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Factors Contributing to the Spread of Odontogenic Infections

A prospective pilot study

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العوامل المؤدية إلى انتشار التهابات الأسنان

دراسة استباقية ارتيادية

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الملخص: الهدف: يعد انتشار الالتهابات السنية من أكثر الالتهابات خطورة في منطقة الفم والوجه. تم القيام بدراسة استباقية متعددة المراكز في مقاطعة غرب اسكوتلاندا للتحقق من دور العوامل الاجتماعية والبدنية والجرثومية في حصول وانتشار التهابات الأسنان. **الطريقة:** تم دراسة 25 مريضا مصابا بالتهابات الأسنان الشديدة خلال فترة 6 أشهر. عند دخول المستشفى شمل التقييم الطبي الأولي ارتفاع درجة حرارة الجسم وفحوصات الدم والفحوصات الكيماوية الحياتية . تم جمع البيانات السكانية والاجتماعية والطبية للمرضى. تم أخذ العينات الجرثومية لدراسة الجراثيم المسببة بالإضافة إلى تسجيل الطريقة الطبية المستخدمة في علاج الالتهابات لكل مريض. **النتائج:** معظم الالتهابات كانت لها علاقة بالأسنان أو بجذور الأسنان.كان 80% من المرضى من المدخنين و 72% منهم كانوا من سكان أحياء فقيرة. خمسة مرضى كانوا يتعاطون المخدرات عن طريق الوريد. وأربعة مرضى مدمنون على الكحول. وستة مرضى مصابون بأمراض بدنية واثنان معرضان لسوء التغذية . ارتفاع مستوى البروتين المتفاعل (ج) عند دخول المستشفى كان مؤشرا مفيدا لتقييم شدة الالتهاب. سوء استخدام المضاد الحيوي سابقا بدون إزالة سبب الالتهاب كان شائعا في هذه الدراسة. تشير نتائج زراعة جراثيم الالتهابات إلى عدة جراثيم لاهوائية خاصة العقديات اللا هوائية والبريتوفيللا والمغزلية. . **الخلاصة:** انتشار الالتهابات السنية لا يزال شائعا وأظهرت الدراسة الارتيادية الحالية إلى وجود علاقة وثيقة مع حالة الفقر الاجتماعي والتدخين. زيادة التحقق من دور سوء التغذية في انتشار الالتهابات السنية سيكون مستحبا. الوصف الجزيئي للجراثيم المسببة لالتهابات الأسنان سيساعد على إيضاح فيما إذا كانت العوامل البكتيرية لها دور في تحويل خراج الاسنان الموضعي إلى التهابات منتشرة و خطيرة.

مفتاح الكلمات: التهاب الأسنان، الجراثيم اللاهوائية، مضاعفات.

ABSTRACT: ***Objectives:*** Spreading odontogenic infections (SOI) are the commonest type of serious infections encountered in the orofacial region. A prospective multi-centre study was conducted in the West of Scotland to investigate the contributing role of social, systemic and microbial factors in the pathogenesis of SOI. ***Methods:*** Twenty-five patients with severe odontogenic infections were recruited over a period of six months. At admission, clinical assessment included temperature rise, haematological and biochemical investigations. Demographic data, social and past medical histories were obtained. Microbiology samples were collected to identify causative microorganisms and the clinical management of each infection was recorded. ***Results:*** Most infections were associated with teeth or roots. Eighty percent of the patients were tobacco smokers and 72% came from deprived areas. Five patients were intravenous drug users, four admitted chronic alcohol abuse, six had underlying systemic disorders and two were at high risk of malnutrition. A raised C-reactive protein at admission was a useful indicator of the severity of infection. Inappropriate prior antibiotic treatment in the absence of surgical drainage was common. Microbiology results showed a predominance of strict anaerobes, notably anaerobic *streptococci, Prevotella* and *Fusobacterium* species. ***Conclusion:*** SOIs remain surprisingly common and our present pilot study showed a particular association with social deprivation and tobacco smoking. Further elucidation of the role of malnutrition in SOI would be of interest. Molecular characterisation of the microflora associated with SOI may help to highlight whether bacterial factors play a role in converting a localised dentoalveolar abscess into a serious, spreading odontogenic infection.

Key words: Dental focal infection; Anaerobic bacteria; Complications.

Advances in Knowledge

1. *The study shows that spreading odontogenic infection (SOI) has a particular association with social deprivation and tobacco smoking.*
2. *Molecular characterisation of the associated microflora may help to determine the pathogenicity of the microorganisms involved in SOI.*
3. *The study stimulates the need to conduct futher studies into the role of social and systemic factors in the pathogenesis of SOI.*

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Application to Patient Care

1. *Raised C-reactive protein level at admission was a useful indicator of the severity of SOI compared to white cell counts.*
2. *The microbiology of SOI is mixed in nature with a predominance of strict anaerobes.*
3. *The management of SOI includes: airway monitoring, surgical draining with removal of causative agent and administration of empirical antibiotics.*

Spreading odontogenic infections (SOI) are the commonest type of serious orofacial infection encountered by oral and maxillofacial surgeons.[1-3] Although the incidence of these infections has decreased over the past few decades, they do still occur and expeditious early management is required to prevent or minimise the development of potentially serious complications such as airway obstruction.[2,4,5]

There have been relatively few studies of the factors contributing to the spread of odontogenic infections, but local, systemic and social factors are believed to play a role.[2,5,6] While there is a considerable understanding of the influence of local factors, such as the anatomic location of teeth and the surrounding facial planes,[2, 5] there is limited literature on the contribution of other factors such as poverty, deprivation, smoking and substance abuse, which may all play contributory roles in the development and severity of such infections. Furthermore, there is also a limited literature on the role of systemic factors in the spread of odontogenic infections. In 1992, Helfrick and Kelly[6] proposed 13 risk factors, which were associated with increased potential for complications in odontogenic infections. Among these factors was the presence of co-existing major systemic disease that puts the patient into an American Society of Anesthesiologists (ASA) classification of II, III or IV. In addition, systemic conditions that interfere with normal healing processes and haemostasis were highlighted as risk factors, including diabetes mellitus, bleeding dyscrasias, steroid therapy, immune suppression and malnutrition. It is also recognised that patients with pre-existing medical conditions often suffer from more serious SOI and have an increased length of hospital stay.[7-9]

Published data describing the microbiology of SOI, highlight their polymicrobial nature,[10-12] which is similar to localised dentoalveolar infection. However, a higher incidence of *Fusobacterium* and *Bacteroides* species has been reported in spreading infections.[10] There is also a higher prevalence of *Streptococcus milleri* (now classified as the *anginosus* group of oral *streptococci*) in severe odontogenic infections.[10, 13] The combination of *Streptococci milleri* and *Fusobacterium* species has also been reported in life-threatening SOI, highlighting the important concept of bacterial synergism.[10, 14, 15]

To date, we are unaware of any published work that has looked prospectively at factors which contribute to SOI. Addressing such factors could be of great importance in the prevention and management of these infections. To address this gap in our knowledge, a prospective pilot study was devised to investigate the role of social factors (such as deprivation, smoking, alcohol and drug abuse), systemic factors (including malnutrition and underlying systemic disease) and the microbiological flora in the pathogenesis of SOI.

Methods

This prospective multi-centre pilot study was conducted in the West of Scotland Oral & Maxillofacial Service Centres, United Kingdom. Patients presenting with SOI at the above centres for treatment, from February to July 2003, were included in this study. The hospitals involved were Glasgow Dental Hospital & School, Canniesburn Hospital, Victoria Infirmary, Western Infirmary, Glasgow Royal Infirmary, Crosshouse District General Hospital, Monkland's District General Hospital and Yorkhill Royal Hospital for Sick Children. Ethical approval was obtained from the respective Research Ethics Committees in the participating hospitals. Patients with SOI which involved one or more fascial spaces were enrolled. Patients requiring treatment under local or general anaesthesia were eligible for inclusion. All patients gave informed consent before enrolment into the study.

At admission, demographic data were collected for each patient together with social and past medical histories. The deprivation category for each was obtained by utilising the postcode area

Table 1: Simple Nutritional Screening Tool

Risk Factors	1 Point	2 Points	Score
BMI - Adult (< 64 yrs of age)	17-18.4	<17	
- Elderly (> 65 yrs of age)	21-23.9	<21	
Albumin	28-35g/l	<28g/l	
Total score of tool 0 - 1 point = low risk of PEM 2 - 4 points = high risk of PEM			Total Score

Legend: BMI = body mass index; PEM = protein energy malnutrition

of the patient and the Carstairs scores for Scottish postcode sectors from the 1991 census.[16] Category 1 refers to the most affluent and Category 7 to the most deprived areas. A full history of the current complaint was collected, including duration and any recent treatment. Alcohol intake was measured in units per week. Acceptable limits were as 21 units/week for males and 14 units/week for females. Smoking history was quantified by pack per year (PY), quantified as "number of cigarettes x number of smoking years/20".

The temperature on admission was recorded for all patients. The source of infection was identified, together with the facial spaces involved. Trismus was recorded on a four point scale from none to severe (< 10mm), and pain was assessed by each patient using a visual analogue scale.

Venous blood was collected from each patient for a full blood count, haematinics (vitamin B12, folate and ferritin), serum proteins (albumin, prealbumin, transferring globulins and total proteins), random blood glucose, liver function test, and C-reactive protein (CRP).

The weight in kilogrammes and height in metres were recorded in order to calculate the body mass index (BMI). The risk of protein energy malnutrition was assessed by means of the Simple Nutritional Screening Tool (SNST), which utilises the body mass index (BMI) and serum albumin level to provide a score of 0-4 [Table 1].[17] Individuals with a score of 2-4 are categorized as at high risk for protein energy malnutrition.

During the surgical management of the infection, a note was taken of whether an emergency airway was needed, of the method of drainage and any antibiotics prescribed. In addition, pus samples were obtained for microbiological investigations. A note was taken of whether antibiotics had been administered prior to sample collection. Before sampling, the oral mucosa was disinfected with 0.2% chlorhexidine gluconate solution (Corsody1, SmithKline Beecham Healthcare, UK) and the skin was disinfected with a 10% alcoholic solution of povidone-iodine (Betadine, Seton, England). Sampling was accomplished either intra-orally through intact oral mucosa or extra-orally through intact skin, using a sterile, disposable 5ml syringe (Plastipak™, Becton Dickinson, Spain) through a gauge-21 needle (Microlance, Becton Dickinson, Spain). In cases where no pus could be aspirated, sampling of sero-sanguinous fluid was undertaken using a sterile transport swab (Probact, Technical Service Consultants Ltd, UK).

A direct Gram-stained smear was prepared from each aspirate. Each specimen was then inoculated onto Columbia blood agar for incubation in 5% CO_2 at 37°C and onto fastidious anaerobe agar (BioConnections, Wetherby, UK) with 7.5% horse blood for anaerobic incubation at 37°C. Plates were incubated for 48 hours and purity plates prepared of each morphological colony type. Isolates were identified according to standard laboratory techniques and antimicrobial drug susceptibilities determined by the Stokes method.

Results

Of the 25 patients who participated, 16 (64%) were male. The age range of the study patients was 8-57 years (mean 28.7 years), of whom 36% were in the 21-30 year age group. Thirteen patients (52%) were categorised in the deprivation category 7 and a further 10 patients (40%) divided equally between deprivation categories 5 and 6. One patient was in each of the deprivation categories 1 and 2. Twenty patients (80%) were active smokers. The mean PY for smokers was 17.2 with a range from 0.5 to 80 PY. Of the 16 male patients, 11 were smokers; all of the

Table 2: Type of antibiotic prescribed to patients (n = 17) prior to admission

Antibiotic used	Number (%)
Amoxycillin	5 (29.4%)
Erythromycin	4 (23.5%)
Penicillin	2 (11.8%)
Metronidazole	1 (5.9%)
Amoxycillin and metronidazole	4 (23.5%)
Penicillin and metronidazole	1 (5.9%)

female patients smoked. The mean PY for females was 19.5 and for males were 15.1, but the difference was not statistically significant. Seven patients (28%) reported no alcohol intake. Fourteen of the remaining 18 patients reported alcohol intake within acceptable limits. Four patients (16%) consumed more than 25 units of alcohol per week. Five patients (20%), of whom three were male, gave a history of previous or current recreational intravenous drug use (IVDU). All these five patients were also active smokers. Six patients (24%) suffered from an underlying medical condition. One had drug-controlled diabetes mellitus; one was hypertensive and taking atenolol; two were asthmatic controlled with prednisolone, becotide 100 and ventolin and two had iron deficiency anaemia. According to the SNST, two patients were at high risk of protein energy malnutrition, with SNST scores of 3.

All of the patients presented with pain and swelling. Most (92%) also had fever and trismus. Sixteen (64%) patients had dysphagia and three (12%) were suffering respiratory distress. Twenty-two (88%) patients had a combination of hard and fluctuant areas of swelling, cellulites and a discharging sinus. The mean duration of infection was 3 days (range 1-10 days). Previous episodes of infection were reported by 48% of the patients. Eight patients (32%) gave no recent history of antibiotic use. Seventeen patients (68%) were on oral antibiotics at admission. These had been prescribed by a general medical practitioner in 13 cases (77%) and by a general dental practitioner in four cases (23%). Amoxicillin, both singly and in combination with metronidazole, was the most commonly prescribed antibiotic [Table 2].

Each case of SOI was categorised by the fascial space or spaces involved, as described by Laskin.[5] In 14 patients, multiple fascial spaces (up to a maximum of 5) were involved. The buccal space was the most commonly involved fascial space (96%), followed by the submandibular space (68%) [Table 3]. The most common source of infection was carious teeth and roots (88% of cases). In two patients, the infection was post-extraction, one after surgical removal of a wisdom tooth and the other following multiple extractions of grossly carious deciduous molars. The source of infection was an impacted wisdom tooth in one elderly patient. The mandibular posterior teeth were the most common source of infection (64%), particularly the first and second molars, followed by the upper anterior teeth (16%).

All patients were managed by incision and drainage, removal of the source of infection and antibiotics. Twenty-two patients were managed as in-patients and the remaining three as out-patients. All patients underwent surgical drainage within 24 hours of initial presentation. Five of the in-patients and three outpatients were managed under local anaesthesia (LA). Seventeen in-patients received surgical drainage under general anaesthesia (GA), three of whom required further surgical drainage, two under LA and one patient, with diabetes mellitus, requiring a second GA to establish adequate drainage. All patients received a combination of two antibiotics. Those treated as in-patients received intravenous antibiotics. Metronidazole was prescribed to all 25 patients. The choice of second antibiotic was variable. Cefuroxime (10 cases) and augmentin (6 cases) were the most commonly prescribed agents. Two patients received benzyl penicillin, four amoxicillin and one flucloxacillin. Erythromycin was used in two cases for patients who were allergic to penicillin, although two patients who received cefuroxime were also allergic to penicillin. Four patients (16%) required airway control. Three of these patients had a compromised airway with difficulty breathing at admission; one had an extensive swelling with a potential risk of airway obstruction. As a secure method of airway control, three patients had a tracheostomy under general anaesthesia and one had an endotracheal intubation over a period of four days. The mean period of hospitalisation for the 22 in-patients was 4.2 days (range 1-16 days).

Investigations at admission revealed that twenty-three patients (92%) had pyrexia (> 37°C)

Table 3: Frequency of involvement of fascial spaces in SOI (25 patients)

Spaces	Frequency (%)
Buccal	24 (96%)
Submandibular	17 (68%)
Submasseteric	9 (36%)
Sublingual	7 (28%)
Lateral Pharyngeal (Parapharyngeal)	4 (16%)
Submental	3 (12%)
Canine	2 (8%)
Pterygomandibular	1 (4%)
Retropharyngeal	1 (4%)

on admission. The mean temperature was 37.9°C (range 37.2-39°C). Haematological investigations found that the range of white cell counts (WBC) was 7.9 - 20.9 x 10/L (mean 13.2 x 10/L). The mean haemoglobin (Hb) level was 13.5g/L (range 10.1 - 16.6g/L), and within the normal range for age and sex in all but five patients. Two of these patients had an associated low serum ferritin indicative of iron deficiency anaemia. No patients demonstrated reduced vitamin B_{12} or folate levels. Biochemical investigations revealed that the level of CRP was raised in all patients (mean 126.9 mg/L; range of 20-393 mg/L). The mean CRP level was higher in females (154.3 mg/L) than males (115.5 mg/L), but the difference was not found to be statistically significant. Liver function tests were normal in 24 patients. One patient, who reported high alcohol consumption, demonstrated raised serum aspartate aminotransferase (AST) and serum alanine aminotransferase (ALT) liver enzymes levels.

Microbiology samples from 13 patients were processed at the Specialist Oral Microbiology Diagnostic Laboratory at Glasgow Dental Hospital (GDH). The remaining 12 samples were processed in the general medical microbiology laboratories at three of the other hospitals participating in the study. Due to variation in the standard operating and reporting procedures of the four laboratories, results could not be compared directly. For this reason, microbiology data are only presented for the 13 specimens that were processed in the specialist oral microbiology laboratory. One of the 13 samples provided no growth. This patient had been taking antibiotics for more than five days. Of the remaining 12 samples, three yielded growth of anaerobes only and nine were mixtures of aerobic and anaerobic bacteria. Table 4 shows the bacteria isolated from the 12 remaining samples. The ratio of anaerobes to aerobes/facultative anaerobes was 2:1. Among the aerobes/facultative anaerobes, microorganisms from the *anginosus* group of *streptococci* were the most commonly isolated organisms, accounting for six isolates (35.5%). Anaerobic bacteria, notably anaerobic *streptococci*, *Prevotella*, and *Fusobacterium* species were the most frequently isolated obligate anaerobes. The average number of bacterial species per sample was 4.3. Antibiotic sensitivity tests showed that erythromycin resistance was encountered in three patients with five resistant microorganisms (*Streptococcus constellatus,* two *Prevotella* species*, Fusobacterium nucleatum* and *Haemophilus parainfluenza*e). Penicillin resistance was also encountered in two patients with three different microorganisms, two strains of *Bacteroides* species and one strain of *Fusobacterium* species. A cefuroxime-resistant *Bacteroides* species was encountered in one patient [Table 4]. Metronidazole was active against all isolates of strict anaerobes.

Discussion

The spread of odontogenic infections through fascial spaces can result in significant morbidity and risk of mortality if clinical management is inappropriate.[1,4] An understanding of the infection process, risk factors and the microbiology of these infections is of importance if effective clinical protocols are to be developed.

The predominance of male patients with SOI identified in this study has been reported by others,[3,18] although this predominance has been less marked in other series.[10,12] We identified a broad range of ages of patients, from 8 to 57 years (mean 28.8 years), with 36% of patients in the 21-30 year group. This finding compares well with other studies.[8, 12, 14]

Har-El *et al.,* in a retrospective study of 110 patients with deep neck abscesses, reported a high incidence of infections in socially deprived patients.[9] In the present pilot study, we used the Carstairs Scores for Scottish Postcode Sectors (CSSPS) to assess the Deprivation category and

Table 4: Bacteria cultured at Glasgow Dental Hospital from 12 pus samples of spreading odontogenic infections

Bacteria isolated	No. of times isolated
Aerobes/Facultative anaerobes	
Streptococcus anginosus	5
Streptococcus constellatus	1
Streptococcus oralis	2
Streptococcus parasanguis	1
Streptococcus mitis	1
Streptococcus sanguis	1
Streptococcus sobrinus	1
Streptococcus salivarius	1
Haemophilus parainfluenzae	2
Actinomyces naeslundii	1
Eikenella corrodens	1
Total Aerobes/Facultative anaerobes	**17**
Anaerobes	
Anaerobic *streptococci*	8
Fusobacterium nucleatum	2
Fusobacterium species (unspecific)	4
Prevotella intermedia	2
Prevotella oralis	2
Prevotella loeschii	1
Prevotella buccae	2
Prevotella melaninogenica	1
Prevotella dentocola	1
Bacteroides ureolyticus	1
Bacteroides capillosus	1
Bacteroides species (unspecific)	2
Veillonella species	4
Propionibacterium propionicum	1
Propionibacterium acne	1
Bifidobacterium species	1
Total anaerobes	**34**
Total bacteria isolated	**51**

thereby the socio-economic status of our patients. The CSSPS has been widely used as a method of recording the deprivation category for many epidemiological studies, including the Scottish Boards Dental Epidemiological Programme.[16] Based on this system we observed a high incidence (72%) of SOI among patients living in deprived areas (Deprivation categories 6 and 7).

There is evidence in the literature supporting the role of smoking in the pathogenesis of periodontal disease.[2] In the present study there was a high prevalence of smokers among those with SOI. It is unclear whether this is an indirect reflection of health neglect or a more subtle influence of tobacco smoking on immune responses to odontogenic infection. This area is worthy of future study.

A few case studies have reported SOI in IVDU.[2,3,19] Five patients (20%) with SOI in the present study were IVDU, four of whom were on a methadone programme. Methadone, which is widely used in the United Kingdom for patients undergoing rehabilitation from opioids addiction, is frequently delivered orally in the form of a sugar-containing syrup. This high sugar content can result in the development of rampant caries in patients with poor oral hygiene.[20] Four patients were categorised as alcohol users, with an average intake of >25 units/week. None had clinical symptoms of liver disease, although one had elevated liver enzymes levels.

Six patients (24%) had an underlying systemic disease. The association between underlying medical conditions or immunosuppressive treatments, such as diabetes mellitus and steroid therapy, and the risk of SOI is well documented.[2, 6, 9, 19] The association between nutritional deficiencies and immune deficiency is also recognised.[21] However, to our knowledge there have been no studies of malnutrition in relation to SOI. In the light of the high level of deprivation for many of the patients in this study, the role of nutritional status is worthy of examination. Detailed assessment of nutritional status for the patients recruited in this study proved difficult. Initial attempts involved making a number of measurements, tests and completion of a detailed dietary questionnaire, all of which were logistically very difficult with acutely ill patients. Instead, the Simple Nutritional Screening Tool was used, which required only height, weight and serum albumin estimation. Two patients were identified by this method to be at high risk of protein energy malnutrition. This preliminary finding suggests that a carefully constructed and controlled study of nutritional factors in SOI would be worthwhile.

At initial presentation, the mean duration of

symptoms for our sample of patients was 3 days, ranging from 1-10 days. Krishnan *et al.*, in a review of 50 maxillofacial infections, stated that most of their patients had presented with symptoms of at least one week in duration.[22] Ylijoki *et al.* reported that dental pathology caused by carious or periodontally involved teeth was the commonest cause of SOI, accounting for 74% in a sample of 100 patients.[19] Post-extraction was the second most common cause (15%) followed by pericoronitis related to impacted third molars (9%), and infected dental cysts (2%). Our findings are in agreement with this and other studies.[19,22] Our finding that the molars were the most commonly involved teeth in SOI also accords with previously published studies.[6,8,12,23]

Odontogenic infections usually spread from the structures supporting the teeth along the path of least resistance to involve the potential fascial spaces of the head and neck.[5] In the current study, we observed that the offending teeth showed an obvious relationship to the adjacent anatomical spaces involved in the infection. The buccal space was the most frequently involved space (96%), followed by the submandibular space (68%) and the submasseteric space (36%). This finding contradicts earlier reports that the submandibular space is the most frequently involved in SOI.[10,22] While our study identified a different order of the frequency of involvement of fascial spaces, we found a much higher proportion of submandibular and buccal space infections than previously reported.[8, 19]

Many published reports have indicated that most patients with SOI were on antibiotics at admission.[6,7,14,22] Furthermore, Ylijoki *et al.*[19] observed that 55% of a sample of 100 patients with SOI had received antibiotics prior to hospitalisation, most commonly a combination of penicillin and metronidazole. Our results were similar, but with a much higher observed percentage of antibiotic use on admission (68%) than previously reported.[7,10,19] These antibiotics were prescribed by general medical practitioners for 77% of patients and by general dental practitioners for 23% of patients. This observation highlights the willingness of patients with SOI to visit their medical rather than dental practitioner, and the inappropriate use of antibiotics in primary care for the management of odontogenic infection, as opposed to establishing adequate surgical drainage.

It is widely accepted that antimicrobial agents should not be considered as a substitute for surgical intervention in the management of SOI.[1-3,5] The protocol of the West of Scotland Oral & Maxillofacial Services for the management of SOI consists of both early surgical and medical intervention, in agreement with other published protocols.[12, 23] However, there was no clear antibiotic prescribing protocol within these surgical units for the management of SOI. All the patients received metronidazole in combination with another antibiotic, of which cefuroxime was the most frequently prescribed (40%), followed by augmentin (24%) and amoxicillin (16%). This pattern of antimicrobial use reflects the polymicrobial nature of SOI, which typically includes the anaerobic bacteria.[1, 22]

At admission, an elevated temperature was observed in 23 (92%) patients, with a mean temperature of 37.9°C, ranging from 37.2 to 39°C. Many others have reported fever on admission[7,12,23] an expected finding in patients with infections of the severity described in these studies.

Various haematological and biochemical tests were undertaken to provide a comprehensive clinical assessment of the patients. Traditionally, the white blood cell count, erythrocyte sedimentation rate and admission temperature have been used to monitor the progress of infectious diseases.[7] However, the WBC may react slowly to bacterial infections.[24] In our study, the mean WBC was 13.2 x 0^9 /L with a range between 7.9 - 20.9 x 10^9 /L, similar to earlier studies.[7,12,4,19] Clearly the WBC at admission is normal or only slightly raised in many patients with SOI. Heimdahl *et al.*[14] concluded that the WBC is of minor importance when judging the severity of orofacial infections, a view that the present study would support. The WBC is perhaps more useful in assessing a patient's response to therapy.

Levels of CRP are widely used to aid the diagnosis and to monitor many infections such as pneumonia, septic arthritis and acute meningitis.[19] However, CRP levels in odontogenic infections have not been widely studied. Boucher *et al.* reported that high CRP values were associated with acute dental abscesses.[25] Ylijoki *et al.* suggested that CRP levels may be useful in the clinical assessment of patients with SOI.[19] In their prospective study of 100 patients with SOI, they reported a mean CRP level of 140.2mg/L in the patients who required critical care, compared to 76.7mg/L in non-critical care patients following surgical treatment of SOI.

Furthermore, the eight patients who needed re-operation to establish further drainage of the infection had a mean CRP level of 147.9 mg/L. The CRP levels in all patients had fallen to near normal (10mg/L) by the time of discharge from hospital care. In our own study, the mean CRP level was 126.9mg/L, ranging from 20 to 393mg/L. The three patients who required repeat incision and drainage had a mean CRP level of 256 mg/L. On this basis, the CRP level rises faster than WBC in SOI, in agreement with published reports.[19, 24, 25]

The detailed microbiology resulst based on thirteen samples, indicated a predominance of anaerobic microorganisms over aerobic/facultative anaerobes, in line with other reports.[3,10,14] The average number of bacterial species per sample was 4.3, similar to earlier reports.[10,15] Among the isolated aerobic/facultative anaerobic microorganisms, the *anginosus* group of oral streptococci was the most frequently isolated, with a total of six isolates (35.3%). This finding is similar to that reported in other studies and in published case reports of patients with SOI.[2,4,10,11,15,26,27] With regard to the anaerobic bacteria, *Prevotella* and anaerobic *streptococci* species were the most common isolates, followed by *Fusobacterium* and *Bacteroides* species. This finding, despite the relatively small size of the sample, correlates well with that of Heimdahl *et al.*,[10] who reported a significantly higher frequency of *Bacteroides* and *Fusobacterium* species among patients with SOI compared to localised infections. However, these microbiology data are all derived from traditional culture techniques. Recent work on endodontic infections and dentoalveolar abscesses, utilising molecular biological techniques, has shown the presence of a wide range of fastidious and non-cultivable species.[28] Recently published work from from Glasgow University Dental School, utilising molecular techniques has identified a far more diverse microflora in SOI with predominance of *Prevotella* species.[29] It is likely that such species may play a role in SOI and, indeed, may be responsible for the aggressive nature of these infections. Further work is required to examine in more detail the pathogenicity of microorganisms involved in SOI and the associated host responses. With regard to antibiotic resistance, our experience, despite the observed resistance of some strains of bacteria to the antibiotics used, including penicillin, erythromycin and cefuroxime, shows that the use of a combination of antimicrobial agents, especially including metronidazole along with early surgical drainage, was associated with a complete and uneventful cure of the majority of studied patients except three patients who required second procedures to establish further drainage without the need to change the course of antibiotics. This observation was similar to the published work by Labriola[30] and Kuriyama[31] who reported that most patients were clinically well by the time antibiotic resistance was discovered.

Conclusion

Spreading odontogenic infections remain surprisingly common. In the present study, they showed a particular association with social deprivation and tobacco smoking and were typically caused by carious teeth or roots. A raised CRP at admission was a useful indicator of the severity of infection. The microflora associated with SOI was very similar to that reported for dentoalveolar abscesses, namely mixed infections with an anaerobic component. Inappropriate prior treatment with an antibiotic in the absence of surgical drainage was common. Additional work to elucidate the role of malnutrition in SOI would be of interest. Furthermore, molecular characterisation of the microflora associated with SOI may help to highlight whether bacterial factors play a role in converting a localised dentoalveolar abscess into a serious, spreading odontogenic infection.

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CONFLICT OF INTEREST

The authors report no conflict of interest.

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