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RAPID DIAGNOSTICS FOR ORAL AND MAXILLOFACIAL INFECTIONS: IMPACT ON ANTIBIOTIC PRESCRIBING, REFERRAL TIMING, COMPLICATIONS, AND CARE PATHWAYS; A SYSTEMATIC REVIEW

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Abstract

Background: Oral and maxillofacial infections range from localized abscesses to deep neck infections with airway risk. Conventional culture is slow, which can prolong broad-spectrum antibiotics and delay targeted referral pathways. Rapid diagnostics, including biomarkers and molecular testing, may improve early risk stratification and antimicrobial stewardship. **Objective:** To evaluate the impact of rapid diagnostics (POCT, biomarkers, molecular tests, and sequencing-based microbiology) on antibiotic prescribing, referral timing, complications, and care pathways in oral and maxillofacial infections. **Methods:** We performed a PRISMA-guided systematic review of PMC-indexed full-text studies on rapid diagnostics in odontogenic, oral-maxillofacial infections and related head, neck infection pathways. Outcomes included antibiotic de-escalation, time to targeted therapy or referral, complications, and pathway, decision support. Studies were grouped into biomarker-based severity assessment and molecular, NGS pathogen and resistance characterization. **Results:** Ten original studies were included (n varied by study). Biomarker studies reported that procalcitonin and presepsin correlated with infection severity or systemic involvement and may support earlier escalation decisions. Molecular studies described polymicrobial profiles and resistance markers in abscess material and periodontal abscesses, supporting faster etiologic characterization compared with culture-dependent pathways. In a pediatric head, neck pathway study, nasal PCR availability was associated with faster de-escalation of anti-MRSA therapy without worse clinical outcomes. **Conclusion:** Rapid diagnostics show the strongest direct evidence for improving antibiotic decisions in pathway-based PCR stewardship and provide supportive evidence that biomarker and molecular testing can improve early stratification and organism, resistance recognition. More trials are needed linking these tools to time-to-referral, complication reduction, and standardized oral-maxillofacial care pathways.

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Keywords: Oral and Maxillofacial Infection; Odontogenic Infection; Point-of-Care Testing; Biomarkers; Procalcitonin; Presepsin; Molecular Diagnostics; 16S rRNA Sequencing; Antibiotic Stewardship; Care Pathways.

INTRODUCTION

Oral and maxillofacial infections are commonly polymicrobial and can progress from localized odontogenic abscesses to deep neck infection or systemic inflammation, where delayed recognition increases morbidity and resource use. (Prakash et al. 2013; Haque et al. 2019) Inappropriate or prolonged empirical antibiotic therapy contributes to resistance and may delay definitive source control and referral escalation. (Haque et al. 2019; Meinen et al. 2021)

Traditional culture-based microbiology is limited by time-to-result and difficulty detecting fastidious or unculturable organisms; consequently, clinicians often rely on broad empirical regimens while awaiting results. (Clarridge et al. 2004; Meinen et al. 2021) Rapid diagnostics aim to shorten time to actionable information by providing (1) biomarker-based severity, triage signals (inflammatory and sepsis biomarkers) and (2) molecular identification of pathogens and resistance determinants (PCR, 16S sequencing, and metagenomics). (Reinhart et al. 2012; Clarridge et al. 2004)

POCT strategies have shown, in other infection settings, the potential to reduce unnecessary antibiotic prescribing when integrated into decision pathways (CRP POCT), supporting the concept that faster objective data can change prescribing behavior. (Cals et al. 2010) Systematic review evidence similarly suggests POCT biomarkers can reduce antibiotic use in primary care respiratory infections, highlighting a transferable stewardship principle for oral, maxillofacial infection pathways when an equivalent test-pathway link exists. (Martinez-Gonzalez et al. 2020)

However, for oral and maxillofacial infections specifically, the real-world impact of rapid diagnostics on antibiotic prescribing, referral timing, complications, and pathway decisions remains variable and depends on implementation design. Therefore, this systematic review synthesizes evidence from biomarker, PCR, and sequencing-based studies to clarify what outcomes have been measured and where evidence gaps persist. (Meinen et al. 2021; Clarridge et al. 2004)

METHODS

Protocol and reporting

This systematic review followed PRISMA principles for study identification, screening, eligibility assessment, and inclusion. We include studies conducted in children or adults with suspected, confirmed odontogenic, oral, maxillofacial, or closely related head, neck infections where dental, oral sources were relevant; biomarkers, POCT used for severity assessment or escalation decisions (procalcitonin, presepsin); molecular tests (PCR-based) used for pathogen detection or stewardship decisions. 16S rRNA sequencing, metagenomics, NGS for microbiome profiling or resistance prediction. standard care,

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conventional diagnostics (culture), or between-group comparisons based on test availability, use (where applicable); antibiotic prescribing (initiation, de-escalation, duration), time to referral, escalation, complications (systemic involvement, ICU, surgery, LOS), and care pathway impacts;RCTs, cohort studies, cross-sectional diagnostic studies, retrospective studies, and microbiologic analytic studies with clinical context.

Information sources and search strategy

We searched PubMed Central for full-text eligible studies. Search terms combined concepts for:

(Odontogenic OR oral OR maxillofacial OR “head and neck”) AND (infection OR abscess) AND

(POCT OR “point of care” OR biomarker OR procalcitonin OR presepsin OR PCR OR “16S” OR sequencing OR metagenomics).

Study selection

Two-stage screening: title, abstract screening followed by full-text assessment. Inclusion required oral, maxillofacial relevance and a rapid diagnostic component with extractable clinical or pathway implications.

Data extraction

We extracted: author, year, country, setting, design, sample size, infection type, diagnostic test, comparator (if any), outcomes, and key findings relevant to antibiotic decisions, referral timing, complications, or pathways.

Risk of bias

Because included studies were heterogeneous (biomarker prognostic studies, stewardship pathway studies, microbiome profiling), we assessed bias narratively in: selection bias, measurement bias, confounding, and outcome reporting. We used qualitative synthesis with tabulation. Studies were grouped into: Biomarker severity stratification; molecular organism and resistance characterization; PCR pathway implementation.

RESULTS

Study selection and included studies

Ten original PMC full-text studies met inclusion criteria: three biomarker-based severity studies, one PCR stewardship, pathway study, and six molecular, NGS or PCR microbiology studies focused on organism identification and resistance characterization. (Kim et al. 2021; Kang et al. 2022; Lin et al. 2022; Patel et al. 2021; Thol et al. 2024)

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Table 1: Characteristics of included original studies

Study	Design, Setting	Population, Infection	Rapid diagnostic	Comparator	Outcomes captured
Kim et al. 2021	Retrospective; OMFS inpatients	Severe odontogenic maxillofacial infection	Serum procalcitonin	Other markers, clinical severity comparisons	Severity, prognosis association
Kang et al. 2022	Retrospective	Odontogenic infection	Serum presepsin	vs WBC, CRP, PCT performance	Diagnostic value; severity signals
Lin et al. 2022	Observational	Elderly oral-maxillofacial space infection	Serum procalcitonin	Clinical severity grouping	Severity, prognostic association
Patel et al. 2021	Retrospective pathway evaluation	Pediatric head and neck infections	*S. aureus* nasal PCR	PCR used vs not used	Time to de-escalation; LOS; failure; AKI
Beka et al. 2019	Prospective, observational	Deep neck infections	16S rRNA PCR, sequencing	Conventional culture context	Etiology identification; clinical correlation
Thol et al. 2024	Cross-sectional microbiome study	Odontogenic abscess	NGS (16S, NGS microbiome)	Culture context	Microbiome mapping; resistance profile implications
Böttger et al. 2021	Cross-sectional microbiome study	Odontogenic infections (saliva, pus)	16S, NGS	Culture context	Community profile; diagnostic yield (microbiome)
Chen et al. 2019	Cross-sectional	Periodontal abscess	16S rDNA sequencing	Healthy, adjacent site comparison	Microbiota profile; pathogen enrichment
Rezazadeh et al. 2020	Cross-sectional	Bacteremia after extraction	Multiplex PCR	Conventional susceptibility testing	Detection + resistance patterns
Judith et al. 2022	In vitro cross-sectional	Odontogenic abscess pus	Culture + susceptibility (rapid actionable)	Empirical antibiotics context	Susceptibility patterns relevant to empiric choice

Table 2: Main findings mapped to your outcomes

Outcome domain	Evidence from included studies	What was directly measured
Antibiotic prescribing, de-escalation	Nasal PCR availability associated with faster de-escalation of anti-MRSA coverage in pediatric head, neck infections without worse outcomes. (Patel et al. 2021)	Median time to de-escalation; LOS; failure; AKI
Empiric antibiotic selection	Abscess and bacteremia studies described susceptibility, resistance patterns that inform empiric choices. (Judith et al. 2022; Rezazadeh et al. 2020)	Culture, PCR detection; antibiograms; resistance patterns
Referral timing, escalation	Biomarker studies support risk stratification for severe disease (higher systemic involvement),	Associations between biomarkers and severity,

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	potentially prompting earlier referral or airway, surgical escalation. (Kim et al. 2021; Kang et al. 2022; Lin et al. 2022)	prognosis (not randomized referral timing)
Complications, severity outcomes	Biomarkers associated with infection severity and prognostic categories. (Kim et al. 2021; Lin et al. 2022)	Severity correlations; prognostic value
Care pathways, microbiology workflow	16S, NGS studies mapped polymicrobial communities and suggested improved organism detection compared with culture-only workflows, supporting earlier organism-aware decisions where implemented. (Thol et al. 2024; Beka et al. 2019; Chen et al. 2019; Böttger et al. 2021)	Microbiome identification; relative abundance; organism detection; resistance mapping (process outcomes more than clinical endpoints)

In odontogenic and oral-maxillofacial infection cohorts, serum procalcitonin and presepsin were evaluated as severity-related biomarkers, supporting their role as rapid adjuncts for escalation decisions in settings where systemic involvement is a concern. (Kim et al. 2021; Kang et al. 2022; Lin et al. 2022). In pediatric head and neck infections, *S. aureus* nasal PCR use was associated with faster de-escalation timing compared with cases without PCR use, while LOS and adverse outcomes were not significantly different. (Patel et al. 2021). Sequencing and PCR-based studies characterized complex polymicrobial patterns in odontogenic and periodontal abscesses and highlighted resistance-relevant findings that can inform targeted therapy when coupled to clinical pathways. (Thol et al. 2024; Beka et al. 2019; Chen et al. 2019; Rezazadeh et al. 2020)

DISCUSSION

This review shows that the strongest direct prescribing impact evidence in the oral, head-neck sphere comes from pathway-linked PCR stewardship, where a rapid test result is explicitly connected to a de-escalation rule and measurable prescribing outcomes. (Patel et al. 2021) This aligns with broader POCT evidence demonstrating that rapid objective testing can reduce unnecessary antibiotic use when embedded into clinical decision pathways rather than used as isolated data points. (Cals et al. 2010; Martinez-Gonzalez et al. 2020)

For biomarkers, procalcitonin and presepsin studies in odontogenic, oral-maxillofacial infections primarily demonstrate associations with severity and systemic inflammatory involvement rather than randomized pathway outcomes. (Kang et al. 2022; Lin et al. 2022; Kim et al. 2021) Nonetheless, severity-linked biomarkers may support earlier referral escalation (urgent OMFS review, airway evaluation, or early surgical source control) by providing additional objective signals, especially when clinical assessment is borderline or resources are constrained. (Reinhart et al. 2012)

Molecular, NGS studies highlight the limitation of culture-only workflows in polymicrobial oral infections, where unculturable organisms and complex anaerobic communities are common. (Clarridge et al. 2004; Chen et al. 2019; Thol et al. 2024) By providing richer organism identification (and, in some designs, resistance-related insights), sequencing could shorten time to organism-aware decisions, but this benefit depends on turnaround time, local availability, and whether results are delivered in a format that triggers action

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(switching antibiotics, narrowing therapy, or fast-tracking surgical drainage). (Meinen et al. 2021; Thol et al. 2024) A recurring challenge is the evidence gap between microbiologic discovery and measured clinical endpoints. Studies mapping microbiota profiles are valuable for understanding etiology and resistance ecology, but most do not directly measure antibiotic de-escalation, time to referral, or complication reduction. (Chen et al. 2019; Thol et al. 2024) This mirrors concerns in antimicrobial resistance literature that diagnostic innovations must be integrated into stewardship systems to produce measurable improvements in prescribing and outcomes. (Haque et al. 2019; Meinen et al. 2021; Velissaris et al. 2021)

Implications for care pathways: Based on the included evidence, a practical pathway approach would combine (1) early severity triage (clinical + biomarker adjuncts), (2) rapid MRSA, organism-rule-out tests where appropriate, and (3) molecular, NGS use in severe, recurrent, or treatment-refractory infections to support targeted therapy and surgical planning. (Patel et al. 2021; Kang et al. 2022; Thol et al. 2024)

CONCLUSION

Rapid diagnostics for oral and maxillofacial infections demonstrate clear, measurable prescribing benefit when embedded in stewardship pathways (nasal PCR supporting faster anti-MRSA de-escalation). Procalcitonin, presepsin and molecular, NGS approaches provide supportive evidence for improved early stratification and organism, resistance recognition, but most studies still lack direct trials linking these tools to reduced complications, faster referral, and standardized care pathway performance.

List of abbreviations

AKI: Acute Kidney Injury

CRP: C-reactive protein

DNA: deoxyribonucleic acid

LOS: length of stay

MRSA: methicillin-resistant *Staphylococcus aureus*

NGS: next-generation sequencing

OMFS: oral and maxillofacial surgery

PCR: polymerase chain reaction

PCT: procalcitonin

POCT: point-of-care testing

PSEP: presepsin

PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

rRNA: ribosomal ribonucleic acid

SIRS: systemic inflammatory response syndrome

WBC: white blood cell count

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