Periodontal Disease as a Primary Cause of Surgical Site Infection in Fractures of the Mandible – is smoking a confounding variable?

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Abstract

Fractures of the mandible are common in contemporary Oral and Maxillofacial Practice. Wound infection is the most common complication after open reduction and internal fixation and the management of these is complex and costly in terms of morbidity to the patient and in fiscal terms. Whilst numerous epidemiological studies implicate smoking, alcohol, drug use, adverse behaviour as well as fracture complexity and diabetes as important risk factors, the role of periodontal disease is only occasionally mentioned and not formally investigated.

The aim of this study was to assess the presence of periodontal disease and severity according to the 2018 EFP/AAP periodontitis case classification in a population of patients with fractured mandibles presenting to a single level 1 trauma centre, and to look for a possible association with surgical site infection.

A total of 305 patients were assessed retrospectively following open reduction and internal fixation via transoral incisions with load sharing osteosynthesis. The post-operative infection rate was 22.95%.
Statistical analysis using multivariate and multiple logistic regression revealed that there was a strong association between periodontal staging and post-operative surgical site infection.

Over 7 times more likely to develop wound infection than disease negative individuals. This has implications in risk adjustment, prognostication, treatment planning, and post-operative care.

Surprisingly in this study cigarette smoking did not achieve statistical significance as it is an established risk factor in the pathogenesis of periodontal disease, potentially conflicting with established literature.

**Keywords:** surgical site infection; mandibular fracture; Complications; infected fracture; plate infection; biofilm; miniplate; periodontal disease; non union mandible; osteomyelitis

**Introduction**

Fractures of the mandible are common in facial trauma practice and management has undergone a stepwise evolution following increased understanding and advances in surgical materials. Operative surgery is now focused upon open reduction and internal fixation conducted through transoral incisions. Whilst this surgery has predictable outcomes it is not without risk of complications which could vary and be categorized as wound infection, wound dehiscence, non-union, osteomyelitis, nerve damage, and malocclusion. Wound infection was the most common complication after open reduction and internal fixation and accounted for up to one-third of all complications encountered (1).

Infections of plates like in orthopaedics occur with the establishment of an oral biofilm which is highly predictive of plate failure (2). The precise microbiology of infected fractures is not established. Management of the infected miniplate is confusing as the literature does not distinguish between mucosal dehiscence and established infection with biofilm (3), but the management of an established infected fracture requires definitive hardware removal, debridement, and load-bearing osteosynthesis (4).
Historically, there have been several published reports looking at risk factors for poor outcomes which are described in several ways. Smoking is frequently cited as a common risk factor and microbial biofilm was also linked to the chronic infections associated with failed craniofacial osteosynthesis plates. Confocal microscopy identified 75% of the plates exhibited evidence of biofilm to varying degrees (2).

Periodontitis is a chronic multifactorial inflammatory disease associated with dysbiotic plaque biofilms and characterized by progressive destruction of the tooth-supporting apparatus (5). The recently introduced 2018 EFP/AAP periodontitis case classification of periodontal disease allows clinicians to identify clinical entities and facilitate the process of treatment planning. (6). Clinical attachment and marginal alveolar bone loss have remained the key features to classify the severity of periodontitis which share similar features to that of infected fractures.

Given that periodontal disease can be quantified the hypothesis is postulated that severity of the disease can be predictive of fracture failure. Therefore, the aim of this present study was to assess periodontal disease using the 2018 EFP/AAP periodontitis case classification among patients with mandibular fractures in relation to mandibular fracture.

Material and Methods

A retrospective analysis was conducted at Royal London Hospital. Data were collected from clinical records and the radiographs from picture archiving and communication system (PACS) of patients with mandibular fractures admitted for surgical management using intra oral incisions and load sharing osteosynthesis between 2017 and 2020. Exclusion criteria included patients under the age of 18, patients with isolated mandibular condylar process fractures, edentulous fractures, fracture patterns requiring load bearing reconstructions with or without preexisting infections, and patients with incomplete clinical or radiological data. Details of patient’s information, including physical status (ASA) classification, smoking and homelessness were obtained. Panoramic radiographs were also analyzed. Radiographic assessments were performed to obtain the following information: Fig 1 and 2.
1) periodontal staging (6)

2) periodontal grading (6)

3) extent of periodontitis (7)

4) the number of remaining teeth

Details of the modified criteria for data collection is shown in Table 1. Examples of radiographic assessment in mandibular fracture patients without and with post-operative infection are illustrated in figure 1 and figure 2, respectively.

The presence of infection was recorded from the notes and included physical signs of pathological swelling, gross wound dehiscence, pathological sinus, presence of pus at site of repair, and observation of gross granulation tissue at the incision line.

Statistical analyses were performed using IBM SPSS statistics (version 27.0 Inc., New York, NY, USA). The level of significance was set at 0.05. Bivariate analysis using Chi-square test were performed to test the statistical significance of risk factors and infection. Variables that were statistically significant were subsequently subjected to multiple logistic regression to predict the rate of infection.

Results

Table 2
A total of 388 patients with a fracture of the mandible were admitted for operative intervention between 2017 and 2020. Of these, 305 patients were included in the analysis following application of exclusion criteria.

The median age of patients was 29 years (ranging from 18 to 90 years), and the majority of patients were male (85.6%). Seventy patients experienced infection with an overall infection rate of 22.95%. Confirmed smokers, non-smokers, and patients with unknown smoking status were found in 197 (64.6%), 74 (24.3%), and 34 (11.1%), respectively.

126 out of 305 patients did not have diagnosable periodontal disease, while 179 patients had an objective degree of periodontitis. Staging of periodontitis was assessed as Severe (Periodontal stage III and IV) in 52 (17%) out of all periodontitis patients. The number of patients that were graded as A, B, and C were 9 (5%), 113 (32%), and 57 (63%), respectively. There were 266 (68.6%) patients who presented with ≥20 remaining teeth with 10 opposing pairs, 23 (5.9%) of patients presented with ≥20 remaining teeth without 10 opposing pairs, and 15 patients (3.9%) presented with <20 remaining teeth without 10 opposing pairs. Regarding teeth in the line of plates, 70 (18%) of patients presented with no association of line of plates and teeth, 190 (49%) of patients presented with teeth associated with the line of plates but without signs of pathologies of associated teeth, and 45 of patients (11.6%) presented with teeth associated with the line of plates with signs of pathologies including periodontitis and dental caries.

Bivariate analysis using Chi-squared tests indicated that there were statistical associations between physical status (ASA classification), homelessness, periodontal stage, periodontal grade, periodontal extent and mandibular fracture with post-operative infection (Table 3). The results from logistic regression analysis (Table 4) showed that only periodontal stage remained statistically significant (p <0.001) in the final model. The odds ratio (95% CI) of periodontal stage III/IV was 7.169 (2.952-17.410) (p<0.001), supporting our observation that it was those patients with extensive periodontal disease who were most susceptible for wound infection.
Discussion

The Royal London Hospital is a level one trauma centre and is situated in a poor socioeconomic area with a significant case mix volume of both routine and complex facial trauma. The high mandibular infection rate of 23% is reflected in other studies involving inner city populations with adversarial co-factors such as alcohol, drug, substance abuse, and poor health and social measures (8). Historically in addition to social and behavioural factors (9-11), site of fracture and complexity (1, 12), medical co-factors (13), time to surgery (14), experience of surgeon (15) and even types of plating strategy (16) are quoted. In almost all studies smoking is universally implicated as the primary factor in plate infection and subsequent failure, and yet despite the well-recognised role of tobacco in primary pathogenesis of periodontal disease (17), the formal association between periodontal disease and fracture infection in a dose dependent manner remains unproven until now.

Severe periodontitis affects around 11.2% of the population globally, representing the sixth-most prevalent condition in the world (18). Epidemiological studies indicate that the prevalence of periodontitis increases among male patients, patients with low educational and income levels, and smokers (19, 20). The high prevalence of periodontitis in this study was observed despite relatively young patients which may be explained by the fact that the Hospital is situated in a poor socioeconomic area as well as the majority of the patients were male and smokers (21). The extent of dental disease within our catchment area was evidenced by the Tower Hamlets Joint Strategic Needs Assessment of 2015 whereby 39% of adults had decayed teeth and 77% had periodontal disease (22).

The prevalence of periodontitis and its severity classified by the 2018 EFP/AAP classification found in this study was in line with a previous study. In this study, 26.6% and 17% of patients were diagnosed with stage II and III&IV respectively, which is comparable to 24.6% and 19.7% in Germen’s study (23). Patients who were classified with periodontal stage III and IV were much more likely to experience a post-
operative infection with the odds of up to 7-fold (OR: 7.17, 95% CI: 2.95-17.41) compared to patients with no detectable periodontal bone loss. Periodontitis stages I and II showed an increasing rate of post-operative infection compared to patients with no detectable periodontal disease although they were not statistically significant (p=0.116 and 0.170, respectively). These findings strongly highlighted periodontal disease as an important risk indicator affecting post-operative infection rate among patients with mandibular fractures.

The results of the present study indicated the periodontal disease using 2018 EFP/AAP classification could potentially be an important screening tool to predict the rate of complication after treatment of a mandibular fracture, this observation also is important in risk adjustment of outcome and almost certainly explains the higher rates of infection in inner city populations with poor health behaviors.

Grading reflects the patient’s susceptibility to periodontal disease as well as indicates the presence of risk factors (e.g., smoking and diabetes). This study utilized mainly the ratio of the percentage of bone loss/age as a key determinant to define grading as it also had been suggested to be the most pragmatic to reflect the average rate of disease progression over time (24). More than half of the patients (63.1%) were classified with grade B, this was due to either displaying the percentage of bone loss per age >0.25-1 or their smoking status. The fact that up to one-third of the patients in this study were classified as grade C, indicating that a substantial proportion of patients with mandibular fractures showed a rapid rate of periodontal progression (6).

Tobacco smoking, which was recently suggested to be a nicotine-dependent condition and chronic relapsing medical disorder, is an important risk factor for periodontal disease (25). This important modifying factor increases the risk of periodontal disease and results in higher rate of tooth loss (20, 26, 27). The detrimental effect of smoking could be observed in the alteration of microbial community toward dysbiosis, effects on neutrophil function toward a more destructive direction, and the impairment of vasculature and periodontal healing by affecting fibroblast function (28). Smoking was also cited as the important risk factor associated with an increased complication rate among patients treated for mandibular fracture (29-31). Most of the patients (64.6%) in this present study were smokers.
Nevertheless, smoking had failed to show a significant association with mandibular fracture infection. This was in line with a recent finding by Oksa et al. (2022) demonstrating that smoking also failed to show a significant association with infection after treatment of mandibular fracture (32). Moreover, periodontal disease as part of tooth index was utilized in that study, which also include dental caries and apical periodontitis. Thus, the true effect of periodontal disease and the association with mandibular fracture infection may be confounded by other dental-related factors.

Most of the patients in this present study were classified to ASA class I or II, indicating healthy patients or patients with only mild systemic disease were included in the analysis. Homelessness was common (6.6%) which possess a higher risk for oral and dental disease as well as limited access to dental and medical care. Both of these factors were significant on univariate analysis, but not in the final model. Periodontal disease is certainly exacerbated by ill health and also frequently see in the homeless. The strength of the association of periodontal staging possibly reduced the significance of these two factors (33).

This retrospective study is not without limitations particularly as periodontal status was determined radiologically rather than clinically. However in mitigation it has been suggested that radiographic bone loss could be used for periodontitis staging/grading assessment with caution in that radiographs may underestimate the loss of interdental bone (34) meaning that patients may have more severe periodontal disease than what was detected on panoramic radiographs. Despite a possibility of underestimation of periodontal bone loss by radiographic examination, plate infections were still found to be highly correlated with the stage of periodontal disease.

Conclusion

The prognostication and therapeutic implications of linking periodontal status with fracture healing are obvious, and a prospective study to include clinical assessment of periodontal disease is obvious and relationship to other published risk factors is underway and remain to be further investigated.
There are no conflicts of interest
**Ethics statement/confirmation of patient permission**

The local ethics committee (Bartshealth NHS Trust and QMUL) were approached and passed the study as low risk. Patient permission obtained.

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Figure 1: An example of radiographic assessment in patient without post-operative infection.

Figure 2: An example of radiographic assessment in patient with post-operative infection subsequently treated with a load bearing osteosynthesis — the subsequent healing and union was uneventful.
### Table 1. The modified criteria

| Measure                        | 0                                      | 1                                      | 2                                      | 3                                      |
|-------------------------------|----------------------------------------|----------------------------------------|----------------------------------------|----------------------------------------|
| **Periodontitis stage**       | No bone loss                           | Bone loss <15% (stage I)               | Bone loss 15-33% (stage II)            | Extending to middle third of root or beyond (stage III & IV) |
| **Periodontitis grade**       | %Bone loss/age <0.25 regardless of smoking status | %Bone loss/age 0.25-1.0 or smokers     | %Bone loss/age > 1.0 regardless of smoking status |
| **Periodontitis extent**      | Localised < 30%                        | Generalised >30%                       |                                        |                                        |
| **Number of teeth present**  | ≥ 20 teeth with 10 opposing pairs      | ≥ 20 teeth without 10 opposing pairs   | < 20 teeth without 10 opposing pairs   |                                        |
| **Teeth in line of fracture** | Not associated or teeth were already removed | Associated with teeth without disease | Associated with teeth with periodontal disease or dental caries |                                        |

### Table 2. Results
| Category                        | Outcome |
|--------------------------------|---------|
| Sample (N)                     | 305     |
| Gender (male)                  | 261 (85.6%) |
| Age median (range)             |         |
| All subjects                   | 29 (18-90) |
| Male                           | 28 (18-82) |
| Female                         | 33 (18-90) |
| Infection                      | 70 (22.95%) |
| Physical status                |         |
| ASA I                           | 162 (53.1%) |
| ASA II                          | 125 (41.0%) |
| ASA III                         | 13 (4.3%) |
| Smokers                         | 197 (64.6%) |
| Homelessness                    | 20 (6.6%) |
| Patients with periodontitis     | 179 (58.69%) |
| Periodontal stage               |         |
| Periodontitis stage I           | 46 (15.1%) |
| Periodontitis stage II          | 81 (26.6%) |
| Severe periodontitis (stage III/IV) | 52 (17%) |
| Periodontitis grade A | 9 (5%) |
|-----------------------|--------|
| Periodontitis grade B | 113 (63.1%) |
| Periodontitis grade C | 57 (31.8%) |

### Number of teeth

| Number of teeth                                      |       |
|------------------------------------------------------|-------|
| ≥ 20 teeth & ≥ 10 opposing pairs                     | 266 (68.6%) |
| ≥ 20 teeth & < 10 opposing pairs                     | 23 (5.9%) |
| < 20 teeth & < 10 opposing pairs                     | 15 (3.9%) |

### Teeth in line of fracture

| Teeth in line of fracture                            |       |
|------------------------------------------------------|-------|
| No teeth in line of fracture                         | 70 (18%) |
| Teeth free of pathology in line of fracture          | 190 (49%) |
| Tooth with pathology in line of fracture             | 45 (11.6%) |

**Table 3. Bivariate analysis on (possible) risk factors and plate infection (Chi-square test)**

| Factor                     | P-value |
|----------------------------|---------|
| Gender                     | 0.942   |
| ASA                        | 0.019*  |
| Smoking                    | 0.427   |
### Table 4. Final model of logistic regression analysis on the risk factors and plate infection.

| Factor                        | Estimate (SE) | Odds ratio (95% CI) | p-value |
|-------------------------------|---------------|---------------------|---------|
| Periodontal stage             |               |                     | <0.001**|
| No detectable bone loss*      |               |                     |         |
| Periodontal stage I           | 0.802 (0.510) | 2.230 (0.821-6.060) | 0.116   |
| Periodontal stage II          | 0.620 (0.451) | 1.859 (0.767-4.501) | 0.170   |

* In patients with periodontitis only

*p<0.05

**p<0.001

In patients with periodontitis only
| Factor                  | Estimate (SE) | Odds ratio (95% CI) | p-value |
|------------------------|---------------|---------------------|---------|
| Periodontal stage III/IV | 1.970 (0.453) | 7.169 (2.952-17.410) | <0.001** |
| Constant               | -2.124 (0.319) |                     | <0.001** |

* Reference category

**p<0.001