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ORIGINAL ARTICLE

The surgical management of severe dentofacial infections (DFI)—a prospective study

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Abstract

Background Dentofacial infections (DFI) lead to morbidity and, rarely, mortality.

Aim We hypothesised that certain clinical and laboratory parameters may be associated with a more severe course and an increased length of stay.

Method We designed a prospective study that included all patients admitted with a DFI to the Oral and Maxillofacial Department between July 2014 and July 2015.

Results A total of 125 were enrolled. We found that serum concentration of C-reactive protein (CRP) on admission and increasing number of fascial spaces involved by the infection were significant predictors of hospital stay ($p = 0.02$ and $p = 0.01$, respectively). The average length of stay for a dentofacial infection requiring admission was 4.5 days.

Conclusion Most patients require surgical intervention in combination with intravenous antibiotics for successful resolution. The serum CRP on admission and the increasing number of fascial space involvement can be effective predictors of increased length of stay. Improved and timely access to primary dental care is likely to reduce the burden for patients, their families and the acute hospital service as a consequence of advanced DFI.

Keywords Abscess · C-reactive protein · Fascial space · Infection · Odontogenic

Introduction

Dentofacial infections (DFI) lead to morbidity and rarely, mortality. Dental caries is the most common cause of DFI. An alteration in access to primary dental care in Ireland occurred in April 2010 due to a change in Department of Health regulations. A previous retrospective study confirmed an increase in the number of patients attending the acute hospital service with DFI related to this alteration in regulations [1].

Deep neck space infections occur in potential spaces defined by the anatomic location of deep cervical fascia. The incidence and severity of these infections has decreased with the introduction of improved dental care and with the introduction of antibiotics.

Spreading dental orofacial infections are potentially life-threatening. The airway may be compromised and there is also the potential for spread to the deep anatomical fascial spaces and the mediastinum [2]. Patients commonly present to oral and maxillofacial surgery units for the acute management of severe odontogenic infections [3]. There remains a reported mortality of 8% from deep cervical abscesses, despite early antibiotic and surgical management [2, 4].

In the UK, research has shown a dramatic increase in the number of patients requiring admission for the management of spreading dental infections following the alteration from the fee per item in 2006 to a banding system within the UK National Health Service [5].

The purpose of this prospective study is to identify the clinical presentation, surgical management and financial implications associated with the treatment of patients with DFI.

Methods

Data were prospectively collected on adult patients admitted with DFI to St. James' Hospital, from July 2014 to July 2015.

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Children [< 14 years] and non-odontogenic causes of infection were excluded. The following data were recorded: referral source, demographics, mouth opening, site of infection, pre-existing medical conditions associated with a potential for immunosuppression, diabetes mellitus status, admission white cell count (WCC) and C-reactive protein (CRP), imaging, microbiology, length of hospital stay, ICU admission, need for surgery and airway management technique. The Hospital Ethics Committee approved this prospective study and consent was waived as individual patients could not be identified.

Statistics

Data were analysed using SPSS® (v.23.0) software (SPSS, Chicago, IL, USA). Univariate comparisons between groups were performed using the Student *t* or Mann-Whitney *U* test for continuous or the χ^2 or Fisher exact test for categorical variables. For the multivariate analyses, all clinically relevant variables were inputted into a multivariate logistic regression model using a forward stepwise selection procedure was used to study the correlation of these variables to length of stay. Data are reported as mean ± standard deviation (SD) unless otherwise specified. All statistical analyses were two-tailed with the threshold of significance set at $p < 0.05$.

Results

One hundred and twenty nine patients were admitted to the National Oral and Maxillofacial Unit with a presentation of facial infection as follows: 4 (3%) presented with a non-odontogenic infection and 125 (97%) with odontogenic infection. Patients with non-odontogenic infection were excluded. The study population included 125 patients. There were 64(51%) males and 61(49%) females. The mean (SD) age was 35.9 (13.2) years (range 15–91).

The most common referral source was from acute hospital emergency departments 76 (61%) patients.

Seventy-five (60%) patients had trismus defined as a mouth opening (interincisal distance) measuring less than 30 mm. The average mouth opening was 21.7 mm (range 1–45). The average mouth opening for one fascial space involvement was 32 mm. If there were two or more spaces involved, this reduced to 20.3 mm.

Trismus on admission and length of stay were not found to have statistically significant positive correlation ($p = 0.35$; CI 0.14–0.38).

The fascial spaces involved were determined by both clinical examination (preoperatively and intra-operatively) and CT scans if scans were available. The number of fascial spaces involved averaged 1.4 (range 1–5). The total number of fascial spaces involved was 177 fascial spaces in 125 patients. The fascial spaces involved were buccal 56, submandibular 55, sub-masseteric 18, infraorbital 22, parapharyngeal 6 and other spaces 20. Eighty-four patients had one fascial space involved, with 33 having 2 spaces involved, a further 6 patients having 3 spaces involved, 1 involved 4 spaces and 1 patient having 5 fascial spaces involved. Table 1 shows the sites of infection. The number of spaces involved was a significant predictor associated with a prolonged hospital stay, ($p = 0.001$ (CI 0.395–1.33).

Table 1 Head and neck spaces involved in patients with odontogenic infections

Space	No. of patients
Buccal	56
Submandibular	55
Sub-masseteric	18
Infraorbital	22
Parapharyngeal	6
Other	20
No. of spaces affected	
1	84
2	33
3	6
4	1
5	1

The mean white cell count on admission was 11.5 (3.9–23×10^9/L) (reference range 4–11) and the mean C-reactive protein level (CRP) on admission was 91.2 (1–416 mg/L). There is a correlation between an elevated CRP on admission and increased length of hospital stay ($p = 0.02$, CI.15–1.73).

Microbiology sample was sent in 89/125 patients (Table 2). The leading pathogens cultured were from the *Streptococcus milleri* group (SMG) (36%) and anaerobic bacteria not otherwise specified (NOS) (20.2%).

All patients had panoramic radiographs and 21 (17%) had computed tomography of the head and neck.

One hundred and ten (88%) patients required surgical intervention, 86(69%) under general anaesthesia and 24(19%) under local anaesthesia. Fifteen (12%) patients were treated with intravenous antibiotics alone. Fibre-optic intubation was carried out in 58 (53%) patients. One patient required a temporary tracheostomy. Five patients (0.4%) patients required post-operative admission to the intensive care unit. They had an average mouth opening of 8.6 mm (range 1–10 mm). The

Table 2 Microbiology species cultured from odontogenic infections

Pathogens	
S. Milleri group, 32	*S. constellatus*, 16 *S. anginosus*, 14 *S. intermedius*, 2
Mixed oropharyngeal flora, 29	
Anaerobic organisms, 18	
Candida, 10	

number of fascial spaces involved was 2 (range 1–4). The average length of stay in ICU was 4 days.

The average length of stay in a hospital for patients with DFI was 4.5 (1–17) days.

This amounts to 562.5 bed days used in 1 year. The average cost per admission was calculated at Euro 6444. This was based on operating theatre use per hour, ward costs per day, ICU admission and theatre recovery time consumed. The estimated total cost was Euro 805,500 for DFI during the study period.

To investigate the association between the duration of stay and the predictor variables identified, we introduced a multivariate regression model that included a forward stepwise method. CRP and number of fascial spaces involved were the only significant predictors of hospital stay $p = 0.02$ and $p = 0.01$, respectively (Table 3). The adjusted R^2 value for this model, which was 0.215, meant that 21.5% of the variability of the duration of stay could be attributed to the CRP value on admission, and the number of fascial spaces involved has limited the predictive value of the regression.

Discussion

This study has identified that odontogenic infections are a significant source of morbidity. It is accepted that these infections also have the potential for mortality in the population. The study reviewed 125 patients over a 1-year period. An alteration in the access for patients to primary dental care since April 2010 and the resulting dental health burden placed on the population with medical card and DTBS entitlements have placed a barrier to patients receiving appropriate and timely primary dental care. This has resulted in a trend of increasing numbers of patients accessing the emergency department and ultimately requiring secondary- and tertiary-level care for the management of dental infections [1]. This pattern of clinical presentation and treatment of these patients has significant financial implications for the health service with the need for prolonged hospital and often ICU admission, investigations, advanced imaging and surgical care.

The most frequent source of referrals was from other acute hospitals. This highlights the need for improved access to primary dental care at an earlier point in the disease process, with more patients now attending the emergency departments of hospitals for treatment of their infection.

The presence of coexisting medical conditions can increase the risk of developing severe infection or sepsis. However, the majority of our patients had an unremarkable medical history, which highlights the unpredictable nature of odontogenic infections and again is indicative of advanced untreated dental disease. Peters et al., in a study of 128 patients, showed the underlying medical condition and the location of the infection to be the best predictors of length of hospital stay [6]. Our conclusion is supported by Ylijoki et al. in that they found systemic disease more common in those not treated in intensive care [7].

The clinical examination is critical in the initial assessment of these patients with reference to the severity of the infection and the potential for airway compromise. Restricted mouth opening is an important predictor of the difficulty of intubation and also for surgical access. Trismus was identified in 60% ($n = 75$) of the patients; therefore, early consultation with anaesthetic colleagues is mandatory in order to avoid the potential of airway embarrassment. The trismus on admission and the length of stay were not found to have statistically significant positive correlation.

The location of the infection is also important with the buccal and submandibular space being most frequently involved which is expected, given the anatomic relationship to the roots of the posterior mandibular molar teeth. If more than one fascial space is involved by the infection, there was reduced mouth opening and therefore difficult general anaesthetic and operative access. The number of fascial spaces involved ranged from one to five. The study data confirmed the more spaces that were involved the more severe the trismus. This has implications for the anaesthetist. If the surgeon informs them that two or more fascial spaces are involved, there is increased need for fibre-optic intubation and the need for a consultant anaesthetist with expertise in this area, due to the likely decreased mouth opening which accompanies this. The increased number of fascial space involvement is significantly associated with increased length of stay. This is in keeping with Stathopoulos et al. which showed that odontogenic infections involving more than two fascial spaces increased the length of stay [8].

The white cell count on admission did not have a statistically significant increase in the length of hospital stay. This was in contrast with previous research [9]. However, with less than half of the study population showing a leucocytosis (48%) on admission, the importance of good clinical

Table 3 Predictor variables of length of stay on multivariate logistic regression analysis

	p value
C-reactive protein	0.02
Number of spaces involved	0.01
Anaesthetic required	0.06
Smoker	0.13
Mouth opening in millimetres	0.35
Temperature	0.36
Initial WCC	0.46

$R = 0.52$; $R^2 = 0.271$; adjusted $R^2 = 0.215$

Unstandardised beta coefficient (constant) = 1.51; 95% CI − 0.28 to 3.3

Unstandardised beta coefficient (CRP) = 0.94; 95% CI 0.15 to 1.73

Unstandardised beta coefficient (number of fascial spaces) = 0.86; 95% CI 0.39 to 1.32

examination is emphasised. Further analysis is required to rationalise whether white cell count is most useful in assessing improvement or regression of a patient's response to therapy, rather than as a predictor of actual patient status.

An elevated CRP on admission was shown to have a significant increase in the length of hospital stay. CRP is an acute-phase protein that is present in only small amounts in healthy people, and its serum concentration rises considerably as a reaction to severe infections within a few hours of the onset of symptoms [10]. A high CRP has been strongly associated with severity of odontogenic infections [7].

The increased use of CT in relation to odontogenic infection is indicative of the increased concern for potential airway compromise. There is a requirement for increased access to CT, which has significantly improved both surgical and anaesthetic knowledge in relation to the extent of the infection and difficulty of intubation. However, it also highlights the increased use of a valuable resource and subsequent radiation exposure to treat an essentially preventable disease, that is, caries.

The microbiology results are in keeping with other studies [11, 12]. The leading pathogens cultured were from the *Streptococcus milleri* group (SMG) (36%) and anaerobic bacteria not otherwise specified (NOS) (20.2%). SMG bacteria are known to consist of *Streptococcus intermedius*, *Streptococcus anginosus* and *Streptococcus constellatus*. They can be aggressive pathogens, causing abscess formation in various sites of the body. All patients infected with SMG bacteria responded well to amoxicillin-clavulanic acid, or clindamycin. Routine susceptibility testing for anaerobes was not available under current testing standards at our centre. Nevertheless, anaerobic bacteria NOS were expected to respond to anti-anaerobic antibiotics like amoxicillin-clavulanic acid, clindamycin and metronidazole.

In 12% ($n = 15$), surgical intervention was not required. However, patients were admitted for the administration of the antibiotics and the monitoring of vital signs and supportive care. The average length of stay was 3.9 days. Burnham et al. in 2011 highlighted the over-prescription of antibiotics by non-dental-trained health professionals in the UK, without adequate follow-up or intervention [5]. Ideally, dental abscesses should be seen and managed early in the community with oral antibiotics and treatment of the cause with extraction or drainage if needed. The patient should then be reviewed to ensure the infection has not progressed to a cervicofacial infection [3, 12].

The majority of patients ($n = 110$) in this study population required surgical intervention, either formal incision or drainage of the abscess alone ($n = 16$), with extraction of the offending teeth ($n = 94$). The average length of stay for those patients requiring incision and drainage of their abscess, was 4.8 days and for those with extraction of the offending tooth combined with incision and drainage was 4.6 days. Extraction of the offending tooth leads to a faster clinical resolution of the infection. It has been shown that operating room use is a strong predictor of hospitalisation duration [13, 14].

The length of stay in a hospital (LOS) is a crucial variable for the quality of life of all patients and their families. The average length of stay in our cohort of patients was 4.5 days. Patients usually remain hospitalised until the infection resolves or are controlled, and the patient has returned to their baseline functional status. It has been reported that patients with a length of stay of greater than 4 days may be associated with an unfavourable outcome [6, 15].

It was also found that location of infection had a significant impact on length of stay [10]. Patients seriously ill from these odontogenic infections can require admission to an ICU for airway management and other supportive care. Death from isolated dental infection is rare but progression to Ludwig's angina increases the risk of mortality recognised at 10% [3, 15–17]. Early aggressive surgical drainage, with adjunctive intravenous antibiotics and supportive care, is critical to ensuring successful treatment. Infections involving the masticator spaces will not open upon induction of anaesthesia as there is a mechanical obstruction to mouth opening and is not restricted by pain. This is of vital importance to anaesthetists and good communication between surgeon and anaesthetist prior to induction of anaesthesia is essential. Five patients (0.4%) patients required post-operative admission to the intensive care unit. The number of fascial spaces involved was 2 (range 1–4). The average length of stay in ICU was 4 days (range 2–8).

Conclusion

There is significant health service expenditure dedicated to the treatment of patients with DFI. The serum CRP on admission and the increasing number of fascial space involvement can be effective predictors of increased length of stay. The average length of stay for a dentofacial infection requiring admission was 4.5 days. Most patients require surgical intervention in combination with intravenous antibiotics for successful resolution. Improved and timely access to primary dental care is likely to reduce the burden for patients their families and the acute hospital service as a consequence of advanced DFI.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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