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The prevalence of infection in mandibular fractures treated at the Wits school of oral health science

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The prevalence of infection in mandibular fractures treated at the Wits School of Oral Health Science.

John E Elakhe

A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfillment of the requirements for the degree of Master of Dentistry in the branch of Maxillofacial and Oral Surgery

Johannesburg, 2016.

DECLARATION

I, Dr. JE Elakhe declare that this research report is my own, unaided work. It is being submitted for the degree of Master of Dentistry in the branch of Maxillofacial & Oral Surgery at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

Signed: ……..

On this ……

DEDICATION

This work is dedicated to my loving wife and children, without whose support and understanding it would not have been possible to accomplish**.**

ABSTRACT

Aim: The aim of the study was to compare the infection rates between mandibular fractures treated by closed reduction and those treated by open reduction with internal fixation.

Methodology: This was a randomized prospective study in which 119 patients withclass 1 mandibular fractures (fractures bound by teeth on either side) were randomly allocated into two treatment groups, a closed and an open reduction with internal fixation. Parameters such as site of fracture, seniority of surgeon, cause of fracture, date of injury and site of infection were all recorded. Statistical analysis was used to compare the rates of infection between the two treatment groups.

Results: Of the 119 patients, 88.2% were males while 11.8% were females. The ages ranged from 18 to 59 years with a mean of 29.9 years. The angle of the mandible was the most fractured site (70 of the 161 fractures). Blunt trauma due to interpersonal violence (82.5%) was the predominant cause of the injuries. Overall, the infection rate in this study was 13.5%. Most infections occurred within ten days of treatment. The highest infection rate was in the open reduction and internal fixation group (21.7%). The closed reduction group had a 5.1% infection rate.

Conclusion: The study showed that there was a statistically significant difference in the infection rates between both groups, higher in the open than in the closed treatment group (P value = 0.014). Seniority of the surgeon, patients'

age, compliance and presence of comorbidities did not seem to influence the outcome in this study.

ACKNOWLEDGEMENTS

I would like to take this opportunity to offer sincere gratitude to my supervisor Dr. Ephraim Rikhotsoforthe guidance, knowledge, wisdom and patience that he demonstrated to me over the course of this research project. His insight and understanding gave me the courage to persevere when I did not feel up to the task at hand and his good judgement helped me find solutions when I could not see them myself.

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LIST OF ABBREVIATIONS

ORIF	Open Reduction with Internal Fixation
CRFM	Closed Reduction of Fractured Mandible
IMF	Intermaxillary Fixation
AO/ASIF	Association for the Study of Internal Fixation
HIV	Human Immunodeficiency Virus
PVA	Pedestrian Vehicle Accident
MVA	Motor Vehicle Accident
RVD	Retroviral Disease
IVs	Independent Variables
DVs	Dependent Variables

INTRODUCTION

The mandible is a U-shaped bone consisting of thick buccal and lingual cortices with a thin medullary cavity.[1,2,4,9] The bone is actually made up of two hemimandibles that unite at the symphysis.[4]Each side consists of a horizontal body with a parasymphyseal area anterior to the mental foramen and a perpendicular ramus capped superiorly by the coronoid anteriorly and the condyle posteriorly. The inferior aspect of the ramus is the angle. The condyle articulates with the glenoid fossa to form the temporomandibular joint.[9]

The blood supply of the mandible is from the inferior alveolar artery and from the muscular attachments; the nerve supply is the inferior alveolar nerve, which enters at the mandibular foramen with the artery and exits at the mental foramen.[4,9]

Two main groups of muscles insert and act upon the mandible; the muscles of mastication and the suprahyoid muscles.[4] The former are the masseter, temporalis, lateral and medial pterygoid muscles and the latter group are the digastric, stylohyoid, mylohyoid and geniohyoid muscles.[9]Displacement of fractured segments commonly occurs as a result of differing forces of these muscles.[4,9,17]

A review of the pattern of mandibular fracture presentation at an urban trauma centre found that mandibular fractures overwhelmingly occur in males and are most often caused by interpersonal violence.[1] More than one third of fractures

occur in the 25-34 year old age group. Fracture location by site include condyle 36%, body 21%, angle 20%, symphysis14%, alveolar ridge 3%, ramus 3% and coronoid 2%.[1]

Prior to 1970 most jaw fractures were treated by closed reduction and intermaxillary fixation.[6] Based on a series of animal experiments the Association for the Study of Internal Fixation (AO/ASIF) group in Switzerland came out with a concept of osteosynthesis using open reduction and various plating systems.[4,10,12]

In 1968 Hans Luhr[4] firstproposed thatminiature metalbone plates and screws could beused to fixate a mandibular fracture to improve healing.[4,25]

Fixation of fracture segments must be able to resist the displacing forces acting on the mandible, which can be indirector direct. When direct fixation is used the rigidity can range from asimple osteosynthesis wire across the fracture (non-rigid fixation) to the use of a miniplate (semi-rigid fixation) or a compression bone plate (rigid fixation).[4,25,30]

Michelet et al[30]were the first to describe a technique of osteosynthesisfor reduction and immobilisation of fractures ofthe facial skeleton using miniplates and screws.[4,26,30]

Champy et al [29]modified Michelet's technique of mandibular osteosynthesis, which consists of monocorticaljuxta-alveolar and subapicalosteosynthesis without compression and without intermaxillary fixation.[4,26]He also advocated the number of plates to be placed at various sites of the mandible according to biomechanical principles. He described moments of forces acting at various anatomical regions of the mandible:[4,25] tension forces

(distraction) at the superior border, compression forces at the inferior border of the mandible posteriorly and torsional forces acting mostly at the symphyseal area. He subsequently described the ideal lines of osteosynthesis based on these biomechanics (Fig. 1).He advocated one plate posterior to the mental foramen and two plates anterior to the mental foramen and that the single plate posterior to the mental foramen should be placed more superiorly as the fracture line moves proximally.[26,29]

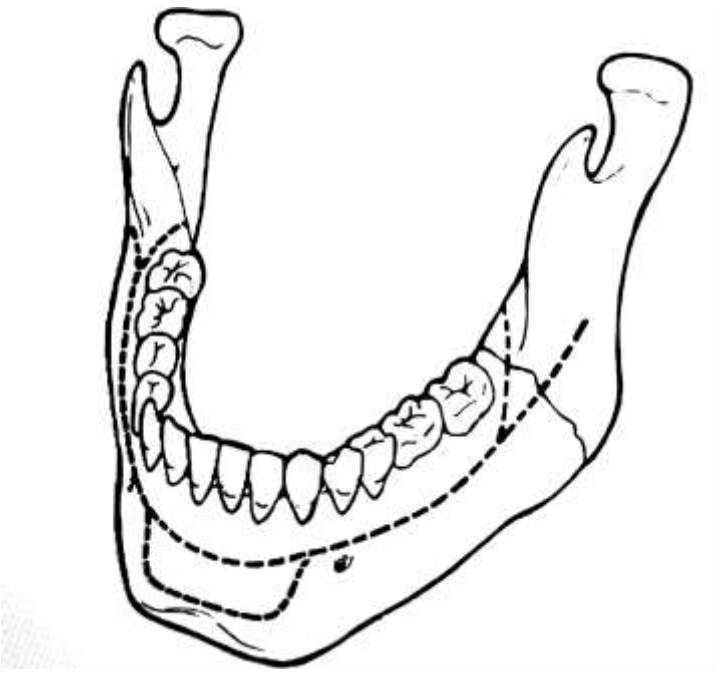

Fig.1 Champy's ideal Osteosynthesis lines.[29]

In the maxillofacial region, modern internal fixation devices have gained popularity and nowadays these devices play an important part in the management of facial bone trauma.[8,9,18]

The advent of plates has relegated closed reduction of fractured mandible (CRFM) as a treatment modality for mandibular fractures to secondary use. Proponents of open reduction with internal fixation (ORIF) state that close approximation and absolute immobility between fractured segments achieved by plates leads to accelerated bone healing, reduces the need for intermaxillary fixation (IMF) and decreases the risk of infection. Potential problems associated with IMF over a prolonged period such as compromised airway, inadequate nutritional intake, hypomobility and weight loss are eliminated.They also claim the following advantages over closed reduction: faster restoration of occlusal function, optimum repositioning of fracture segment as well as economic advantages due to less loss of time away from work.[10]

The putative advantages of ORIF over closed reduction with IMF (less disruption of normal activities and faster return to pre-trauma state) have resulted in ORIF being more frequently used in the treatment of mandibular fractures.

The use of plates and screws for rigid internal fixation is however not without complications. It is estimated that some 20-30% of patients will eventually need to have their plates removed, most often because of infection and other complications in the surgical area.[6] Ellis[34] reported a 7.5% infection rate associated with mandibular angle plates. Despite widespread preference for ORIF using miniplates and screws by many clinicians, closed reduction remains a viable option particularly in non-displaced, grossly comminuted, coronoid, condyle and paediatric mandibular fractures.[10,12]

Proponents of closed reduction cite the following as its benefits: less traumatic procedure, preservation of vascularity of the trauma site, shorter hospitalization

and less expense as no hardware is utilized, reduced risk of nerve injuries, usually an outpatient service and less operator sensitivity.[10,24]

Kazanjian and Converse[47]classified mandibular fractures into three groups: class 1 fracture which is bound by teeth on both sides, class 2 has teeth only on one side of the fracture and class 3 fracture involves an edentulous mandible. Although closed approximation and absolute immobility between fractured fragments proposed by the AO/ASIF group has been claimed to lead to an accelerated healing and less risk of infection, such relationship has not been proven clinically.[10,26] A bone repair study found that controlled micro-movements accelerate bone formation and this concept forms part of the principle of distraction osteogenesis.[10]Against this background, this study was undertaken to compare the rates of infection between mandibular fractures treated by ORIF and those treated by closed reduction.



Fig. 2 Class 1 mandibular fracture as described by Kazanjian and Converse[47]

SIGNIFICANCE OF THE STUDY

This study will add to data on the use of plates in mandibular fractures and also propose guidelines to clinicians on factors to be considered when choosing treatment options for mandibular fractures. It is also envisaged that the recommendations will enable the development of evidence-based protocols to improve the clinical outcomes of mandibular fractures in the future.

HYPOTHESIS

This study seeks to test the null hypothesis which states that there is no statistically significant difference between the two types of treatment. Anecdotal evidence suggests that infections are more commonly associated with mandibular fractures treated by open reduction and internal fixation than those treated by closed reduction.

AIM

To compare the rates of infection in mandibular fractures treated by closed reduction to those treated by open reduction with internal fixation.

OBJECTIVES

- to document the incidence of infection in mandibular fractures
- to identify the predisposing factors to infection in mandibular fractures.

METHODOLOGY

Study design

This was a randomised prospective study in which patients with mandibular fractures were randomly allocated into the two treatment groups using sealed envelopes - group 1 (the closed reduction) and group 2 (open reduction with internal fixation).

Study Population

All patients with isolated converse class 1 mandibular fractures due to trauma presenting at Chris Hani Baragwanath Academic Hospital and Charlotte Maxeke Johannesburg Academic Hospital were included in the study. The following patients wereexcluded from the study:

-comminuted or multi-segmented fractures

-fractures older than 2 weeks at the time of treatment

-septic fractures

-pathological fractures

-fractures in patients younger than 18 years

-failure to present for the 6week follow-up

-edentulous patients and patients with inadequate dentition to effect intermaxillaryfixation

-Class 1 fracture inadvertently converted to a class 2 due to an extraction

-mandibular condyle fractures.

All patients were treated under general anaesthesia. All patients received 1g intravenous kefzol as prophylactic antibiotic and 500mg of amoxicillin eight hourly for five days post-operatively. Those allergic to penicillin received 150mg of clindamycin six hourly.

Closed Reduction

This involved placement of 0.018wires (Ivy loops) around the teeth in both jaws. Five eyelets were placed in each jaw two posteriorly and one in the anterior region and intermaxillary fixation was achieved with straight up and down wires. The fractured segments were then reduced and aligned without exposure. Intermaxillary fixation was maintained for 6 weeks. Follow up visits were done everyfortnight.

Open Reduction

Open reduction with internal fixation entailed raising a mucoperiostealflap to expose the fracture site or sites following placement of Ivy loops or arch bars. The fracture was reduced and aligned,immobilised and fixated with miniplates and monocorticalscrews (see example in Fig. 3). Intermaxillary fixation was maintained for 3 weeks.



Fig. 3 Open reduction and internal fixation.

All patients were reviewed at 1, 3 and 6 weeks post-operatively for signs of infection. Infection for the purpose of this study was diagnosed using clinical and laboratory parameters. The clinical parameters included the cardinal signs of inflammation such as pain as reported by the patient, raised body temperature above 37.5^0C and swelling with or without pus discharge as observed at the surgical site.

Variables

These included the following:

- age of patient
- sexof patient
- date of injury
- cause of injury
- time lapse before treatment
- site of plate placement
- number of plates placed
- seniority of operator
- co-morbidities present at initial examination
- site of infection.

Statistical analysis of the results were carried out using SAS Statistical Software (SAS Institute, Cary, NC).[33]

Between- group tests were conducted as follows: The X^2 test was used to assess the relationships between categorical variables. Fisher's exact test was used for 2 x 2 tables or where the requirements for X^2test could not be met. The strength of the associations was measured by Cramer's V and the phi coefficient respectively.

The relationship between continuous and categorical variables (group) was assessed by the t-test. Where the data did not meet the assumptions of these tests, a non-parametric alternative, the Wilcoxon rank sum test was used.

The predisposing factors for sepsis were determined by logistic regression.

The 5% significance level was used throughout, unless specified otherwise. In other words, p-values < 0.05 indicate significant results.

RESULTS

A total of 119 patients with 161 class 1 mandibular fractures were included in the study. The study group comprised 88.2% males and 11.8% females.

Age

The mean age of the patients was 29.9years (sd=7.7yr; range 18-59yr; median 29yr; interquartile range 25-34 years). The distribution of ages is shown below (Fig. 4).

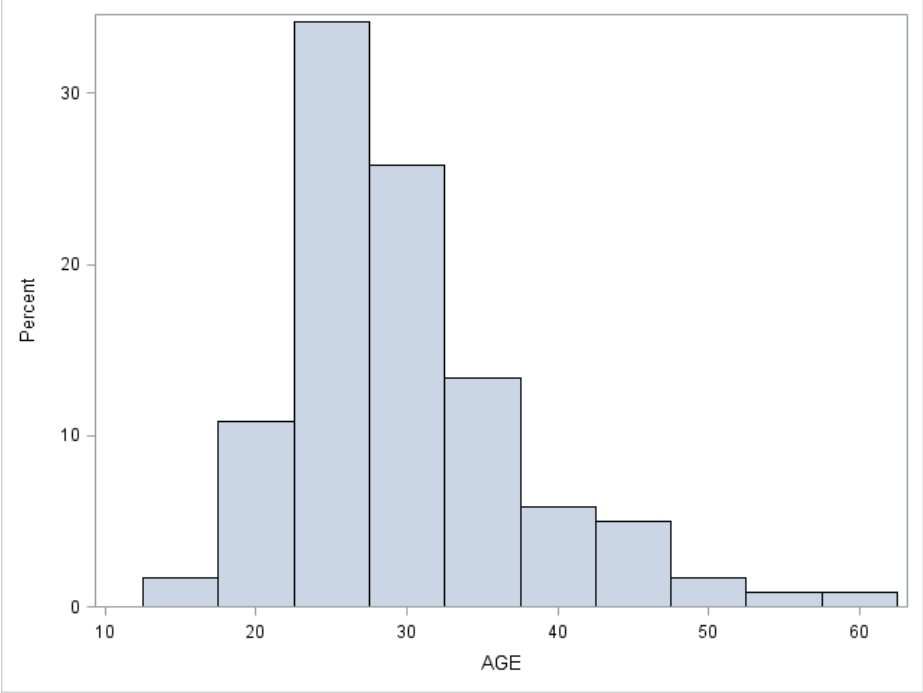

Fig.4 Age distribution.

There was no significant between-group difference in mean age (p=0.20), or in age category (p=0.37).

Cause of injury

The predominant cause of injury (as shown in Fig. 5) was blunt trauma due to interpersonal violence (82.4%), followed by motor vehicle accidents(MVA, 9%) and pedestrian vehicle accidents (PVA, 4%).

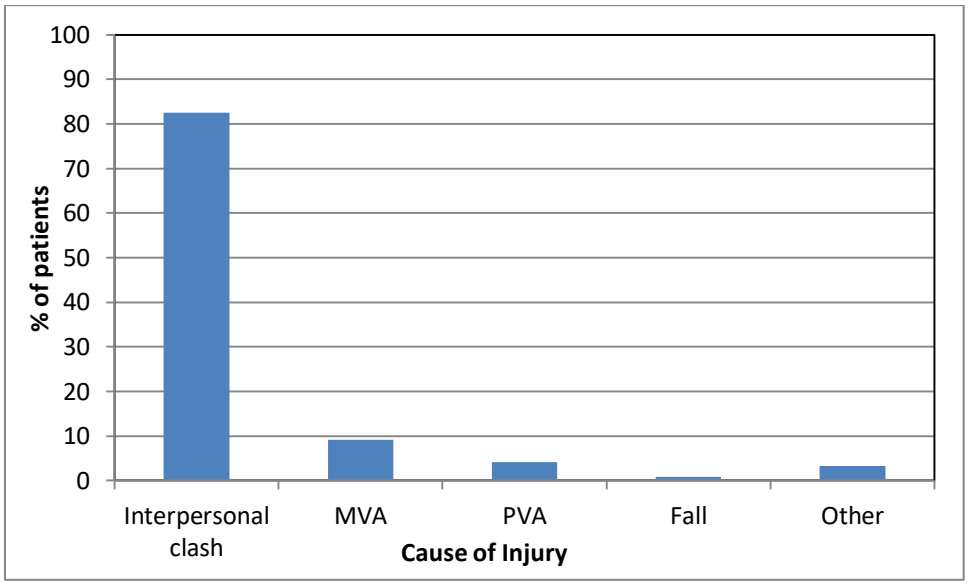

Fig.5 Percentage cause of injury.

There was no significant between-group difference in cause of injury (p=0.65).

Fracture sites

The percentage of patients who presented with the different fracture sites is shown in figure 6. Note that percentages do not sum to 100% since some patients had more than one fracture site.

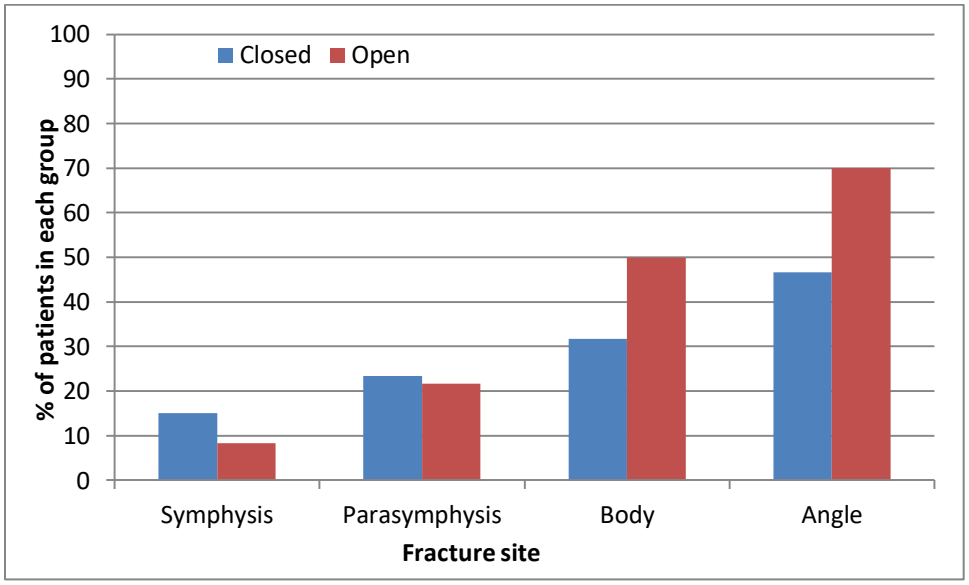

Fig. 6 Distribution of fracture site in relation to treatment.

The angle (70) was the most prevalent fracture site, followed by the body (40). There was a significant between-group difference in the proportion of patients who presented with angle fractures (P value =0.0094). A larger proportion of group 2 had angle fractures.

Time lapse to treatment (TLT)

The median TLT of the patients was 9 days (sd=2.8d; range 1-14d; median 9d; interquartile range 6-10d). The distribution of the TLT is shown in figures 7 and

8.Most of the patients (95.8%) received treatment within 10 days, with 68.1% of patients being treated 8 -10 days after injury.

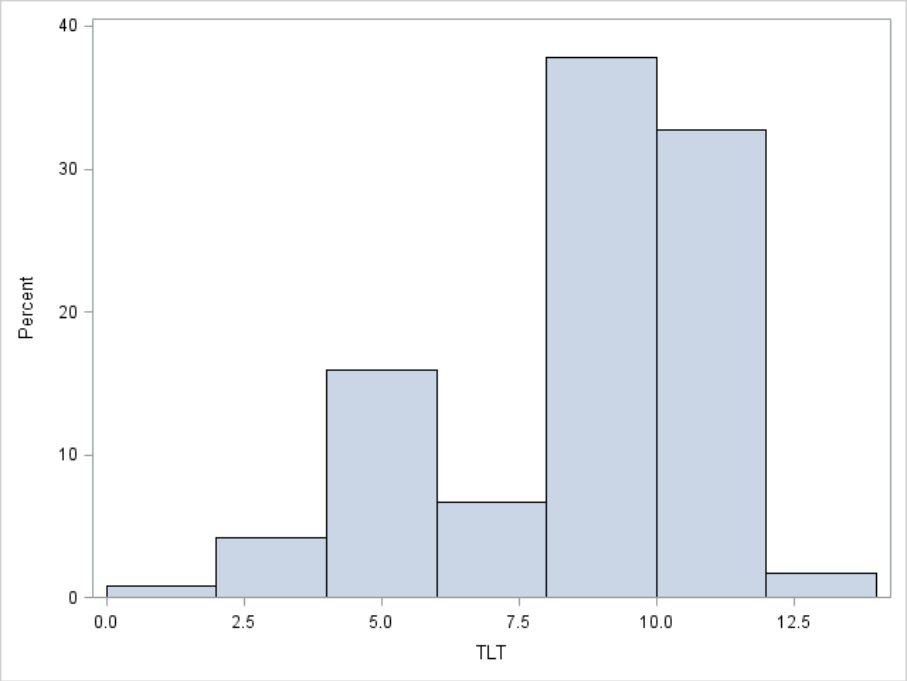

Fig.7Percentage time lapse to treatment in days.

There was a significant between-group difference in TLT (P value <0.0001).

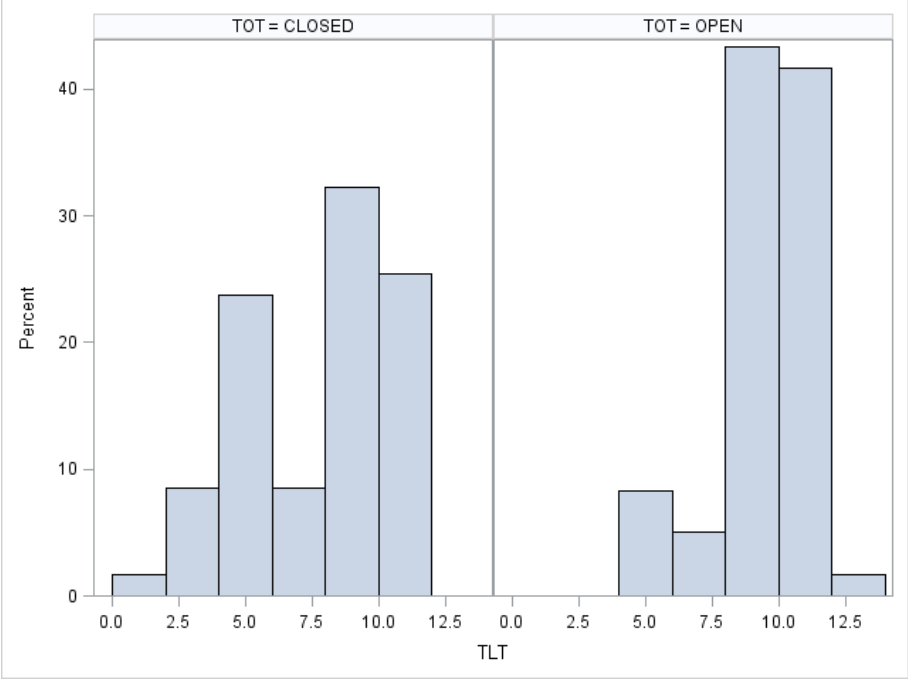

Fig.8 Comparison of time lapse to treatment between the groups in days.

The open group had a significantly narrower distribution of TLT, while the very short and very long TLT's all fell in the closed group.

Number of plates

The total number of plates, as well as the number of plates used in each site, is Illustrated below (Figs 9 and 10) for the open group.

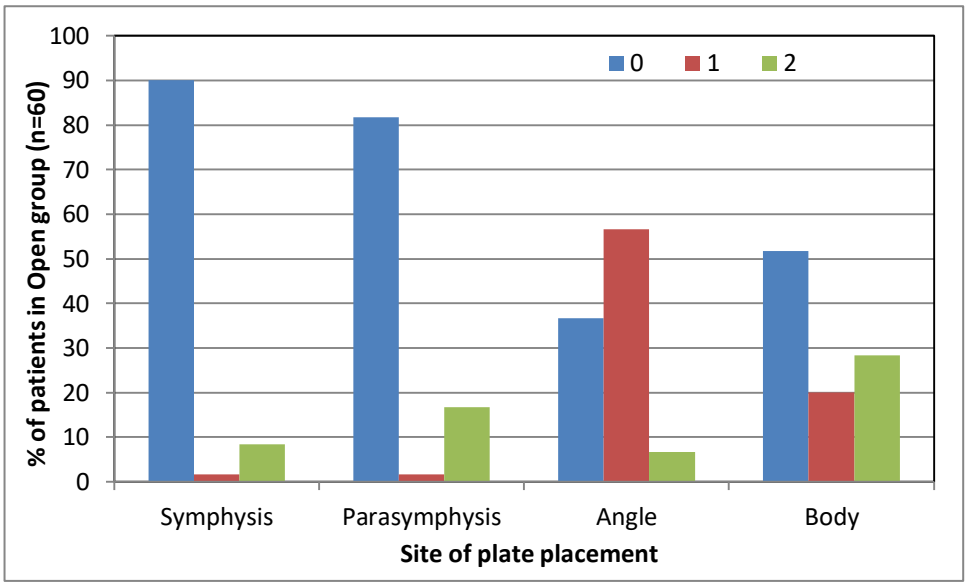

Fig.9 Percentage distribution of patients in relation to the number of plates placed in fracture site. The closed group had no plates (blue column).

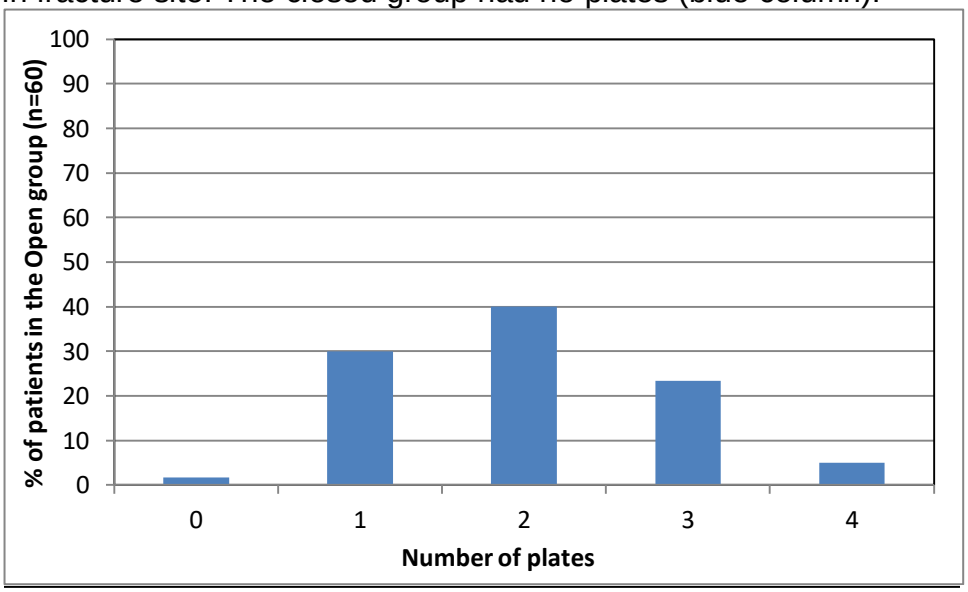

Fig.10 Distribution of the total number of plates placed in fracture sites as well as the percentage of patients in relation to number of plates placed.

Seniority of surgeon

The majority (68.1%) of the surgeries were carried out by junior surgeons. There was a significant between-group difference in seniority of surgeon (Fisher's exact test: $p<0.0001$; phi coefficient=0.49; moderate association). The closed treatments were carried out mainly by junior registrars (JR), while the open reduction and internal fixations were carried out mainly by senior registrars (SR).

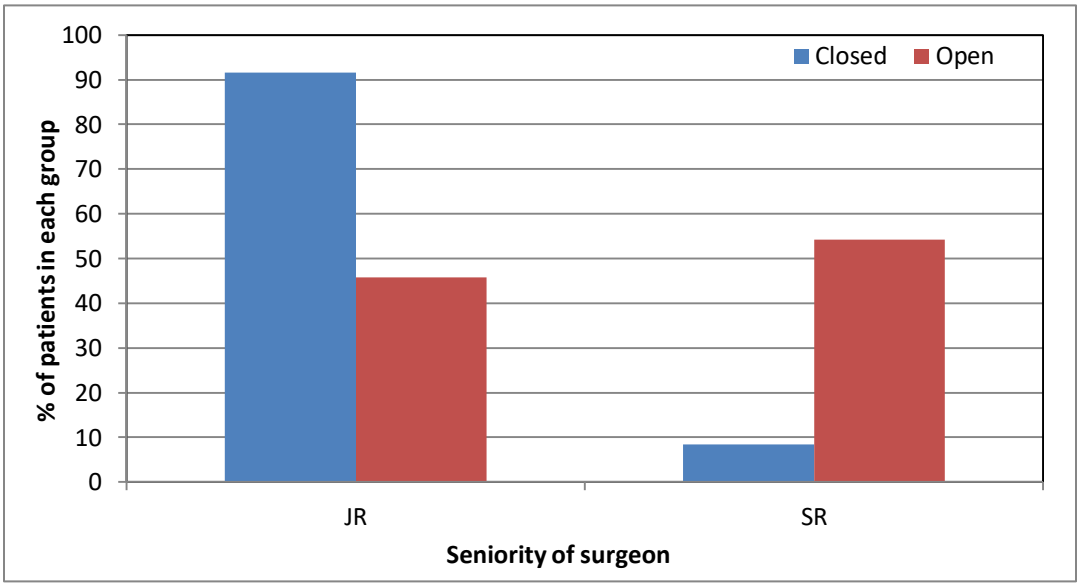

Fig.11 Distribution of the type of treatment performed in relation to seniority of surgeon. (JR=junior registrar, SR=senior registrar)

Medical co-morbidities

The percentage of patients who presented with the different medical co-morbidities is shown in figure 12.

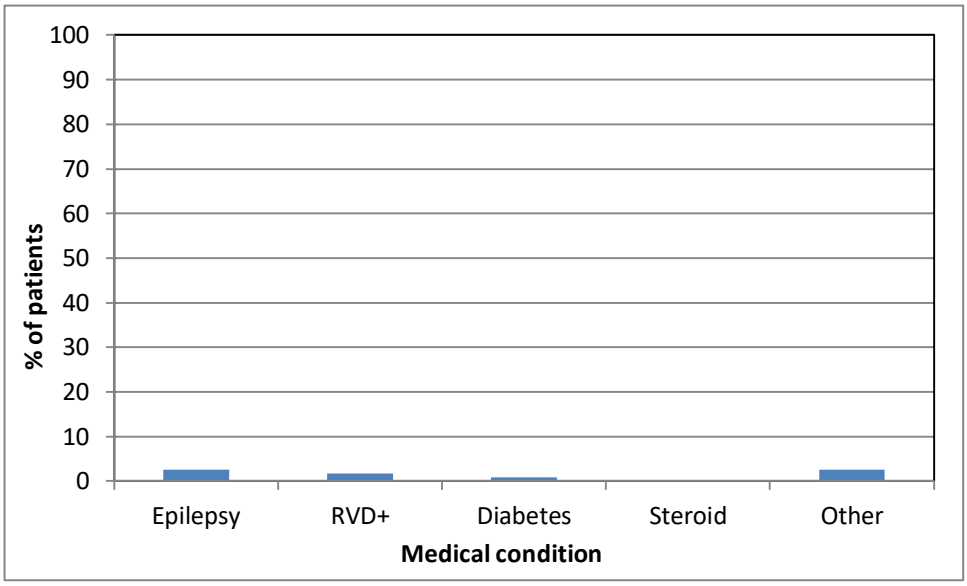

Fig.12 Percentage distribution of patients with co- morbidities.

There were no significant between-group differences (Epilepsy p=0.24, RVD+ p=0.24, Diabetes p>0.99)

DESCRIPTION AND COMPARISON OF OUTCOMES FOR CLOSED AND OPEN GROUPS (n=119)

Presence / absence of infection

Infection occurred in 16 of the 119patients. There was a significant between-group difference in the incidence of infection (Fisher's exact test: p=0.014; phi coefficient=0.24; weak association). The incidence of infection was higher in the open group (n=13, 21.7%) compared to the closed group (n=3, 5.1%).

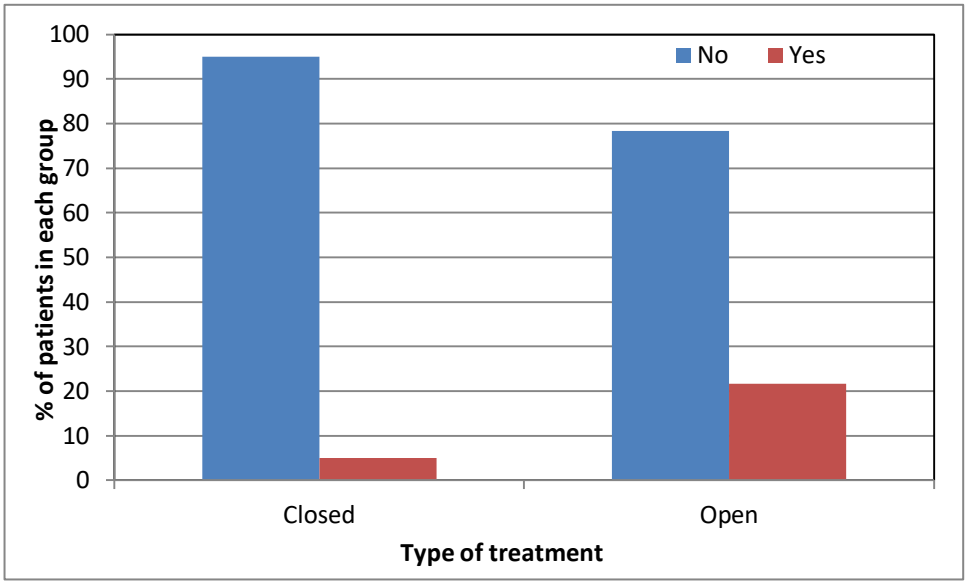

Fig.13 Comparison of the distribution of infection between the groups.

Site of infection (n=16)

The main sites of infection (Fig.14) were body (50.0%) and angle (43.8%). Note that percentages do not sum to 100% since some patients had infection at more than one site.

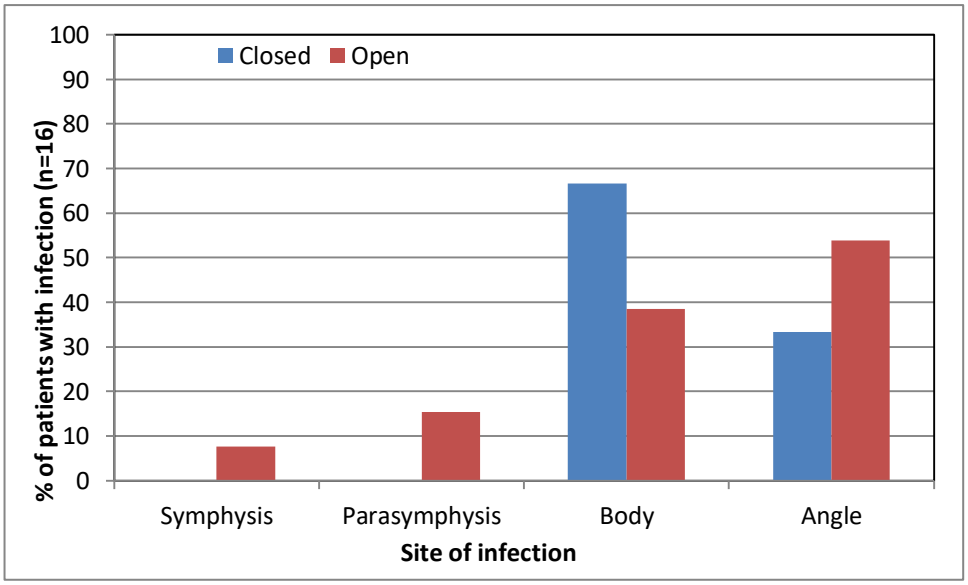

Fig.14 Comparison of the distribution of the site of infection between the groups.

In both treatment groups the majority of the infections occurred in the angle and body region; no infection was noted in the symphysis and parasymphysis in the closed group.

Time lapse to infection (TLI)

Overall, the mean TLI of the patients was 33.1 days (SD=10.0d; range 14-46d; median 34.5d; interquartile range 28-40.5d. The distribution of the TLI is shown below (Fig. 15).

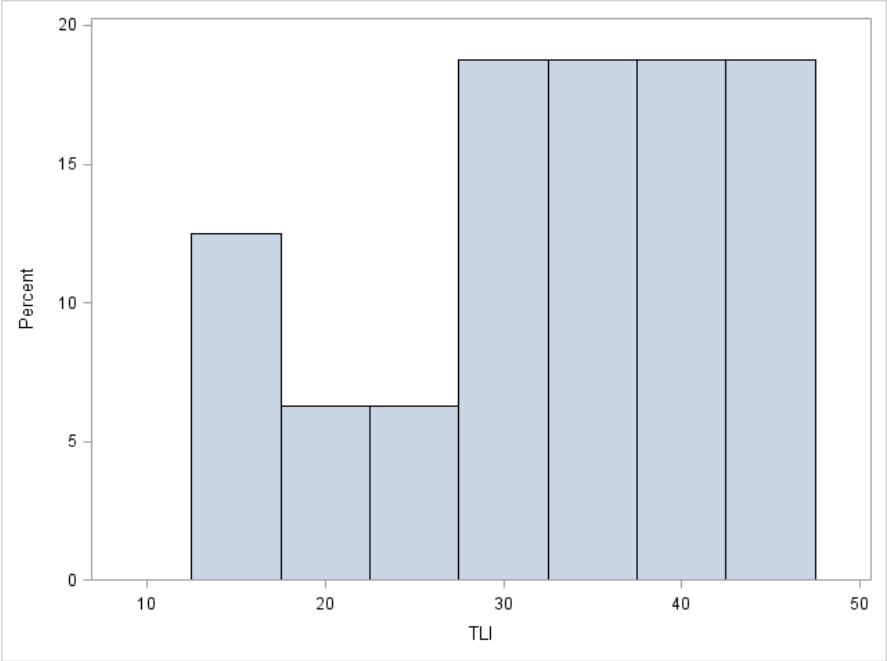

Fig.15 Distribution of the time lapse to infection in days.

There was no significant difference between groups with regard to TLI (p=0.10)

Predisposing factors for sepsis

The predisposing factors (independent variables=IVs) considered were

- TOT=Type of treatment (reference category=Closed)
- Age (reference category=18-24y)
- Gender (reference category=Male)
- COI=Cause of injury (excluding Fall (n=1) and Other) (reference category=Interpersonal clash)
- TLT=Time lapse to treatment (used as continuous variable, and also categorised as 1-7d / 8-10d / 11-20d since most patients were treated in the 8-10d period, which was taken as the reference category)
- FS_S, P, B, A = Fracture sites (reference category=0) [S=symphysis, P=parasymphysis, B=body, A=angle]
- NOP_TOT=Total number of plates (noting that NO plates were used in the Closed group; we combine 3 and 4 plates since there were only 3 patients with 4 plates) (reference category=0) [NOP=number of plates]
- MC_RVD, Epil = Medical conditions (excluding Diabetes (n=1)) (reference category=0) [RVD=retroviral diseases, Epi=Epilepsy]
- SOS=Seniority of surgeon (we exclude Medical Officers and Consultants since there was only 1 case of each) (reference category=JR)

The dependent variable (DV) is whether or not infection occurred. This is a binary variable (yes/no) so logistic regression was used. The reference category was 'no infection'.

For sample size considerations in logistic regression, the rule of thumb given by Peduzzi et al[32] was used, which states that the minimum size of the smallest dependent variable (DV) class should be 10 times the number of IV parameters to be estimated. In these cases the smallest DV class is infection=yes, which has size n=16. Thus we can afford to estimate only one independent variable parameter! The full variable list given above includes many parameters, so variable selection will have to be done.

Given the large number of IVs, and the sample size limitations, univariate logistic regression was first performed with each independent variable (IV) separately. Variables with a Wald statistic significant at $p<0.20$ were retained for multiple logistic regression analysis (marked in red). The retained variables were:

- Type of reduction (open/closed)
- Gender
- Fracture site: Body
- Number of plates
- Medical condition: RVD+
- Seniority of surgeon

Before commencing multiple logistic regression analysis, bivariate correlation analysis was conducted among the independent variables (IVs) retained above: phi coefficients were determined between two dichotomous variables and Cramer's V between two categorical variables. The results are tabulated in the spreadsheet (tab: Between IVs). Significant associations are marked (blue: $p<0.05$; red: $p<0.01$). Strong associations (absolute value of Cramer's V or phi coefficients > 0.5) are marked with yellow highlighting – these represent combinations of variables to be avoided in a multiple logistic regression. The following was found:

Cramer's V or phi coefficient	TOT	SEX	FS-B	NOP_TOT	MC_RVD
SEX	0.06				
FS-B	0.18	0.01			
NOP_TOT	0.98	0.13	0.39		
MC_RVD	0.13	0.16	0.16	0.13	
SOS	0.50	0.09	0.19	0.51	0.09

Fig. 16 Variable Coefficient.

- TOT and NOP_TOT are almost completely confounded: we already know this, since no plates were used in the closed group.
- TOT and SOS are strongly associated: we already know this from the earlier between-group analysis.
- Derived from the two relationships above, NOP_TOT and SOS are thus strongly associated.

Thus, TOT was retained for multiple logistic regression analysis, and SOS and NOP_TOT were omitted, since TOT is the most meaningful variable of the three.

The remaining IVs were then included in the multiple logistic regression analysis. In the multiple logistic regression analysis, variables which were not significant at the 5% level were sequentially removed from the model.

The results may be interpreted as follows:

- The odds of infection (vs. no infection) for open reduction was 7.6times the odds of infection for closed reduction, controlling for the other variables in the model. (Odds ratio=7.6; 95% CI 1.6-35).
- The odds of infection (vs. no infection) for RVD+ patients was 28 times the odds of infection for patients without this medical condition, controlling for the other variables in the model. (Odds ratio=28; 95% CI 1.2-616).

Note:

- We have estimated two parameters here, which is more than our sample size estimation actually allows. Thus, the logistic regression model may be over-fitted and generalizability is compromised.
- The 95% confidence intervals for the odds ratios are very wide, reflecting the low sample size (infected cases) and in particular the low number of cases who were RVD+.

DISCUSSION

The demographic data of patients in our study (age, gender, personal history) and the general characteristics of the fractures (aetiology, location of fractures) are similar to those recorded in other studies.[19,20,35] Our sample was generally young (mean age of 29.9 years, range of 18-59 years), predominantly male (88.2% male, 11.8% female) and healthy. This is in line with previously reported studies.

The most common cause of injury was blunt trauma due to interpersonal violence (82.5%) followed by MVA and PVA. This is similar to previous studies.[1,35] The percentage of mandibular fractures caused by assault or interpersonal violence in our study is however much higher than that reported by Moreno et al.[35] This unfortunately highlights the high levels of interpersonal violence in our region.

The most prevalent mandibular fracture site in our study was the angle (43.5%) followed by the body (30.4%). There was a significant between group differences in the proportion of patients who presented with angle fractures (P value = 0.016). Studies by Bolourian et al [21], Lamphier et al[19], Gabrielli et al [22] and Gutta et al [1] also found that the angle was the most common site for mandibular fracture. This is in agreement with the widely accepted belief that fractures sustained during an altercation show a high incidence of fractures at the angle. A blow to the lateral portion of the mandible causes a fracture at this site and commonly a fracture on the opposite body/symphysealregion. A number of

reasons have been proposed to explain the high incidence of mandibular angle fractures:

a. presence of third molars: it is suggested that they weaken the angle of the mandible and are associated with fractures more commonly than when there is no tooth present.[43] For this reason, some authors have even recommended prophylactic removal of third molars to eliminate the weakening effect in the angle region, in anticipation of preventing fractures from occurring[7,34,37]
b. thinner cross-section area than tooth-bearing regions: it has been shown that the mandibular angle region is thinner than the bone of the body region located more anteriorly and the bone of the ramus locatedmore posteriorly.[36]Fractures would therefore tend to occur at points of greatest weakness

c. biomechanically the angle is considered to be a lever area where an abrupt change in shape from horizontal to the vertical rami occurs, possibly subjecting it to more complex forces than a more linear geometric shape.[11]

The occurrence of postoperative infections in mandibular fracture patients continue to plague Maxillofacial and Oral Surgeons regardless of antimicrobial therapy.[19] Typically the infections are of minor consequence but they have the potential to develop into more significant sequelae leading to extended

hospitalisation with an increased financial burden. This is particularly important in our setting where the government bears the cost of medical care.

The infection rate in our study was 13.5%. The incidence of infection was higher in group 2 (21.7%) than in group 1 (5.1%). Since these treatments were carried out under the same conditions, this study suggests that as far as mandibular fractures are concerned, in a given space of time, plating will generally result in more complications (infections in particular) than closed reduction. The infection rate in the open group (21.7%) is much higher than that reported by Gabrielli et al,[22] who reported a 7.85% incidence following fixation of mandibular fractures with 2.0mm miniplates in 191 patients. However, when only angle fractures were considered, the incidence increased to 18.98%.In their assessment of mandibular angle fractures following fixation with one or two non-compressionmini-plates, Ellis and Walker[34]recorded a 16% and 28% complication rate respectively. Most of theircomplications were postoperative infections requiring surgical drainage and subsequent hardware removal.

Gutta et al[1] assessed the outcomes of mandibular fractures treated by open reduction and internal fixation on 560 patients and found an overall 26.45% complication rate (hardware failure 15.4% and infection 15.15% being the most common complications). Overall, the infection rate in our study is comparable with that reported in the literature.

It is the opinion of the investigators that the following are risk factors in the development of postoperative infections of mandibular fractures:

1. Plating

Our study clearly shows that closed reduction hadalower infection rate, a finding similar to the study by Lamphier al.[19]They compared complications associated with open and closed treatment of mandibular fractures in 358 patients with 594 fractures. The closed reduction group had a complication rate of 7.6% while the open reduction group had a 23.7% complication rate. They concluded that treatment of mandibular fractures by closed reduction resulted in the least number of postoperative complications in all anatomical regions of the mandible. They suggestedthat less complicated fractures, which are generally more amenable to closed treatment, are usually selected for the closed treatment group, hence the fewer complications.

Cawood[42] also compared 50 consecutive patients with mini-plates to 50 with wire fixation plus 6 weeks of IMF. Although patients who had mini-plates fixation regained their ability to function much sooner, the infection rates (6% versus 4%) and dehiscence (12% versus 6%) were higher in the mini-plate group than the closed reduction group. Stone et al,[39] in his study to determine the risk factors for postoperative infection, found that open surgical treatment was the only variable statistically significant for increased risk of infection.

Ellis et al[7,34,37,40] showed a 17% complication rate for mandibular angle fractures with the use of nonrigid fixation, 16% with mini-plates fixation and 29% with two mini-dynamic compression plates at the angle.

Despite these inherent complications, open reduction with internal fixation represents a major advancement in the treatment of mandibular fractures and it is a service that if indicated should be offered to patients. However, closed reduction yields equally good functional outcomes as open reduction and results in fewer complications, and should therefore not be regarded as an inferior or compromised treatment option. Both patients and clinicians should be aware of the risks associated with ORIF.

2. Delay in treatment

In a referral public hospital such as ours it is often difficult to getpatient to the operating room quickly after admission, a situation that is frequently beyond the control of the surgeon. Older fractures often require increased anaesthetic and surgical time.

Champy et al[17,26,29]recommended plate osteosynthesis to be performed soon after injury (12 to 24 hours post-injury) to minimize the incidence of infection. The average time lapse to treatment in ourstudy was 8 days. This delay in treatment may be partly responsible for the high rate of infection seen in group 2. This corroborates previous findings that a delay in treatment can result in an increase in the infection rate in both closed and open reduction with internal fixation.[20,24,34,39]A study by Iizuka et al[41] has shown a lack of correlation between delay of treatment and postsurgical infectionafter closed reduction or surgery with open reduction and internal fixation, provided that the treatment is performed within the first two days.

3. Site of fracture.

Most of the infections in our study occurred in the body and angle regions of the mandible. Access to these areas is poor relative to the more anterior regions of the mandible and this may also impede adequate oral hygiene.

Intra-operative measures such as elevating the mucoperiosteum and the masseter muscle to facilitate open reduction with internal fixation at the angle region inevitably leads to severance of vascular supply to the cortical bone.[20,35] These factors may explain the higher rate of infection at the angle and body regions.

4. Number of plates.

A study indicated that the use of two plates at the angle of the mandible resulted in more infections as compared to the use of one plate.[34] The lowest complication in angle fractures appears to be by using a single miniplate according to Champy's principles.[34,37,40]

In our study two patients had two plates placed at the angle and both cases became infected.

5. Teeth in the line of fracture

Some of the infections noted in this study appeared to be related to teeth left in the line of fracture.

As these appeared to be firm and vital at the time of surgery, they were not extracted. The management of teeth left in the line of fracture remains controversial. Rowe and Killey,[48] Converse[47] and Bradley[49] have stated that retained teeth often become a nidus for infection. They recommended that teeth in fracture lines (even if vital) be removed to reduce the risk of complications. Authors such as Trauner,[46] Kruger[45] and Shetty[44] questioned the advantage of routine extraction of all teeth in the fracture line. Shetty and Freymiller[44]recommended that teeth in the fracture line be extracted under the following conditions: 1/ teeth that prevent fracture reduction 2/teeth with exposed or fractured root 3/ teeth with poor periodontal health. However, clinicians are often confronted by borderline cases where extraction or non-extraction of teeth in the fracture line is not a simple decision.

Shettyet al[44] also stated that the timing of fracture treatment is a factor in the decision of whether to extract or not to extract teeth in the line of fracture. They concluded that complications will be an exception when fracturereduction and adequate fixation is instituted as soon as possible.

Contrary to other studies, age and presence ofco-morbiditydid not seem to influence the outcome in this study.[15,20]There is plausible justification of the relationship between age andcomplications of mandibular fractures. The basis for

this argument is commonly that as individuals age, their immunity drops, theirhealing capability deteriorates and they are prone to disease andcomplications including those related to use of plates in mandibularfractures. Despite this established medical theory, our findings suggest that age has no bearing on the healing of fractures. This could be explained by the fact that most of the patients wereyoung, and generally healthy with less comorbidity. One would also expect immune-compromised patients such as HIVpositive patients and poorly controlled diabetics to be moresusceptible to septic complications than the healthy patients. Since HIV is not a notifiable disease and routine screening is not carried out in our unit, we were unable to ascertain the prevalence of HIV and its correlation to post-treatmentinfection.

Seniority of the surgeon did not appear to improve the outcome as the senior registrars performed most of the open reductions. Our assumption is that if the majority of the ORIF'swere done by junior registrars, they would have taken much longer to complete the operation and this would have had an impact on the infection rate.

CONCLUSION

This study has attempted to compare the rates of infection between open reduction with internal fixation and closed reduction. Angle and body fractures occurred more commonly in our study. Blunt trauma due to interpersonal violence was the predominant cause of the injuries. Overall, the infection rate in this study was 13.5%. The highest infection rate was in the open reduction and

internal fixation group (21.7%). The closed reduction group had a 5.1% infection rate. Seniority of the registrars, patients' age, and presence of comorbidities did not seem to influence the outcome in this study. Based on our study we recommend the following when treating mandibular fractures:

1. early intervention
2. in the presence of adequate dentition where adequate stability of fractured segments can be achieved closed reduction should be considered as first line therapy for mandibular fractures
3. prophylactic removal of teeth in fracture line, especially for fractures with late presentation
4. adequate debridement of the fracture sites, with atraumatic management of the soft tissues
5. in situations where ORIF is indicated use fewer numbers of plates and avoid excessive stripping of the tissues, which may compromise vascular supply to the fractured segments
6. treatment of the fractures in an aseptic environment or conditions.

LIMITATIONS

The validity of the findings of this study is limited by the small sample size and lack of follow-up beyond the 6week period. Many patients failed to attend follow-up visits once their wire fixation had been removed. A larger sample size and longer follow-up would have strengthened the study.

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