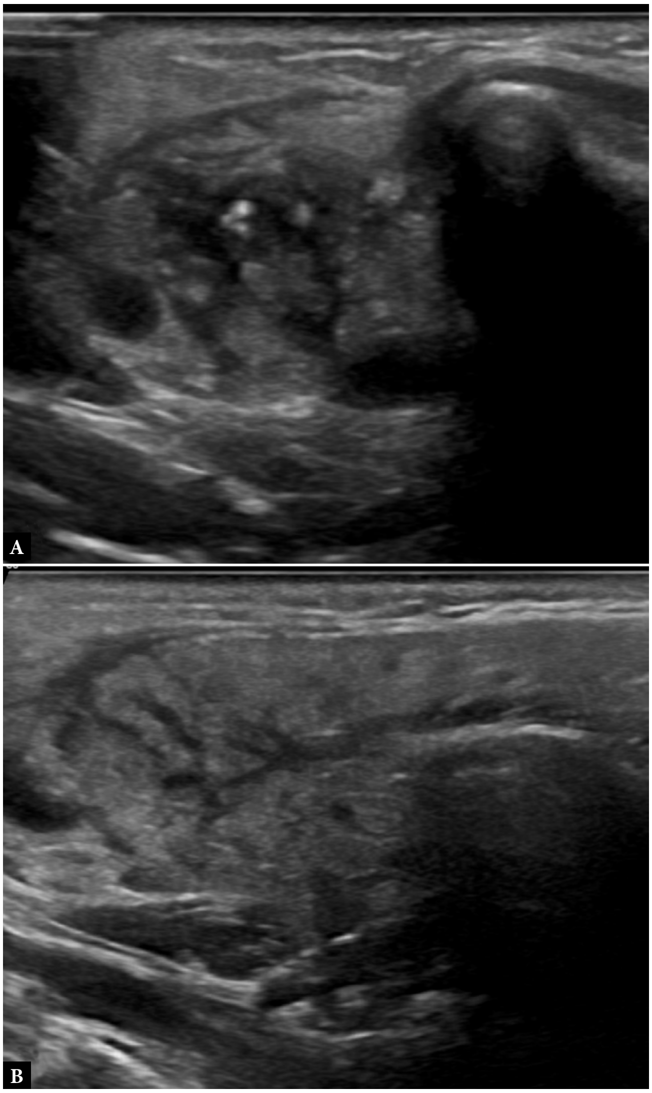


Fig. 14. *Intraparotid abscess with sialolithiasis. B-mode (***A***) Hypoechoic heterogeneous intraparotid mass located in the deep lobe of the right parotid gland. It has poorly defined margins, thick internal echoes and hyperechoic foci representing small stones (microlithiasis). B-mode (***B***) Enlarged right parotid gland with moderately dilated ducts and edematous appearance of Stensen's duct*

Discussion

Clinically, there are differences between cellulitis and an abscess, relating primarily to the appearance of fluctuance in the latter case. Cellulitis is the initial presentation of an infection and it is an acute process. An abscess, while also acute, is often considered to be the evolution phase of clinical swelling. The standard criterion for determining the presence of an abscess in patients clinically is the demonstration of pus and the formation of a fluctuant point. Also, the pain described by patients with cellulitis tends to be more severe and generalized than the localized pain associated with an abscess[6–8]. Numerous studies have established the differential diagnostic features of maxillofacial infections.

It has been suggested both in the medical and dental literature that US can help establish the diagnosis of swelling and determine the

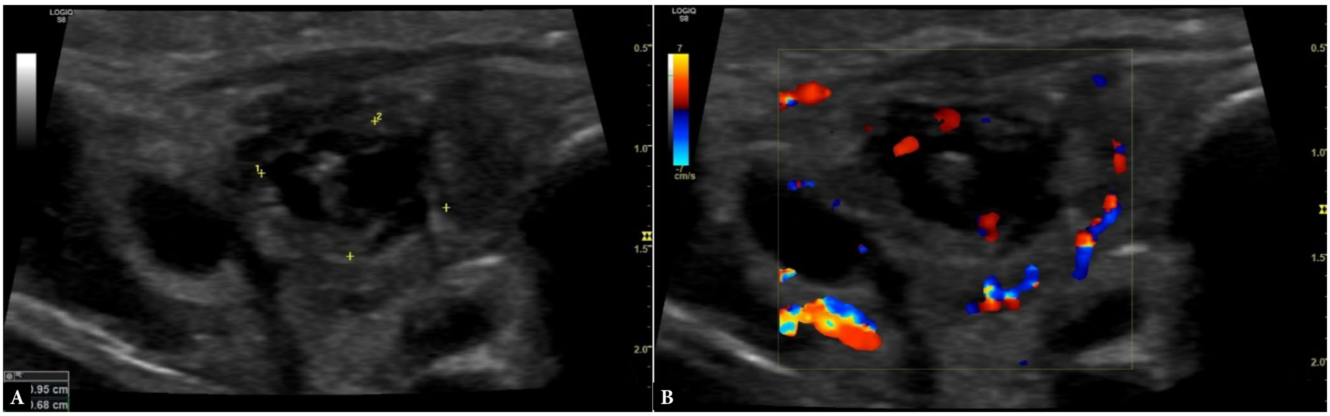


Fig. 15. *Intraparotid abscess. B-mode (***A***) Anechoic lesion with a thickened wall and internal septations. Color Doppler (***B***) Increased vascularity of the round tissue*

exact location of an abscess to allow for a more accurate sitefor an incision, should drainage be required[4,5,9–14].

US is a quick, widely available, inexpensive, and relatively painless imaging modality, and can be repeated as often as necessary without any risk to the patient. Also, the images are often easy to compare between various examinations performed in the same patient[10].

Ramirez-Schrempp *et al.*[5] stated that "Ultrasound is an efficient, noninvasive diagnostic tool which can augment the physician's clinical examination. Ultrasound has been shown to be superior to clinical judgement alone in determining the presence or the absence of occult abscess formation, ensuring appropriate management, and limiting unnecessary invasive procedures"[5].

The question is which of those features can help dentists determine the type of inflammatory lesion they are dealing with. On ultrasound, skin has an organized pattern and is depicted on the near field of the image. The dermis and epidermis are bright and hyperechoic relative to the subcutaneous tissues, which are more hypoechoic. The echogenicities of tissues in the inflammatory lesions are isoechoic, similar to the normal or uninfected side but with an increased fluid content. In cellulitis, the tissues appearhyperechoic because of the massive inflammatory infiltration. In the pre-abscess stage, the tissues appear mixed (both hypoechoic and hyperechoic), indicating that the swelling is at the end of the cellulitis stage and at the onset of the abscess formation stage. In the abscess stage, the echogenicity of the tissues isanechoic (absent) because of the abscess cavity. An abscess has also been described as a heterogeneous, anechoic, or hypoechoic mass that contains a variable amount of internal echoes. They are usually spherical in shape, with ill-defined borders, and the movement or "swirling" of the pus may be seen. The movement of an abscess's internal content can be induced by any maneuver of the probe over the abscess or by turning on the spectral Doppler mode or power Doppler technique, increasing the ultrasound beam's magnitude. The cellulitis type of swelling has also been described to show a thickening and diffuse hyperechogenicity commonly referred to as "cobblestoning"[2].

Squire *et al.*[2] showed that US is easy to use, and after only a 30-minute instruction and hands-on training session, both emergency physicians and residents were able to accurately differentiate between an abscess and cellulitis. The teaching portion consisted of images and video clips of abscesses and cellulitis,whilethe hands-on portion allowed the physicians and residents to perform scans on healthy volunteers[2]. Nevertheless, it is not advisable for medical practitioners to perform US examinations, unless they are fully trained and certified based on the international guidelines and recommendations[3].

A study by Squire *et al.*[2] sought to determine the sensitivity and specificity of the accuracy of clinical examination and ultrasound in odontogenic infections[2]. In this study, the authors found that the sensitivity of clinical examination for abscesses was 86% and the specificity was 70%, while those figures increased to 98% and 88%, respectively, with the use of US.

Studies on the applications of US in the differential diagnosis of inflammatory maxillofacial lesions have beenpublished since 1987, when Siegert[15] used US to investigate inflammatory soft tissue swelling of the head and neck region and compared it to the clinical examination. The final diagnosis was determined on the basis of either surgical intervention or resolution due to nonsurgical treatment. Seventy-nine patients were examined in the study, and a classification system consisting of five categories was used to assign to the US images.

Class I was edema, and three patients (4%) were found to fall into this category. Class II was the infiltrate category in which 24 patients (30%) were grouped. The pre-abscess category, class III, showed an infiltrate with slight or not well-delineated echo reduction. Twelve patients (15%) were included in this category. Classes 4 and 5 were considered to be the abscess category, with 40 patients (51%), split into two types, classified in this group.

One of the major advantages of US is that it can readily determine the exact border and extent of a lesion, confirming masticator, parapharyngeal and sublingual space involvement. US is helpful in staging the infections from edematous changes to cellulitis and abscess formation.

Regarding the spaces where inflammation spreads:

The sublingual space becomes infected when a mandibular tooth infection erodes through the cortical plate and the apex or apices of the involved tooth lie above the mylohyoid muscle attachment.

The submandibular space is located between the mylohyoid muscle superiorly and the platysma inferiorly, and it communicates with the secondary fascial spaces posteriorly. Thespace becomes involved in mandibular posterior tooth infections, as the apices of the tooth lie below the mylohyoid muscle attachment.

In a previous study by our group[16], Ludwig angina (LA) is described as a type of rapidly evolving cellulitis of the upper neck area. It is diffused inflammation of bacterial origin and its expansion occurs by tissue continuity. In most cases, it extends to various neck spaces, involving the sublingual submandibular and submental spaces[17]. Ludwig angina spreads fromthe original source of infection, which is dental, usually an untreated or undiagnosed dental abscess The condition can also arise from otitis media, tongue piercing, sialadenitis, or sialolithiasis of the submandibular glands[18–20]. In advanced cases, airway obstruction is the major problem that presents, while other complications of the condition include pneumothorax[21], thoracic empyema[21], septicemia etc[22,23]. The use of ultrasound for evaluating the extent of the condition is not often reported (and it is reported as isolated case reports) in the literature, though modern imaging systemsallow for an advanced and detailed estimation of the extent of infection and its possible spread into the surrounding tissues[24]. In many cases, ultrasonography is the initial radiographic examination of choice. This is because it is readily available in hospital emergency departments, it visualizes soft tissues with enough detail to set the initial diagnosis in most cases, and it involves no radiation exposure to the patient[24].

The cervical spaces include the lateral pharyngeal, retropharyngeal, prevertebral, and pretracheal spaces. The lateral pharyngeal space lies between the medial pterygoid muscle laterally and the superior constrictor muscle medially, the base of the skull superiorly and the hyoid bone inferiorly, the pterygomandibular raphe anteriorly and the prevertebral fascia or carotid space posteriorly[5,6]. When this space is involved, the infection is severe, and it progresses rapidly.

The retropharyngeal space is defined by the superior constrictor muscles anteriorly, the prevertebral fascia posteriorly, and the retroesophageal space inferiorly, which extends into the posterior compartment of the mediastinum[5,6]. The major concern associated with infections developing in this space is that they can spread inferiorly into the mediastinum very rapidly, with infection of the mediastinum being a serious complication[6].

Overall, the management and treatment of swelling may depend upon the stage of infection. Although the most frequent expansion course is the one of minimum resistance in the maxillofacial region, where the tissues are thin and delicate and show thin layers, the spread of inflammation can be both rapid and worrying to the patient. The majority of cases are handled without ultrasonography, and in many cases patients are given large amounts of radiation that could be avoided with ultrasonography.

Conclusions

Even though maxillofacial inflammations are often treated without imaging in their initial phase, ultrasound can provide an inexpensive, easy-to-use, and readily available modality that accurately visualizes the characteristics and expansion patterns of the lesions, based on their origin and area of initial presentation.

Conflict of interest

The authors do not report any financial or personal connections with other persons or organizations which might negatively affect the contents of this publication and/or claim authorship rights to this publication.

Author contributions

Original concept of study: AD, AS, VR. Writing of manuscript: AD, AS, VR. Analysis and interpretation of data: AD, NG, VR. Final approval of manuscript: AD. Collection, recording and/or compilation of data: AD. Critical review of manuscript: AD.

References

1. Lewis C, Lynch H, Johnston B: Dental complaints in emergency department: a national perspective. Ann Emerg Med 2003;42:93–99. doi: 10.1067/mem.2003.234.
2. Squire BT, Fox JC, Anderson C: ABSCESS: applied bedside sonography for convenient evaluation of superficial soft tissue infections. Acad Emerg Med 2005;12:601–606. doi: 10.1197/j.aem.2005.01.016.
3. Todsen T, Ewertsen C, Jenssen C, Evans R, Kuenzel J: Head and neck ultrasound – EFSUMB training recommendations for the practice of medical ultrasound in Europe. /Ultrasound Int Open 2022; 8: E229–E34. doi: 10.1055/a-1922-6778.
4. Peleg M, Heyman Z, Ardekian L, Taicher S: The use of ultrasonography as a diagnostic tool for superficial fascial space infections. J Oral Maxillofac Surg 1998; 56: 1129–1131. doi: 10.1016/s0278-2391(98)90751-0.
5. Ramirez-Schrempp D, Dorfman DH, Baker WE, Liteplo AS: Ultrasound soft-tissue applications in the pediatric emergency department: to drain or not to drain? Pediatr Emerg Care 2009; 25: 44–48. doi: 10.1097/pec.0b013e318191d963.
6. Scatterwood S, Moore S, Prior A, Yusuf GT, Sidhu PS: Percutaneous drainage of a parotid gland abscess under contrast-enhanced ultrasound guidance: a case report. Ultrasound 2018; 26(3): 182–186. doi: 10.1177/1742271x18766705.
7. Martino M, Fodor D, Fresilli D, Guiban O, Rubini A, Cassoni A *et al.*: Narrative review of multiparametric ultrasound in parotid gland evaluation. Gland Surg 2020; 9(6): 2295–2311. doi: 10.21037/gs-20-530.
8. Hargreaves K, Cohen S: Pathways of the Pulp. Tenth Ed. Mosby 2011.
9. Peterson L, Ellis E, Hupp J, Tucker M: Contemporary Oral and Maxillofacial Surgery. Fourth Ed. Mosby 2003.
10. Bassiony M, Yang J, Abdel-Monem T, Elmogy S, Elnagdy M: Exploration of ultrasonography in assessment of fascial space spread of odontogenic infections. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009; 107: 861–869. doi: 10.1016/j.tripleo.2009.02.016.
11. Bailey E, Kroshinsky D: Cellulitis: diagnosis and management. Dermatol Ther 2011; 24: 229–239. doi: 10.1111/j.1529-8019.2011.01398.x.
12. Ozseker B, Ozcan UA, Rasa K, Cizmeli O: Treatment of breast abscesses with ultrasound-guided aspiration and irrigation in the emergency setting. Emerg Radiol 2008; 15: 105–108. doi: 10.1007/s10140-007-0683-0.
13. Larawin V, Naipao J, Dubey SP: Head and neck space infections. Otolaryngol Head Neck Surg 2006; 135(6): 889–893. doi: 10.1016/j.otohns.2006.07.007.
14. Tayal V, Hasan N, Norton J, Tomaszewski C: The effect of soft-tissue ultrasound on the management of cellulitis in the emergency department. Acad Emerg Med 2006; 13: 384–388. doi: 10.1197/j.aem.2005.11.074.
15. Siegert R: Ultrasonography of inflammatory soft tissue swellings of the head and neck. J Oral Maxillofac Surg 1987; 45: 842–346. doi: 10.1016/0278-2391(87)90233-3.
16. Delantoni A, Sarafopoulos A, Tsiropoulos G, Deniz A, Orhan K: Ludwig's Angina: case series with description of the ultrasonographic features of the emergency conditions. J Emerg Med Case Rep 2020; 11(4): 111–115.
17. Bramwell KJ, Davis DP: Ludwig's angina. J Emerg Med 1998; 3: 481–483. doi: 10.1016/s0736-4679(98)00024-9.
18. Har-El G, Aroesty JH, Shaha A, Lucente FE: Changing trends in deep neck abscess. A retrospective study of 110 patients. Oral Surg Oral Med Oral Pathol 1994; 77: 446–450. doi: 10.1016/0030-4220(94)90221-6.
19. Iwu CO: Ludwig's angina: report of seven cases and review of current concepts in managment. Br J Oral Maxillofac Surg 1990; 28: 189–193. doi: 10.1016/0266-4356(90)90087-2.
20. Polat G, Sade R: Radiologic imaging of Ludwig angina in a pediatric patient. J Craniofac Surg 2018; 29(6): e603–e604. doi: 10.1097/scs.0000000000004646.
21. Barsamian JG, Scheffer RB: Spontaneous pneumothorax: an unusual occurrence in a patient with Ludwig's angina. J Oral Maxillofac Surg 1987; 45: 157–159. doi: 10.1016/0278-2391(87)90407-1.
22. Busch RF, Shah D: Ludwig's angina: improved treatment. Otolaryngol Head Neck Surg 1997; 117: 172–175. doi: 10.1016/s0194-59989770093-7.
23. Busch RF: Ludwig angina: early aggressive therapy. Arch Otolaryngol Head Neck Surg 1999; 125: 1283–1284.
24. Dugan MJ, Lazow SK, Berger JR: Thoracic empyema resulting from direct extension of Ludwig's angina: a case report. J Oral Maxillofac Surg 1998; 56: 968–971. doi: 10.1016/s0278-2391(98)90660-7.