

Value of ultrasound-guided drainage in the treatment of odontogenic space infections of the maxillofacial region: a clinical analysis of 23 cases

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Abstract

Objective To explore the clinical value of ultrasound-guided drainage in the treatment of odontogenic space infections of the maxillofacial region.

Methods We retrospectively analyzed data for 23 patients with maxillofacial space infections treated between October 2015 and October 2025. All patients underwent ultrasound-guided drainage. Clinical observation indicators comprised puncture success rate, time to clinical symptom improvement, pathogenic distribution, and complications.

Results One-time puncture was successful in all 23 patients (100% success rate). Postoperative clinical symptoms improved rapidly; the visual analog scale score for local pain decreased by $\geq 50\%$ within 1.6 ± 0.1 days, swelling began to resolve after 2.3 ± 0.2 days, and the times for body temperature and the white blood cell count to return to normal were 3.3 ± 0.2 days and 5.0 ± 0.3 days, respectively. The most common infection site was the neck space. The positive rate of pus culture was 82.6% (19/23), with Gram-positive bacteria predominating, and *Streptococcus* was cultured most often (21.7%). No major complications, such as vascular or nerve injuries, occurred.

Conclusion Ultrasound-guided drainage has the advantages of precision, minimal invasiveness, and safety in treating maxillofacial space infections. This approach effectively promotes rapid relief of clinical symptoms and is worthy of clinical promotion.

Keywords: ultrasound, drainage, maxillofacial, infection, minimally invasive treatment

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Introduction

The maxillofacial region features a complex anatomical architecture, and infections arising within its potential fascial spaces, known as maxillofacial space infections (MSIs), represent one of the most common infections in the head and neck [1]. The pathogenesis of MSIs is multifactorial, primarily involving odontogenic infections, lymphadenitis, and traumatic injuries [2]. Although the widespread use of antibiotics and improved oral hygiene practices have significantly reduced the epidemiological prevalence of MSIs, they remain a potentially critical clinical concern. If inadequately managed, these infections can progress to life-threatening complications, including airway obstruction, necrotizing fasciitis, systemic sepsis, and descending mediastinitis [3].

Conventional incision and drainage remain the cornerstone intervention for MSI management in current clinical practice. However, this approach is highly dependent on surgical experience and anatomical knowledge, and its inherent nature as a “blind exploration” involves considerable limitations. These include unnecessary tissue disruption, inaccurate targeting, and an increased risk of complications [4]. Recently, the integration of ultrasound-guided interventional techniques has transformed clinical workflows. With its real-time dynamic visualization, absence of ionizing radiation, and precise delineation of abscess geometry and adjacent neurovascular structures, ultrasound guidance has led to new paradigms for minimally invasive MSI management [5].

In this study, we performed a retrospective analysis of 23 confirmed MSI cases to comprehensively assess the therapeutic performance and safety profile of ultrasound-guided drainage. The aim of this study was to elucidate the definitive clinical value of this technique

in contemporary infectious disease practice.

Materials and Methods

Patient selection and characteristics

We retrospectively analyzed data for 35 patients diagnosed with MSI who underwent ultrasound-guided drainage in the Department of Ultrasound Diagnosis at the First Medical Center of the Chinese People's Liberation Army General Hospital between January 2015 and October 2025. The diagnosis of abscess formation was confirmed in all patients through clinical evaluation and imaging studies. Twelve patients with incomplete clinical data were excluded, resulting in a final cohort of 23 patients.

The inclusion criteria were as follows: (1) confirmed diagnosis of MSI based on clinical presentation and imaging findings; (2) availability of a safe puncture pathway assessed by ultrasonography; and (3) signed informed consent by the patient or their guardian.

The exclusion criteria were as follows: (1) presence of cellulitis without a localized, drainable abscess; (2) severe coagulation dysfunction; (3) inability to tolerate the procedure due to impaired consciousness or poor cooperation; and (4) missing or incomplete clinical medical records.

Instruments and Technical Procedure

The following equipment was used for the procedures: (1) ultrasound systems: MyLab Twice Esaote (Genova, Italy), Siemens Acuson Sequoia (Siemens Medical Solutions, Mountain View, CA, USA), and HI VISION Preirus (Hitachi, Tokyo, Japan) equipped with high-frequency linear array transducers (4–12 MHz); (2) sterile puncture set containing a curved basin, aperture drape,

gauze, and sterile gloves; (3) puncture needles: 16G or 18G percutaneous transhepatic cholangiography needles for initial abscess puncture and guidewire placement; and (4) drainage catheters: 8F–12F multi-side-hole pigtail drainage catheters. For viscous pus, larger catheters (e.g., 10F–12F) were used to ensure adequate drainage.

Technical Procedure

•Preoperative assessment and planning

(1) The patient was positioned supine or semi-recumbent, with the operative area fully exposed.

(2) Comprehensive ultrasonography was performed to determine the abscess location, size, depth, internal echogenicity, and spatial relationship to adjacent vital structures (e.g., facial vessels, branches of the external carotid artery, and nerves).

(3) The abscess boundary was marked on the skin surface, and the optimal puncture site and needle path were determined and marked following the “shortest safe path” principle.

(4) Routine skin disinfection of the puncture area was performed, followed by sterile draping.

(5) Local anesthesia infiltration was administered along the planned puncture path using 2% lidocaine, from the skin to the abscess wall.

•Ultrasound-guided puncture and drainage catheter placement

(1) Under continuous ultrasound monitoring (in either the longitudinal or transverse plane), the percutaneous transhepatic cholangiography needle was advanced slowly along the predetermined path. The needle tip,

visualized as a hyperechoic focal area, was carefully tracked to ensure accurate placement into the center of the abscess cavity. Successful entry was confirmed by the aspiration of purulent material.

(2) Pus was aspirated as completely as possible. For patients requiring continuous drainage, a catheter was subsequently placed.

(3) Catheter placement via the Seldinger technique: A guidewire was introduced through the puncture needle and observed under ultrasonography for coiling within the abscess cavity. The needle was withdrawn, leaving the guidewire in place. The subcutaneous tract was gently dilated over the guidewire. A multi-sidehole pigtail drainage catheter was advanced into the cavity, after which the guidewire was withdrawn. The catheter was secured to the skin with a suture or adhesive dressing after confirming satisfactory positioning and coiling of the tip within the cavity. The external end was connected to a closed drainage bag.

Postoperative Management

Aspirated pus specimens were sent immediately for microbiological culture and pathologic examination. The abscess cavity was irrigated daily via the catheter with normal saline or sensitive antibiotic solutions until the drainage fluid became clear. Drainage volume and character were monitored closely. Regular ultrasonographic examinations were performed to evaluate abscess resolution.

Catheter removal criteria: The drainage catheter was removed when the patient met all of the following criteria: normalization of body temperature and white blood cell count, resolution of local symptoms, daily drainage volume < 5 mL, ultrasonographic confirmation of marked abscess resolution, and maintenance of clinical stability

after a 24-hour trial of catheter clamping.

Results

Patients’ baseline characteristics

Twenty-three patients were included in this study, comprising 10 men (43.5%) and 13 women (56.5%), with a male-to-female ratio of 1:1.3. The mean patients’ age was 45 (39 ± 21.18) years; range: 20–91 years. The most common etiology of infection was odontogenic (19 cases, 82.6%), followed by traumatic (2 cases, 8.7%), glandular (1 case, 4.3%), and “other” causes (1 case, 4.3%). Three patients (13.0%) had underlying systemic diseases, such as diabetes mellitus. Prior to treatment, the mean white blood cell count was $14.22 \pm 0.82 \times 10^9/L$, and the mean body temperature was $37.84 \pm 0.17^\circ C$. No serious complications, including injury to major blood vessels or nerves, occurred in any patient. Detailed baseline characteristics are presented in Table 1.

Abscess characteristics and puncture drainage outcomes

The results of the analysis of the abscess characteristics and procedural outcomes for all 23 patients are

presented in Table 2. Infections involving multiple neck spaces were the most common (11 cases, 47.8%), followed by the submandibular space (5 cases, 21.7%) and the masseteric space (3 cases, 13.0%). The maximum diameter of the abscesses suitable for intervention ranged from 3.65 to 5.95 cm. The largest abscesses were located in the infraorbital space (5.95 ± 2.55 cm), while the depth of the puncture path varied considerably with anatomical location.

The overall first-attempt success rate for ultrasound-guided puncture was 100%. Site-specific analysis demonstrated a 100% first-attempt success rate in the submandibular, masseteric, infraorbital, and buccal spaces. In the multi-space neck infection subgroup, abscess cavities all 11 cases (100%) were successfully accessed on the initial attempt. Regarding drainage management, simple needle aspiration alone was sufficient in 20 patients (87.0%). Indwelling catheter drainage was required in only 3 cases (27.3% of the multi-space neck subgroup), primarily because of extensive cavity size or high pus viscosity.

Analysis of clinical efficacy

Ultrasound-guided drainage resulted in rapid clinical

Table 1. Baseline characteristics and pre-treatment clinical data of the study population (n=23).			
Item		Frequency (n)	Percentage (%)
Gender	Male	10	43.5
	Female	13	56.5
Age (years)	20-40	13	56.5
	41-91	10	43.5
Etiology (cases)	Odontogenic	19	82.6
	Glandular	1	4.3
	Traumatic	2	8.7
	Other	1	4.3
Comorbidities	DM	3	13.0
Severe Complications		0	0.0
Distance from Skin (cm)		0.96 ± 0.08	
Pre-treatment WBC ($\times 10^9/L$)		14.22 ± 0.82	
Pre-treatment Temperature ($^\circ C$)		37.84 ± 0.17	

Notes: DM, diabetes mellitus; severe complication includes vascular injury, nerve damage, and others.

Table 2. Abscess characteristics and puncture drainage outcomes (n=23).

Abscess Location	Cases (n)	Maximum Diameter (cm)	Depth of Puncture Path (cm)	First-Attempt Success (n, %)	Catheter Drainage (n, %)
Submandibular Space	5	3.90 ± 1.08	0.98 ± 0.13	5 (100)	0 (0.0)
Masseteric Space	3	4.70 ± 1.85	1.27 ± 0.67	3 (100)	0 (0.0)
Infraorbital Space	2	5.95 ± 2.55	0.25 ± 0.05	2 (100)	0 (0.0)
Buccal Space	2	4.23 ± 1.42	1.10 ± 0.21	2 (100)	0 (0.0)
Multi-Space Neck Infection	11	3.65 ± 0.39	0.98 ± 0.09	11 (100)	3 (27.4)

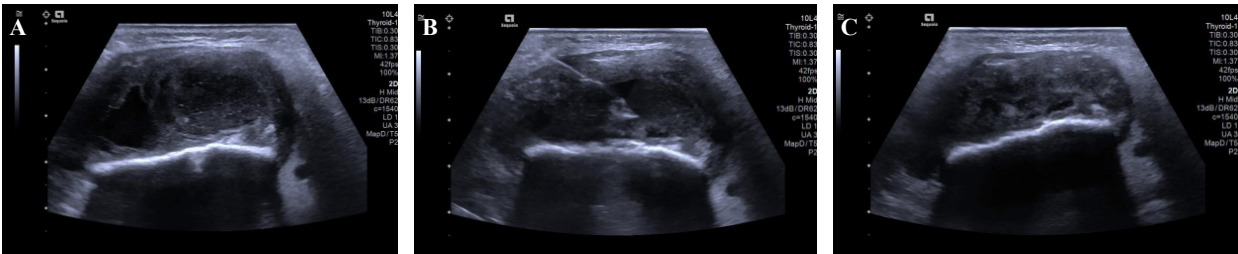


Figure 1. Puncture and drainage procedure for a chronic masseteric space abscess.

(A) A heterogeneous hypoechoic mass measuring approximately 2.6 cm × 1.8 cm × 3.4 cm is visible in the left cheek adjacent to the mandible and located at a depth of 1.2 cm from the skin surface. (B) A 50-ml syringe with an attached needle was advanced into the cavity center, and 13 ml of purulent material was aspirated before needle withdrawal. (C) Post-procedure: The abscess cavity showed a marked reduction in size following aspiration.

improvement in all 23 patients, with marked resolution of both local symptoms and systemic inflammatory markers observed within a short period postoperatively (Table 3). The earliest response was seen in pain control, with a mean duration of 1.61 ± 0.14 days to achieve ≥ 50% reduction in visual analog scale (VAS) scores. Local edema began to resolve within approximately 2 days, with a mean resolution time of 2.34 ± 0.22 days. Systemic inflammatory parameters also demonstrated substantial improvement: fever resolved (body temperature < 37.3°C) within a mean of 3.26 ± 0.16 days, and leukocyte counts normalized after a mean of 5.00 ± 0.32 days.

Table 3. Time to improvement of clinical symptoms and signs following treatment (n=23).

Observation Parameter	Mean Time (days)
Time to Body Temperature Normalization (<37.3°C)	3.26 ± 0.16
Time to Significant Pain Relief (VAS Score ↓ ≥50%)	1.61 ± 0.14
Time to Initiation of Swelling Resolution	2.34 ± 0.22
Time to White Blood Cell Count Normalization	5.00 ± 0.32

Notes: VAS, visual analog scale

Microbiological findings

Microbiological analysis of pus specimens revealed a diverse pathogenic profile, predominantly featuring mixed infections and Gram-positive organisms (Table 4). Mixed infections were most frequent (8 cases, 34.8%), highlighting the polymicrobial nature of MSIs. Among monomicrobial isolates, Gram-positive bacteria predominated (collectively, 30.4%), with *Streptococcus* species as the most common pathogen (5 cases, 21.7%). Notably, *Mycobacterium tuberculosis* was identified in 3 cases (13.0%). The culture-negative rate was 17.4% (4 cases), which may be attributed in part to preoperative antibiotic administration.

Discussion

Ultrasound guidance represents an significant advancement in the minimally invasive management of MSIs, demonstrating substantial clinical value across three fundamental domains: precision, safety, and therapeutic efficacy.

Table 4. Pathogen distribution in pus specimens (n=23).

	Pathogen Type	Number (n)	Percentage (%)
Gram-positive	<i>Streptococcus</i>	5	21.7
	<i>S. aureus</i>	1	4.3
	<i>S. epidermidis</i>	1	4.3
Gram-negative	<i>Burkholderia</i>	1	4.3
Mycobacteria	<i>M. tuberculosis</i>	3	13
Mixed Infection		8	34.8
Culture-negative	No growth	4	17.4

Regarding precision, ultrasound guidance supersedes conventional blind puncture, which relies on superficial anatomical landmarks and fluctuation, by providing real-time dynamic visualization. Under continuous sonographic guidance, operators can accurately track the needle’s trajectory and localize the tip position, enabling precise placement [6]. Our data indicate a 100% first-attempt success rate, attributable to the ability to position drainage catheters optimally within the most dependent or central region of the abscess in a single attempt. This precision mitigates the risks of repeat punctures, incomplete drainage, and pseudocapsule formation. In complex multiloculated abscesses, ultrasonography clearly delineates internal septations and facilitates targeted access to individual compartments, ensuring comprehensive drainage, which is beyond the reach of blind techniques. This is particularly critical in deep-seated or small-volume collections, where ultrasonography enables a shift from macroscopic estimation to microscale accuracy.

Regarding safety, ultrasound-guided intervention offers superior risk mitigation. The maxillofacial region involves intricate anatomy with a high density of neurovascular structures. In blind puncture, these structures are susceptible to injury and include the external carotid branches, internal jugular vein, and facial nerve [4]. In contrast, ultrasonography facilitates preoperative mapping and real-time intraoperative monitoring, allowing operators to dynamically adjust needle trajectory to avoid vital structures, minimizing the risk of neurovascular

compromise or hematoma formation [7]. In our cohort, no major vascular or neural injuries were noted. Moreover, the technique necessitates only a single cutaneous access point and constitutes a truly minimally invasive approach. Relative to conventional open drainage, this approach reduces tissue trauma, alleviates postoperative pain, accelerates recovery, and shortens hospital stay [5-8].

Regarding therapeutic efficacy, ultrasound-guided drainage demonstrates consistent superiority over blind puncture. This approach ensures not only accurate initial catheter placement but also permits ongoing assessment of drainage adequacy. When augmented with pulsed lavage, ultrasound-guided drainage effectively clears purulent and necrotic material, shortening antibiotic courses and overall treatment duration. Patients in our study exhibited rapid improvement across several clinical parameters, underscoring the integrated benefit of this approach in infection control and functional recovery. Local pain diminished swiftly, with a mean time to $\geq 50\%$ reduction in VAS scores of 1.6 ± 0.1 days. Precise needle navigation minimized injury to perilesional sensitive structures, while prompt abscess decompression directly mitigated pain and inflammation. These findings align with those of Cheng et al., who reported significantly lower VAS scores within 24 hours in ultrasound-guided cohorts compared with open surgery ($P < 0.05$) [9]. Swelling began to resolve after a mean of 2.34 ± 0.22 days, with notable improvement within 1 week. Mechanistically, targeted drainage reduces intracavitary pressure, enhances local perfusion, and alleviates tissue edema, which supports the restoration of mouth opening and masticatory function [10]. Systemic inflammatory markers also normalized rapidly, in the present study, and body temperature returned to baseline within 3.26 ± 0.16 days, corroborating the role of source control in resolving systemic inflammation indicated by decreases in highly sensitive C-reactive protein in previous studies [10]. In the present

study, leukocyte counts normalized in 5.00 ± 0.32 days, indicating prompt resolution of immune activation. Previous studies have confirmed that ultrasound-guided drainage combined with antibiotic irrigation leads to significantly faster leukocyte recovery compared with pharmacotherapy alone ($P < 0.05$)^[11], reinforcing its clinical utility. Aesthetically, ultrasound-guided drainage avoids conspicuous scars in the sensitive maxillofacial region, harmonizing therapeutic success and cosmesis and enhancing patient satisfaction.

Microbiological analysis of pus specimens from the 23 patients in the present study revealed a diverse pathogen spectrum. Gram-positive organisms predominated (30.4%), with *Streptococcus* spp. most prevalent (21.7%), aligning with published data^[12]. Isolation of coagulase-negative staphylococci and *Staphylococcus aureus* suggests potential cutaneous contamination or nosocomial transmission. The high frequency of polymicrobial infections (34.8%) underscores the common coexistence of aerobic and anaerobic bacteria, a finding that validates the use of broad-spectrum or combination validates antibiotic therapy^[13-15]. Detection of *Mycobacterium tuberculosis* in 13% of the cases in the present study highlights the need to consider tuberculosis as an etiology in non-responsive infections. The 17.4% culture-negative rate, potentially attributable to prior antibiotic exposure, fastidious anaerobes, or atypical organisms, calls for the integration of molecular methods, such as 16S rRNA sequencing to enhance diagnostic sensitivity and comprehensiveness.

This study has several limitations. The single-center, retrospective design and modest sample size ($n = 23$) may affect the generalizability of the conclusions. Treatment protocols, patient characteristics, and operator expertise at a single institution may not be fully representative. Future multicenter, prospective trials with larger cohorts are warranted to validate our findings.

Conclusion

In summary, ultrasound-guided puncture and drainage offers a precise, minimally invasive, and safe approach for managing MSIs. This approach effectively eliminates abscesses while preserving function and enhancing patient recovery. Given its efficacy and procedural advantages, this technique is recommended as a primary interventional option, with important potential to improve clinical outcomes in MSIs.

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Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of Chinese PLA General Hospital (S2024-082-01). All participants signed a written informed consent from.

Author contributions

Mingbo Zhang conceived and designed the case report, supervised the work, and served as the corresponding author. Zhe Yang and Rui Xiao collected clinical data and drafted the initial manuscript. Mingbo Zhang contributed to the literature review and interpretation of findings. Zhe Yang and Rui Xiao assisted in manuscript

revision and provided critical feedback. All authors read and approved the final version of the manuscript.

Conflicts of interest

All authors declare no conflicts of interest.

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