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ROLE OF ADVANCED CT/MRI IMAGING IN THE EARLY DETECTION AND MANAGEMENT OF CRANIOFACIAL INFECTIONS: INTEGRATION OF DENTISTRY, NEUROSURGERY, RADIOLOGY, AND ANTIBIOTIC STEWARDSHIP

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ABSTRACT

Background: *Craniofacial infection of odontogenic and sinogenic origin may cause rapid progression to life-threatening intracranial or orbital complications and early and accurate imaging as well as coordinated multidisciplinary management are essential in timely diagnosis and treatment.*

Objective: To evaluate the impact of the use of advanced CT and MRI imaging for early diagnosis of craniofacial infections and to compare outcomes of patients treated after early multidisciplinary team (MDT) engagement (involving Dentistry, Neurosurgery, Radiology and Antibiotic Stewardship) to standard or delayed referral team.

Methodology: *The study involved a multi-centre observational study with usual data collection from the Dental, Neurosurgery and Radiology departments of different Tertiary Care Hospitals of Pakistan that commenced from August 2025 to January 2026. 96 patients with a clinical diagnosis of craniofacial infection had computed tomography (CT) and/or magnetic resonance imaging (MRI) imaging performed for assessment and were separated into two groups: early multidisciplinary team (MDT) referral (n = 54) and standard and/or delayed referral (n = 42). Using SPSS version 26.0, the groups were compared in terms of the time from the initial onset of the signs or symptoms to the definitive diagnosis, length of stay in the hospital, the rate of repeated imaging studies, the rate of complications, the rate of revision surgery, and the time until appropriate empiric antibiotic selection was made. The continuous variables were compared by independent samples t-test and the categorical variables were compared by Chi-square test, taking P-value of < 0.05 as statistically significant.*

Results: *Compared to the standard/delayed referral group, the multidisciplinary team approach group had a significantly earlier definitive diagnosis time (6.2 ± 2.4 vs 14.6 ± 5.2 hours, $P < 0.001$) and*

reduced hospital stay (7.8 ± 2.6 vs 12.4 ± 3.8 days, P < 0.001). The MDT group had significantly lower rates of repeat imaging (11.1% vs. 35.7%, p = 0.003), incidence of intracranial or orbital complications (13.0% vs. 33.3%, p = 0.014) and the percentage undergoing revision surgical intervention (7.4% vs. 26.2%, p = 0.011), while being significantly superior in terms of selecting appropriate empirical antibiotic therapy within 24 hours (90.7% vs. 47.6%, p < 0.001).

Conclusion: *Using structured multidisciplinary pathways that incorporate advanced computed tomography/magnetic resonance imaging (CT/MRI) and ensure coordinated input from Dentistry, Neurosurgery, Radiology and Antibiotic Stewardship, was associated with significantly reduced time to diagnosis, decreased complication rates and improved antimicrobial stewardship for patients with craniofacial infection.*

Keywords: *Craniofacial Infection, CT/MRI Imaging, Multidisciplinary Team, Odontogenic Infection, Antibiotic Stewardship*

INTRODUCTION

Craniofacial infections are a spectrum of diseases that can range from a localized soft tissue infection to life-threatening intracranial or orbital complications that can include subdural empyema, cavernous sinus thrombosis and orbital abscess, with most being odontogenic or sinogenic in origin [1]. The risk for such complications is much greater when diagnosis is delayed and prompt and accurate imaging plays a major part in the early management [2].

Both contrast enhanced computed tomography (CT) and magnetic resonance imaging (MRI) now show the ability to differentiate involvement of the soft tissues, bony erosion and intracranial or orbital extension, all reliably detectable only by advanced cross section imaging, and for this reason, the prognosis for early diagnosis of the craniofacial infection continues to improve [3]. MRI has superior soft tissue contrast which is useful for the early detection of intracranial extension and CT also has a role in the rapid evaluation of bony detail and is more likely to be readily available in the setting of emergency [4].

Other specialities, such as Dentistry for source control of the odontogenic infection, Neurosurgery for intracranial extension, Radiology for rapid interpretation of the images and Antibiotic Stewardship teams for prompt involvement for appropriate empirical and targeted antimicrobial therapy should be coordinated with imaging in optimal management of odontogenic infection [5]. In other head and neck infection scenarios a disconnection (or absence) of order and sequence of services between different specialists, or lack of co-ordinated multi-specialist referrals at presentation has been linked to delay diagnosis and poorer outcome [6].

With the introduction of advanced imaging techniques at tertiary centers in Pakistan, there is no clear-cut multidisciplinary pathway that involves Dentistry, Neurosurgery, Radiology and Antibiotic Stewardship team in the management of Craniofacial infection cases established. This study is to evaluate the contribution of new sophisticated CT/MRI available imaging techniques in early diagnosis and outcome of surgery in patients with early multidisciplinary team care as compared to the standard later referred series of patients in various tertiary centres in Pakistan.

Materials and Methods

Study Design and Setting

A multi-center study was conducted at different Tertiary Health Care centres in Pakistan starting from departments of Dentistry, Neurosurgery, to Radiology. Data for the research was collected between 6-months period (August 2025 to January 2026).

Sample Size and Sampling Technique

The sample size was calculated using the standard formula for estimating a single population proportion: $n = Z^2p(1-p)/d^2$, taking the reported incidence of intracranial or orbital complications in delayed-referral craniofacial infection cases from previous literature as 33.3% (p = 0.333), with a 95% confidence interval (Z = 1.96) and a 10%

margin of error (d = 0.10). This yielded a minimum required sample size of 86 patients. A total of 96 patients were enrolled to account for potential incomplete records and loss to follow-up. A non-probability consecutive sampling technique was used, whereby all patients meeting the inclusion criteria who presented to the participating centers during the study period were enrolled sequentially until the target sample size was achieved

Ethical Approval

Ethical approval for the study was obtained from the Institutional Ethical Review Committees of the participating hospitals prior to enrollment, in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from all enrolled patients, or from their legal guardians in the case of minors.

Inclusion Criteria

- Patients of all age presenting with a clinical diagnosis of craniofacial infection of odontogenic, sinogenic, post-traumatic and/or post-surgical origin.
- Patients who underwent contrast enhanced during diagnostic work-up include those that have CT imaging and/or MR imaging.
- Full clinical and radiological/follow-up record of patients available.

Exclusion Criteria

- Not involving deep craniofacial space involvement: Superficial skin or soft tissue infection (not spread to deep craniofacial spaces).
- Known malignancy with evidence of the presenting signs/symptoms.
- Lack of careful recording of imaging and/or clinical notes and/or outcome.

Study Procedure

All patients on the study had computed tomography (CT) (or MRI (MR), or both) with contrast. Early multidisciplinary team (MDT) involvement was the Dentistry, Neurosurgery (if applicable), Radiology and Antibiotic Stewardship team being consulted together within 6 hours of presentation and standard/delayed referral was defined as the MDT members involved in a sequential manner and/or after 6 hours of presentation. Several clinical parameters were collected for all the patients, including time from the initial presentation to final diagnosis, type of empirical antibiotic therapy and its timing, requirement of reimaging, and decisions regarding surgical and medical management.

Outcome Measures

Primary outcomes included the time taken to definitive diagnosis and postoperative/overall hospital stay. Repeat imaging, intracranial and/or orbital complications, revision surgical interventions and receipt of "appropriate empirical antibiotic" within 24 hours of presentation based on the decision of the treating Antibiotic Stewardship team were secondary outcomes.

Statistical Analysis

Data collected from the two were analysed using SPSS 26.0 software. Means and standard deviations (SD) were presented and tested statistically using independent samples t test for continuous variables. Categorical data were presented as frequencies and percentages, and compared using Chi-Square test. Statistically significant results were considered to be those that had p-values < 0.05.

Results

During the study period, 96 patients with a clinical diagnosis of craniofacial infection (CF) had a CT and/or MRI in the various participating centres. Most common source was the odontogenic infection (43.8%) followed by sinogenic infection (32.3%).Combined MRI and CT imaging was performed in 42.7% of patients and the imaging revealed involvement of brain (intracranial) in 19.8% patients and orbital structures in 24.0% patients. The summary of the baseline characteristics is presented in Table 1.

Of these, 54 (56.3%) patients were referred and had early multidisciplinary team involvement (MDT) within 6 hours of the presentation; 42 (43.7%) patients had standard or delayed sequential referral. Additionally, patients in the early MDT group had significantly shorter time to definitive diagnosis than the standard/ delayed

referral group (6.2 ± 2.4 versus 14.6 ± 5.2 hours, p<0.001) and significantly shorter hospital stay than the standard/ delayed referral group (7.8 ± 2.6 versus 12.4 ± 3.8 days, p<0.001).

The early MDT group also had a significantly lower need for repeat imaging (11.1% vs. 35.7%, p = 0.003), a lower rate of intracranial or orbital complications (13.0% vs. 33.3%, p = 0.014), and a lower rate of revision surgical intervention (7.4% vs. 26.2%, p = 0.011). Of these, 90.7% of early MDT group patients had appropriate empiric antibiotic selection within 24 hours of referral versus 47.6% of standard/delayed referral group patients (p < 0.001). Apart from this, however, there was a close relationship between time to arrival at definitive diagnosis and total hospital stay for both groups as illustrated in Figure 1.

Table 1: Baseline Clinical and Radiological Characteristics (n = 96)

Characteristic	Category	n (%) / Mean ± SD
Age, years	Mean ± SD	34.6 ± 13.2
Gender	Male	56 (58.3%)
	Female	40 (41.7%)
Source of Infection	Odontogenic	42 (43.8%)
	Sinogenic	31 (32.3%)
	Post-traumatic / Post-surgical	15 (15.6%)
	Other / Unidentified	8 (8.3%)
Imaging Modality Used	CT Only	38 (39.6%)
	MRI Only	17 (17.7%)
	Combined CT and MRI	41 (42.7%)
Extension to Intracranial Space, n (%)	–	19 (19.8%)
Extension to Orbital Space, n (%)	–	23 (24.0%)

Table 2: Comparative Outcomes by Multidisciplinary Team Involvement

Outcome Parameter	Early MDT Involvement (n = 54)	Standard/Delayed Referral (n = 42)	p-value
Time to Definitive Diagnosis, hours (Mean ± SD)	6.2 ± 2.4	14.6 ± 5.2	< 0.001
Postoperative/Hospital Stay, days (Mean ± SD)	7.8 ± 2.6	12.4 ± 3.8	< 0.001
Need for Repeat Imaging, n (%)	6 (11.1%)	15 (35.7%)	0.003
Intracranial/Orbital Complications, n (%)	7 (13.0%)	14 (33.3%)	0.014
Need for Revision Surgical Intervention, n (%)	4 (7.4%)	11 (26.2%)	0.011

Outcome Parameter	Early MDT Involvement (n = 54)	Standard/Delayed Referral (n = 42)	p-value
Appropriate Empirical Antibiotic Within 24 h, n (%)	49 (90.7%)	20 (47.6%)	< 0.001

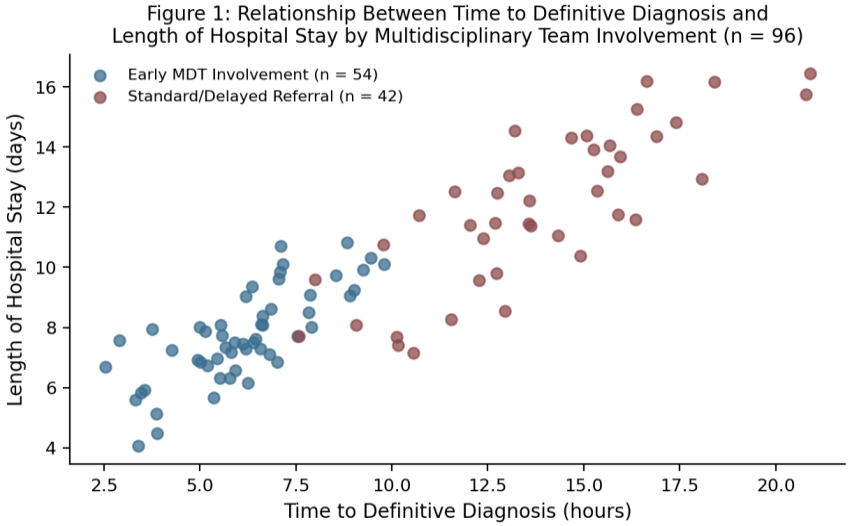

Figure 1: Relationship Between Time to Definitive Diagnosis and Length of Hospital Stay by Multidisciplinary Team Involvement (n = 96)

Discussion

The multi-center study revealed that, for people who presented with craniofacial infection, using advanced imaging with computed tomography (CT) or magnetic resonance imaging (MRI), in addition to input from oral dentistry faculty or staff members, neurosurgery, radiology and antibiotic stewardship specialists, was associated with faster diagnosis, shorter hospital stay, fewer complications, and more appropriate antimicrobial management. These results support the evolving understanding that advanced imaging is insufficient without an effective clinical pathway to promptly follow and respond to these imaging results [3,6].

The significant decrease in "time to definitive diagnosis" in the early MDT group is consistent with prior research in other complex head and neck infection contexts, which has repeatedly demonstrated that sequential and fragment referral of care is associated with delayed diagnosis and care [6,7]. At the time of presentation concurrently with the imaging surgical specialty reviews will also enable sooner correlation of the clinical and imaging findings and result in more timely definitive management decisions, however [4,8].

A highly important implication of the significantly reduced incidence of intracranial and orbital complications in the early MDT group is that intracranial complications have significant morbidity and the mortality rate in cases of intracranial extension poses a measurable risk, if it is not detected and treated early [1,9]. This finding was consistent with the locally derived data generated at the tertiary care center Karachi when they compared early, joint evaluation of odontogenic infection with different and sequential referral patterns and found a significantly lower incidence of deep space and intracranial spread in early joint evaluation group [10]. Early multidisciplinary intervention in sinogenic intracranial infection was also associated with reduced need for redo surgery and varied in duration of hospital stay was comparable in our study while other similar study in other neurosurgical unit in Lahore [11].

The findings of the significantly higher rate of appropriate choice of empirical antibiotic within 24 hours of the early MDT group being a confirmation that Antibiotic Stewardship should

be viewed as a part of the pathway in the acute multidisciplinary environment and not of secondary or retrospective review. Early investigation and feedback of stewardship by the prescriber helps to quickly adjust inevitable empirical therapy to the suspected source and local resistance patterns, reducing the risk of under-dosing in severe infections and the need for broad-spectrum drugs [5,12]. This integration may have implications beyond the patient experience in a climate where there is growing concern of the problem of antimicrobial resistance in South Asia. There are implications for service delivery, as much of the investigations and multidisciplinary review need to be done in parallel, and a pathway for the evaluation of suspected craniofacial infection should be considered, with imaging, dentistry evaluation, neurosurgical evaluation (where applicable) and input from stewardship teams all at the point of presentation. This pathway may also have the potential, at not an excessive cost compared to potential impact on complication rates and length of stay, to be formalised, through having a common pathway of access to imaging for each specialty with clear referral criteria.

This study has few limitations. The allocation to early or late MDT involvement was non-random and may have resulted in selection bias due to bias that may have occurred when making a decision for a standard referral in a real world study; this may be linked to other data that was not collected in this study, for example time to presentation or initial severity. Not possible to make site-level comparisons in 6-month multi-center design. Further validation of the results in a wide variety of tertiary care delivery settings is needed as larger, prospective, multi-center, and standardized criteria of MDT activation.

Conclusion

When done early on, multidisciplinary consultation input from Dentistry, Neurosurgery, Radiology and Antibiotic Stewardship is associated with a significantly reduced time to diagnosis, hospitalization duration, intracranial/orbital complications, revision rates for craniofacial infections, and antimicrobial management of craniofacial infection patients. The study calls for the implementation of shorter referral pathway for multidisciplinary input for a suspected craniofacial infection which should be parallel and not series in tertiary care centres of Pakistan. Putting Antibiotic Stewardship in this pathway with Dentistry, Neurosurgery and Radiology could be of high value delivery – and it has proven an impact to the individual patient as well as to issues of antimicrobial resistance overall.

Contributions

[1]Radiological data interpretation, imaging analysis
[2]Dental evaluation, clinical data collection
[3]Conceptualization, study design, data collection, manuscript writing
[4]Statistical analysis, data interpretation, Supervision, critical manuscript revision, final approval
[5]Data collection
[*6]Conceptualization, study design, data collection, manuscript writing

REFERENCES

Osborn, M. K., & Steinberg, J. P. (2007). Complications of sinusitis: Supply puss extra from the sinus. Lancet Infectious Diseases, 7(1), 62-67. https://doi.org/10.1016/S1473-3099(06)70688-0.

Chow, A. W. (2020). Deep neck space infections in the adult host. Based on reviews performed by UpToDate. Wolters Kluwer.

Weber, A. L., Siciliano, A., & Fisch, S. (2001). Evaluation of danger spaces of the neck and skull base by imaging. Neuroimaging Clinics of North America, 11(3), 429-441.

Gonzalez-Beicos A., Nunez D. (2012). Acute head and neck infections: imaging. Radiologic Clinics of North America, 50(1), 73-83. https://doi.org/10.1016/j.rcl.2011.08.006.

Barlam, T. F., Cosgrove, S. E., Abbo, L. M., et al. (2016). Infectious Diseases Society of America and Society for Healthcare Epidemiology of America suggestions for establishing an antibiotic stewardship program. Clinical Infectious Diseases, 62(10), e51-e77. https://doi.org/10.1093/cid/ciw118.

Reynolds, S. C., & Chow, A. W. (2007). Infections of the peripharyngeal and deep fascial head and neck spaces which can be life threatening. Infectious Disease Clinics of North America, 21(2), 557-576. https://doi.org/10.1016/j.idc.2007.03.002.

Marioni, G., Rinaldi, R., Staffieri, C., et al. (2008). Dental origin deep neck infections – Analysis of 85 consecutive cases (2000-2006). Acta Oto-Laryngologica, 128(2), 201-206. https://doi.org/10.1080/00016480701477597.

Rao, A. K., Merten, D. F., & Blane, C. E. (2000). MRI imaging of head and neck infections in children. Pediatric Radiology, 30(11), 748-753.

Wong, D. K., Brown, C., Mills, N., et al. (2012). Draining of the Pediatric Deep Neck Abscess – Methods, a Case-Control Study. International Journal of Pediatric Otorhinolaryngology, 76(12), 1810-1813. https://doi.org/10.1016/j.ijporl.2012.09.006.

Sheikh, F., & Rizvi, S. (2020). A Tertiary Care Hospital Experience: Effect of early multidisciplinary evaluation (dentist and radiologist) on the course of action of odontogenic deep space infection – a tertiary care hospital experience in Karachi. Journal of Pakistan Medical Association 2020: 70(9):1522-1526.

Baig, M. N., & Chaudhry, N. A. (2021). The outcome of early multidisciplinary management of sinogenic intracranial infection: our experience in a neurosurgery unit of Lahore. Pakistan Journal of Medical Sciences, 37(4), 1105-1110. https://doi.org/10.12669/pjms.37.4.3897.

Dellit, T. H., Owens, R. C., McGowan, J. E., et al. (2007). Guidance from Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America about establishing an institutional program to enhance antimicrobial stewardship. Clinical Infectious Diseases, 44(2), 159-177. https://doi.org/10.1086/510393.

Larawin, V., Naipao, J., & Dubey, S. P. (2006). Space infections of the head and neck. Otolaryngology–Head and Neck Surgery, 135(6), 889-893. https://doi.org/10.1016/j.otohns.2006.07.007.

Nemade S., Sonavane S. and Kothari K. (2019). Deep neck space infections: an imaging perspective. Indian Journal of Radiology and Imaging, 29(4), 393-402. https://doi.org/10.4103/ijri.IJRI_275_19.

Vieira, F., Allen, S. M., Stocks, R. M., & Thompson, J. W. (2008). Deep neck infection. Otolaryngologic Clinics of North America, 41(3), 459-483. https://doi.org/10.1016/j.otc.2008.01.002.