

## Implant Associated Surgical Site Infection in Orthopaedics: A Regional Hospital Experience

1. Madu K.A., FMCS (Ortho), FWACS, 2. Enweani U.N., FMCS (Ortho), FWACS,  
3. Katchy A.U., FMCS(Ortho), FWACS, 4. Madu A.J., FMCPPath, 5. Aguwa E.N., FWACP, FMCPH

1,2,3. Department of Orthopedic Surgery, National Orthopedic Hospital, Enugu.

4. Department of Pathology, University of Nigeria Teaching Hospital, Enugu.

5. Department of Community Medicine, University of Nigeria Teaching Hospital, Enugu.

### ABSTRACT

**BACKGROUND:** Post operative surgical site infection following implant surgery is a major problem in orthopedic surgical practice. Infection occurring after internal fixation of a fracture is a devastating complication and may be difficult to treat. The frequency of occurrence of surgical site infection has decreased with improvements in aseptic technique. The objectives of the study are to determine the incidence of surgical site infection following orthopaedic related implant surgeries and to identify the predisposing factors.

**METHODS:** The study was a prospective study conducted at the National orthopedic hospital, Enugu. Wound surveillance was carried out for the 97 patients included in this study for a period of 6 months postoperatively. The diagnosis of surgical site infection was in accordance with the CDC's guideline for prevention of surgical site infection published in 1999.

**RESULTS:** The study included 61 males and 36 females giving a ratio of 1.7:1. The study population was aged 7 to 83 years with a mean age of 38.7±18.3 years. The infection rate was found to be 9.3% with staphylococcus aureus as the most common causative organism in 55.6% of cases. Two of the nine infected cases required implant removal. Significant factor was a theatre population of more than 6 persons.

**CONCLUSION:** Surgical site infection following implant surgery is relatively common in our environment with staphylococcus aureus as the major causative organism. Increased theatre populations increase the risk of implant associated surgical site infection.

### INTRODUCTION

Surgical site infection following implant surgery constitutes a serious problem when it occurs. Infection occurring after internal fixation of a fracture is a devastating complication and may be difficult to treat<sup>1</sup>. Implant surgeries are increasingly popular due to the early pain free mobilization achieved by open reduction and internal fixation. Despite optimal aseptic conditions and adequate perioperative management, postoperative wound infection cannot be completely avoided.

Koch first recognized the link between an infective foci and microbial growth in his nineteenth century

postulates. Semmelwies demonstrated a 5-fold reduction in puerperal sepsis by hand washing between performing post mortem examinations and entering the delivery room<sup>2</sup>. Joseph Lister showed that living organisms caused fermentation and putrefaction.

Alexander Fleming was credited with the discovery of penicillin, which heralded the decline of postoperative wound infection. Sterilization of instruments began in the 1880s, as did the wearing of gowns, masks and gloves. The above measures led to a decline in post operative wound infection but did not completely eliminate it.

The most widely accepted definition of wound infection is that given by the National Research Council of the U.S.A in 1964 as "the presence of pus in a wound which has either spontaneously discharged or has to be removed by the removal of sutures or reopening of the incision"<sup>3</sup>. The center for disease control replaced the term "surgical wound infection" with "surgical site infection" in 1992<sup>4</sup> and developed standardized surveillance criteria for defining surgical site infections<sup>5</sup>. Surgical site infection is classified into three categories namely

- (1) Superficial surgical site infection involving skin and subcutaneous tissue.
- (2) Deep incisional surgical site infection involving the deeper soft tissue.
- (3) Organ/space surgical site infection involving areas other than the incision itself that were opened in the course of the procedure.

Peel et al<sup>6</sup> classified postoperative wound infection based on aetiology, time of presentation and severity. Early infection presents within 30 days postoperatively, intermediate infection presents between 30 and 90 days postoperatively while late infection presents after 90 days postoperatively.

Various hospitals in Nigeria have reported varying rates of early to intermediate surgical site infection following implant surgery. Onche<sup>7</sup> reported a wound infection rate of 6.4% following implant surgery at the National Orthopedic Hospital, Igbobi. Nwankwo et al<sup>8</sup> reported a postoperative wound infection rate of 15% after Austin-Moore hemiarthroplasty in the National Orthopedic

Hospital, Enugu. Ridgeway et al<sup>9</sup> reported an infection rate of 2.3% after total hip replacement and 4.6% after hip hemiarthroplasty. An infection rate of 2.2% was reported at the Elvis Presley regional center between 1984 and 1993, following femoral and tibial nailings<sup>10</sup>. Collated data on the incidence of wound infection in implant surgery may underestimate the true incidence because some infections occur after the patient has been discharged and as such are not seen by the surgeon who inserted the implant.

Postoperative wound infection is most commonly caused by *Staphylococcus aureus*<sup>11</sup>. Other bacterial organisms are also involved in the causation of infection following implant surgery and they include *Escherichia coli*, *Pseudomonas* species, *Proteus* species and the enterococci. Onche<sup>7</sup> found that 72% of postoperative wound infections following implant surgery were caused by *Staphylococcus aureus* while 14% were caused by *Escherichia coli* and *Klebsiella*. Mbamali<sup>12</sup> found *Staphylococcus aureus* in 60% of wound infections. About two thirds of wound infections at the Baylor College of medicine, Houston, Texas were caused by either *Staphylococcus aureus* or coagulase negative *Staphylococci*<sup>13</sup>.

There has been no study on implant associated surgical site infection in the institution though there have been such studies in other parts of the country. This study aims to document the incidence and the predisposing factors, as well as, to compare these results with findings elsewhere.

## METHODS

This was a prospective study carried out at the National orthopedic hospital, Enugu between 1<sup>st</sup> February 2007 and 31<sup>st</sup> January 2008. Inclusion criteria for the study included all patients with closed fractures of bones treated by open reduction and internal fixation using implants who had no pre-existing or co-existing immunocompromising disease or situation. Exclusion criteria included patients who had previous surgery at the fracture site as well as all open fractures irrespective of the size of the related wound. A thorough history was obtained from the patients. Pre-operative full blood count, erythrocyte sedimentation rate, urinalysis, fasting blood sugar and retroviral screening was done for all patients.

Ninety seven patients met the inclusion criteria and were recruited into the study. Recruited patients had proforma opened for them. All patients were recruited within the 1<sup>st</sup> 6 months of the study and followed up for the next 6 months after recruitment. Informed consent was obtained at recruitment. Approval was obtained from the hospital ethical committee. There was no patient lost to follow up, neither were there deaths in the course of the

study.

All patients received prophylactic antibiotics using cloxacillin with clavulanic acid, ceftriaxone or ciprofloxacin determined by the surgeon's preference. Antibiotics were given at induction of anaesthesia and at regular intervals post operatively for 24 hours.

Standard skin preparation was done with either cetrimide or chlorhexidine with application of spirit after skin cleaning with one of the above. All wounds were inspected 72 hours post operatively and on alternate days if any sign of infection was seen. Patients were monitored for onset of pain at the surgical site, discharge from the wound or pyrexia. Diagnosis of surgical site infection was made in accordance with the CDC guidelines for definition of surgical site infection.

Wound swabs or aspirates were taken from all discharges for microscopy, culture and sensitivity to antibiotics. Patients also had preoperative (72 hours before surgery) and postoperative (72 hours after surgery) full blood count and erythrocyte sedimentation rate. The values of the white cell and differential count were compared in the two results as an index of infection. Patients who had a rising white cell count had closer wound surveillance.

Bone biopsy culture and sensitivity was done for patients needing implant removal following wound infection. All the recruited patients were seen in the outpatient clinic by the authors for 6 months after the surgery. There were no deaths or drop-outs in the course of the study. All patients were seen in clinic at intervals of 6 weeks for the 1<sup>st</sup> two visits and then 3 months after that. Where the authors were unavoidably absent, the consultant or senior registrar in the unit undertook the assessment based on already agreed criteria.

Predisposing factors analyzed include age, sex, length of preoperative hospitalization, duration of operation, surgical technique, theatre population, skin shaving, use of drains, operating theatre suite, type of implant used and type of prophylactic antibiotics. Each variable in this study was divided into two or more groups (e.g surgical technique grouped based on whether the surgeon was a trainee or a qualified surgeon) and the chi-square used to determine association between categories of a given variable. P value less than 0.05 was considered significant.

Multiple logistic regression analysis was also done to determine the predictive value of each variable.

Data was analyzed with EPI-INFO 3.4.1 and SPSS 11 package for incidence and distribution of surgical site infection and a test of statistical significance for the predisposing factors.

## RESULTS

There were no deaths or drop-outs in the course of the study. There were 61 (63%) males and 36 (37%) females giving a male: female ratio of 1.7:1. The mean age was  $38.7 \pm 18.3$  years (range=7-83 years). The infection rate was 9.3%. All infections in this study occurred early (by Peel's classification). Staphylococcus aureus was seen in 55.6% of cases, Escherichia coli in 22.2%, Proteus in 11.1% and multi-bacterial infection in 11.1%.

**Table 1: Distribution of Infecting Organism**

INFECTING ORGANISM	NUMBER OF CASES
	n (%)
Staphylococcus aureus	5 (55.6)
Escherichia coli	2 (22.2)
Proteus	1 (11.1)
Multibacterial (staphylococcus aureus & klebsiella)	1 (11.1)

Two (2.1%) of the infected cases were seen in the twenty four patients aged 1-25 years. Four (4.1%) of the infected cases were seen in fifty one patients aged 26-50 years, while 3(3.1%) infected cases were seen in the 17 patients aged 51-75 years. No infection was seen in the 76-100 year age group. The difference was not statistically significant( $p=0.557$ ).

Surgical site infection occurred in 6(6.2%) males and in 3(3.1%) females. The difference was not statistically significant ( $p=0.805$ ).

The patients were admitted for a range of 1 to 139 days preoperatively. The mean duration of preoperative admission was  $16.3 \pm 18.5$  days, median was 11.0 days. There was no statistically significant difference seen in the groups of patients admitted for less than 2 weeks, two to four weeks and more than four weeks.

The duration of operation ranged from 30 to 240 minutes. The mean duration was  $110 \pm 49.5$  minutes. Seven (7.2%) of the seventy-four patients whose operations lasted less than 120 minutes had surgical site infection, while 2(2.1%) of those whose operations lasted more than 120 minutes had surgical site infection. The difference was not statistically significant ( $p=0.912$ ).

There was no statistically significant difference seen in infection rates for surgeries done by consultants when compared to surgeries done by senior residents. Seven of the sixty eight cases done by consultants developed surgical site infection while two of the twenty nine cases done by senior residents got infected.

All the infected cases had a theatre population of more than 6 people. Three cases were done with 4-6 people in the theatre and no infection was seen in this group. None of the cases were done with less than 4 people in theatre.

Fifty four patients were shaved in the ward, while four were shaved in the theatre. Thirty nine patients were not shaved. Six (6.2%) of those who were shaved in the ward had surgical site infection. Two (2.1%) of those who were not shaved and one (1.0%) of the patients who were shaved in theatre had surgical site infection. The difference was not statistically significant( $p=0.335$ ).

Suction drains were used in 70(78.3%) cases. Duration of drainage was grouped into; 1-3 days and 4-6 days. Three(3.1%) patients in each category had surgical site infection. The difference was not statistically significant( $p=0.665$ ).

Antibiotic prophylaxis involved the use of different types of antibiotics as determined by the surgeon. Six(6.2%) of the 78 patients who received ceftriaxone had surgical site infection, while 1(1.0%) of the 4 patients who received ciprofloxacin developed surgical site infection. Two (2.1%) of the 15 patients who received amoxicillin/clavulanic acid had wound infection. The difference was not statistically significant( $p=0.423$ ).

Surgeries were either done by a consultant surgeon or by a senior trainee with the requisite surgical skill.

Different implants were used for various fractures. Forty seven (48.5%) patients had fixation with plate and screws, while twenty patients (20.6%) had fixation with kuntscher nails. Five (5.1%) patients had hemiarthroplasties with Austin Moore prosthesis, while 4 (4.1%) patients had total hip replacement. Seventeen (17.5%) patients had fixation with screws alone while 4 (4.1%) patients had fixation with staples. Of the 9 cases with post operative wound infection, 3 (3.1%) of those who had kuntscher nailing developed wound infection. Three (3.1%) of those who had fixation with plate and screws developed infection. One (1.0%) patient who had Austin- Moore hemiarthroplasty developed post operative wound infection. One (1.0%) of those who had screw fixation developed post operative wound infection. One (1.0%) of those who had fixation with staples developed post operative wound infection. None of the patients who had hip replacement developed post operative wound infection. The difference was not statistically significant ( $p>0.05$ ).

Two theatre suites were used for the study. Seventy(72.2%) cases were done in theatre suite 1, while 27(27.8%) were done in theatre suite 2. Six (6.2%) of the cases done in theatre suite 1 developed surgical site infection, while 3(3.1%) of the cases done in suite 2 had surgical site infection. The difference was statistically significant( $p=0.006$ ).

Two (2.1%) of the nine patients required implant removal, in a bid to control the infection, though discharge of purulent fluid from the wound persisted bone biopsy m/c/s were done for these cases and yielded

staphylococcus aureus.

The likelihood of developing wound infection can be predicted if the coefficient of regression is known. The higher the coefficient of regression, the higher the

positive predictive value. The closer the value to 0, the higher the negative predictive value e.g. for theatre population, the coefficient of regression was 12.3848 which is positively predictive. For age, the value was 0.0016 which is negatively predictive.

**Table2: Relationship Between Type of Implant and Wound Infection**

IMPLANT	WOUND STATUS		
	INFECTED n (%)	NOT INFECTED n (%)	TOTAL n (%)
Kuntscher nail	3 (3.1)	17 (17.5)	20(20.6)
Plate and screws	3 (3.1)	44 (45.4)	47 (48.5)
Austin Moore	1 (1.0)	4 (4.1)	5 (5.1)
Total Hip	0 (0)	4 (4.1)	4(4.1)
Screws alone	1(1.0)	16 (16.5)	17 (17.5)
staples	1 (1.0)	3 (3.1)	4 (4.1)
	9 (9.3)	88 (90.7)	97 (100)

Chi square = 3.25, 5degrees of freedom

P = 0.587

**Table 3: Results of Logistic Regression**

TERM.	COEFFICIENT OF REGRESSION.
Age	0.0016
Consultant(Yes/No)	1.2393
Implant(K-nail/Austin-Moore)	0.8696
Implant(p &s/Austin-Moore)	1.8881
Implant(screws/Austin-Moore)	1.4461
Implant(THR/Austin-Moore)	-13.4213
Theatre population	12.3848
CONSTANT	-14.4219

The likelihood of developing wound infection can be predicted if a variable is known with the formula

$$y = a + b_1c_1 + b_2c_2 + b_3c_3 \dots$$

Where y= predictive value.

a= constant.

b= coefficient of regression.

c= variable.

## DISCUSSION

Various researchers in Nigeria have reported different rates of surgical site infection. Nwankwo<sup>8</sup>, studying surgical site infection after Austin-Moore hemiarthroplasty in the same institution, reported a rate of 15%. At the National Orthopedic hospital, Lagos, Onche<sup>7</sup> reported a surgical site infection rate of 6%. Enweani<sup>14</sup> reported an infection rate of 4.6% following all orthopedic surgeries while Jaja<sup>15</sup> reported an infection rate of 3.4% at the Lagos university teaching hospital. These two studies were not limited to implant surgeries. In the United Kingdom, Bengner et al<sup>16</sup> reported a postoperative wound infection rate of 6.2% though majority of the infected cases were classified as minor. Ridgeway et al<sup>9</sup> reported an infection rate of 2.3% after total hip replacement and 4.6% after hip hemiarthroplasty.

*Staphylococcus aureus* was the infecting organism in 55.6% of the infected cases in this study. *Escherichia coli* was isolated in 22.2% of cases, while *Proteus* specie was cultured in 11.1%. The isolate from the remaining 11.1% was multi-bacterial (*staphylococcus aureus* and *Klebsiella* specie).

*Staphylococcus aureus* was also the most common micro organism isolated in the study by Onche<sup>7</sup>. Rabih et al<sup>13</sup> and Zimmerli et al<sup>17</sup> found that two-thirds of wound infections were caused by *Staphylococcus aureus* or coagulase negative staphylococci. Grief et al<sup>18</sup>, however, reported that most positive cultures contained several organisms.

## EVALUATION OF RISK FACTORS

In this study, only two of the factors studied were found to be associated with occurrence of impant associated surgical site infection. These factors were theatre population during surgery and the operating suite in which the procedure was done.

Age and sex were not significant risk factors in this study. Onche<sup>7</sup> in Lagos had similar findings. Cruse and Foord<sup>19</sup> reported that patients aged over 66 years were six times more likely to develop surgical site infection than those aged one to fourteen years. Cronquist<sup>20</sup>, however, reported the opposite.

The length of preoperative hospitalization was not found to be a significant risk factor in this study. This contrary to reports by Onche<sup>7</sup>, Enweani<sup>14</sup>, and Ridgeway<sup>9</sup>. Cronquist<sup>20</sup> reported admission from another institution as the only significant predictor of surgical site infection. Ojiegbe<sup>21</sup>, in Enugu, also found no association between preoperative hospitalization and surgical site infection.

Skin shaving, especially in the ward, is generally accepted to increase the risk of surgical site infection. Studies have shown that patients who were neither shaved nor had their hair clipped had a lower incidence of surgical site infection<sup>19</sup>. The finding in this study is

contrary to this as skin shaving was not found to significantly increase the risk of surgical site infection. Duration of operation was not found to be a significant risk factor in this study. This is contrary to studies by various workers<sup>14,19,20</sup>. Cruse and Foord<sup>19</sup> reported that the rate of surgical site infection was found to double for every hour of the procedure, while the relative risk was 1.3 for every additional thirty minutes<sup>20</sup>.

Surgical expertise did not significantly affect the risk of developing surgical site infection. This may be explained by the fact that all surgeries were done by surgeons or trainee with the requisite surgical expertise. This is in keeping with studies by earlier workers<sup>14,21</sup>. Hasselgren<sup>22</sup> reported that the risk of surgical site infection was not increased by using a single knife, though in this study at least two knives were used in each surgery.

The theatre population was found to significantly affect the risk of developing surgical site infection. All cases of surgical site infection occurred where the theatre population was more than 6 persons. This in not suprising as increased theatre population means increased theatre traffic and resultant air contamination. Opinions differ as to the risk of surgical site infection when suction drainage is used<sup>21,23,24</sup>. The use of suction drains was not found to be associated with the occurrence of surgical site infection neither was the duration of drainage found to be a significant factor. The finding in this study is similar to that by Zamora et al<sup>25</sup> who found no corelation between the length of time a drain remained in place and development of surgical site infection. This is contrary to the study by Willemen et al<sup>26</sup> who found that wound colonization increases with the duration of time a drain is left in place.

Three classes of antibiotics were used in this study; a cephalosporin, a quinolone and a penicilin. There was no statistically significant difference between the choice of antibiotic. Many studies have proven the efficacy of preoperative antibiotic administration in the prevention of development of surgical site infection<sup>27,28</sup>.

There was a statistically significant difference in the infection rates in various operating theatre suites, thus theatre was a risk factor in development of surgical site infection. This is contrary to the report by Cruse and Foord<sup>19</sup> but may be explained by the fact that theatre suite is wrongly located on a thoroughfare and was not originally designed as a theatre.

## CONCLUSIONS

The postoperative wound infection rate following implant surgery was 9.3% with *Staphylococcus aureus* as the most common microorganism responsible for postoperative wound infection following implant surgery. The theatre population and theatre suite used were found to be the significant risk factors in

development of implant associated surgical site infection.

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