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Post-operative infection in internally fixed closed fractures – the risk factors, organisms and their sensitivity

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Abstract
Introduction: Incidence of infection after internal fixation of closed fractures is generally lower (1−2%). Aim of this study is to find out risk factors and identify the organism and their sensitivity to commonly used antibiotics in post-operative infected cases following internally fixed closed fractures. Material & Methods: 211 patients of all ages and both sexes underwent elective surgery for internal fixation of closed fractures by a single surgical team at our institute from September 2016 to September 2017. 18 of them developed post-operative infection and were retrospectively analysed. Presence of post-operative infection was diagnosed on basis of history, clinical examination, blood parameters and radiographs. Surgical site infection, superficial or deep, florid or low grade, early or delayed or late onset infection were defined as per existing literature. Microscopy, culture and sensitivity test was done on swabs obtained from discharge through surgical site or sinus tract or from deep tissues during surgical exploration under anaesthesia. Results: The post-operative infection rate in our study was 8.53% (18 cases out of 211). Males (n=14), age > 40 years (n=11), femur (n=9, 50%) especially proximal end (n=7), pre-operative hospital stay for > one week and increased duration of surgery of more than 60 minutes were most commonly affected. 5 out of 40 cases (12.5%) of closed reduction and 13 out of 171 cases (7.6%) of open reduction developed post-operative infection. The percentage of post-operative infection with plate, intramedullary nail, screw and bipolar prosthesis implantation are almost similar. Late onset (50%), superficial (61.11%) and low grade infection (77.78%) were more common than their counterparts. *Staphylococcus aureus* was the most common organism followed by K*lebsiella pneumonae*. Imipenem, ciprofloxacin& vancomycin were most common sensitive antibiotics. Imipenem showed sensitivity to gram negative organisms but Vancomycin, Co-trimoxazole, Cefoxitim and Linezolid were sensitive to *Staphylococcus* species including MRSA (Methicillin resistant Staphylococcus aureus). Ciprofloxacin was sensitive to both Staph species & gram negative organisms. 15 patients had at least one comorbidity and 8 patients had more than 2 comorbidities, anaemia being the most common.
Conclusion: Knowledge of patient related clinical factors and commonly isolated organisms and their antimicrobial sensitivity patterns within a given hospital assists in prophylaxis and treatment of post-operative infection.

Keywords: Post-operative infection, internal fixation, closed fracture, organism, antibiotic sensitivity

Introduction

Orthopaedic implants such as external-fixators, intramedullary nails, plates and screws are increasingly used for fracture fixation [1]. The incidence of infection after internal fixation of closed fractures is generally lower which may exceed up to 30% after fixation of open fractures [2-5]. Postoperative wound infection is a serious complication in presence of hardware implantation [5]. In addition to protracted hospitalization, patients may need additional surgery and antimicrobial treatment as well as the possibility of renewed disability [6]. It can also be an economic disaster for patient and hospitals that treat large numbers of these patients [7, 8]

A major risk factor for these infections is the extent of soft tissue and periosteal damage associated with fracture and subsequent surgery [9]. It is a matter of controversy whether osteosynthesis in different anatomical regions implies a difference in risk of postoperative wound infection [10-13]. Several conditions have been recognised to significantly increase the risk of post-operative infection such as Rheumatoid arthritis, Diabetes mellitus (DM), Sickle cell anaemia, Psoriasis, renal failure, immunosuppression due to prior renal or liver transplant, malnourishment, obesity, concurrent UTI (bladder retention in post operation), malignancy etc. [14]. *Staph aureus*is the most common offending organism [1]. About one third of the infections develop within 3 months, another 3rd develop within one year and reminder develops after one year of surgery [15].

The aim of this study is to find out the risk factors and identify the organism and their sensitivity to the commonly used antibiotics in post-operative infected cases following internally fixed closed fractures.

Materials and Methods

This is a retrospective study conducted in Orthopaedic Department of a tertiary care teaching institute in patients operated within a period of one year from September 2016 to September 2017. Patients of all ages and both sexes who developed infection following elective surgery for internal fixation of closed fractures were included in the study. Open fractures, pathological fractures, fractures treated with external fixation, patient having existing or past history of osteoarticular infections and co-existing infection elsewhere like UTI, RTI etc were excluded from the study. All patients were operated by the same team of surgeons. A surgical site infection was defined according to following Centre of Disease Control's (CDC) criteria [16, 17].

1. Purulent drainage, with or without laboratory confirmation from the incision site or any discharging sinus.
2. Organisms isolated from an aseptically obtained culture of fluid or tissue from the incision site or any discharging sinus.
3. At least one of the following signs or symptoms of infection: pain or tenderness, localised swelling, redness or heat.

Superficial surgical site infection was defined as one that involves only the skin or subcutaneous tissue of the incision [17]. Deep infection was defined as infection involving bones that occur when the infectious process involves tissues deep to the muscular fascia [18]. Florid infection was defined as when there are systemic signs of infection, abscess collection, cellulitis or discharging pus from the sinus tract. Low grade infection was defined by persistent watery sinus track discharge with radiological evidence of osteomyelitis and loosening of implant [19]. Infections after internal fixation were classified into early (less than 2 weeks), delayed (2−10 weeks), and late onset (more than 10 weeks) [1, 20-22].

During our study period, 211 patients underwent elective internal fixation of closed fractures. 159 (75.36%) were males and 52(24.64 %) were females with M: F ratio of 3.06:1. Average age was 39.90 years (range 4 -87 years). Femur (n=91, 43.1%), humerus (n=37, 17.5%), forearm bones (n=31, 14.6%) and tibia (n=21, 9.95%) were the commonly operated bones. Trochanteric fractures (n=33, 15.6%), shaft femur fracture (n=28, 13.2%), fractures neck of femur and fractures of distal humerus (n=21, 9.95%) were the commonly fixed fractures. [Shown in table [1].

The implants used in our study were plates of different types (n=98, 46.44%), k wires alone or in combination with SS wires (n=51, 24.17%), different types of intramedullary nails (n=42, 19.90%) and bipolar prosthesis (n=10, 4.73%) for fracture neck of femur and screw fixation (n=10, 4.73%). DHS for trochanteric fractures (n=22, 10.4%) was the most commonly performed surgical procedure followed by open interlocking nailing for fracture shaft of femur and modified tension band wiring for fracture of patella (n=14 each, 6.63%).[Shown in table 1]

Table 1: Distribution of internally fixed closed fractures with bone and their anatomical site involvement with performed operative procedure

Bone (n=211)	Anatomical region	Total number (n)	Operative procedure		Total number (n)
Femur (n=91)	Neck	21	Hemiarthroplasty		10
			DHS & Derotation	CRIF	5
				ORIF	3
			CRIF with Multiple Cancellous Screw		3
	Trochanter	33	DHS	ORIF	17
				CRIF	5
			ORIF with PFLCP		7
			PFN/TFN	ORIF	3
				CRIF	1
	Sub trochanter	4	PFN/TFN	ORIF	1
				CRIF	1
			ORIF with PFLCP		2
	Shaft	28	Closed IM Nail		10
			Open IM Nail		14
			ORIF with Plating		4
	Distal third	5	ORIF with DFLCP		5
Humerus (n=37)	Proximal part	8	ORIF with PHLCP		7
			Closed IM Nail		1
	Shaft	8	ORIF with Plating		8
	Distal humerus including supra condylar& inter condylar	21	K Wire	CRIF	9
				ORIF	4
			ORIF with Screw		6
			ORIF with Plating		2
Forearm bones (n=31)	Both bones	15	ORIF with Plating		10
			Closed Nailing		2
			Open Nailing		1
			CRIF with K wire		2
	Monteggia	2	ORIF with Plating		2
	Galleazi	4	ORIF with Plating		4
	Olecranon	5	ORIF with TBW		5

	Distal Radius	5	CRIF with K wire	5
Tibia (n=21)	Platue	7	ORIF with Plating	5
			MIPO Plating	2
	Shaft	9	CRIF with IM Nailing	7
			ORIF with IM Nailing	2
	Distal third	1	MIPO Plating	1
	Medial & Lateral Malleoli	4	ORIF with Malleolar Screw & fibular plating	4
Patella (n=18)	Mid third	14	ORIF with Modified TBW	14
	Polar	4	ORIF with TBW	4
Clavicle (n=2)	Middle third	2	ORIF with Plating	2
Metatarsal (n=6)		6	ORIF with K Wire	4
			CRIF with K wire	2
Metacarpal (n=2)		2	ORIF with K Wire	1
			CRIF with K wire	1
Acetabulum (n=1)		1	ORIF with Plating	1
Pelvis (n=1)		1	ORIF with Plating	1
AC Dislocation(n=1)		1	ORIF with Screw	1

18 cases (8.53%) from our study population developed post-operative infection. The patient related information's were retrieved from the case notes of these infected cases. The information obtained were of demographic data, existing co-morbid conditions, current drug use such as steroid, smoking, alcoholism, length of preoperative and total hospital stay, anatomical site of fracture, methods of reduction & fixation devices used, duration of operation and preoperative & post-operative antimicrobial prophylaxis. Physical examination findings to look for clinical signs of infection and to determine location of the infected wounds, sinus, discharge etc were noted. Blood parameters of Haemoglobin Percentage, Total Leucocyte Count, Differential Leucocyte Count, Erythrocyte Sedimentation Rate, Quantitative C-Reactive Protein and radiograph in antero-posterior and lateral views of the involved part were done on clinical suspicion of infection.

The specimens were collected aseptically on the day when patients presented with clinical evidence of infection. The specimens were collected before cleaning of the wound with antiseptic and starting of antibiotic. Using sterile cotton wool, swabs were obtained from infected surgical site or sinus tract without contaminating with skin commensals. Those who didn't have any frank pus discharge from incision site or sinus tract but had clinical suspicion and laboratory parameters suggestive of infection, underwent wound exploration under appropriate anaesthesia and multiple samples of infected tissue were collected from different sites of the explored area. The samples were transported immediately to the microbiology department for gram stain, culture & sensitivity. These reports were compiled and analysed.

Results

18 of our patient (8.53%) developed post-operative infection and therefore data related to them were used for this retrospective analysis. 14 were males (8.80% of total operated male patients) and 4 were females (7.70% of total operated female patients). 4 patients were in the age group of 41-50 years and 3 patients each were in the age group of 21-30 and 51-60 years. Therefore 11 of infected patients (61.11%) were older than 40 years of age. [Shown in table 2]

Femur (n=9, 50%) was the most commonly infected bone with distribution as trochanter and sub trochanter (n= 5), neck (n=2) and shaft (n=2). Tibia (n=5, 27.77%) was the second common post-operatively infected bone with distribution as tibial platue (n=2) and shaft (n=3). 2 proximal humerus and 1 each of distal humerus and patella developed post-operative infection. 5 out of 40 (12.5%) of closed technique of fracture reduction and 13 out of 171 (7.6%) of open technique of fracture reduction developed post-operative infection in our study. [Shown in table 2]

With 1 case of post-operative infection out of 51, k wire alone or in combination with ss wire had least infection rate at 1.96%. The post-operative infection occurred in 10 out of 98 (10.20%) plate, 5 out of 42 (11.9%) intramedullary nail and 1 out of 10 (10%) each for bipolar prosthesis and screw fixation. Thus, in terms of percentage, the rate of post-operative infection following fixation with plate, intramedullary nail, screw and bipolar prosthesis implantation were almost similar in our study. [Shown in table 2]

The early, delayed and late onset infections occurred in 5 (27.77%), 4 (22.22%) and 9 (50%) patients respectively suggesting that late onset infection was more common in our study. Early and delayed onset infections occurred only in open reduced fractures and mostly in proximal femur fractures and plate osteosynthesis. In late onset infections, closed or open technique of fracture reduction and type of implant used for fixation (intramedullary nail and plate) had similar number of cases. [Shown in table 2]

Superficial infection occurred in 11 (61.11%) and deep infection in 7 (38.88%). Superficial infections affected equal number of cases in closed and open technique of fracture reduction as well as in intramedullary nail and plate fixation. However deep infections occurred mostly following open reduction of fracture (n=6) and plate osteosynthesis (n=5) [Shown in table 2] Low grade infection (n=14, 77.78%) were much more common than florid infection (n=4, 22.22%) [Shown in table 2]

The organisms found in decreasing trend were *Staph aureus* 6 (including MRSA 1 &*Coagulase Negative Staph Aureus, CONS 1),* K*lebsiella pneumonae* 5, P*seudomonas aeruginosa 2, Citrobactor 2, Escherichia coli, Proteus vulgaris and Klebsiella oxytoca 1 each.* The most common organism in early onset infections was *klebsiella species (n=2),* in delayed onset infection was *Staph aureus (n=2)* and late onset infection was *Klebsiella pneumonae* and *Staph aureus* including *MRSA (n=3* each).

S*taph aureus (n=4)* caused the highest number of superficial infections and *Klebsiella species (n=4)* caused the highest number of deep seated infection. The highest number of florid infections was caused by *Klebsiella pneumonae* and highest number of low grade infection was caused by *staph aureus* including *MRSA* and *Coagulase Negative Staph Aureus, CONS (n=6)* [Shown in table 2]

The isolated organisms showed their sensitivity to mainly Imipenem (n=10), ciprofloxacin (n=8), vancomycin (n=6), cotrimoxazole (n=5), cefoxitim (n=5) and linezolid (n=4). Imipenem showed sensitivity to the gram negative organisms. Vancomycin, Co-trimoxazole, Cefoxitim and Linezolid were sensitive to *Staph species* including *MRSA*. Ciprofloxacin was sensitive to both *Staph species* as well as gram negative organisms [Shown in table 2]

15 of our post-operative infective patients had at least one medical comorbidity and 8 patients had more than 2 medical comorbidities. Anaemia (n=6) was the most common associated comorbidity followed by hypertension (n=5). 3 patients were smokers with duration of smoking from 1.5 years to 7 years and 3 patients were alcoholic from 2 years to 8 years. Diabetes, hypoalbuminemia, hepatic parenchymal disease and chronic obstructive pulmonary disease were associated with 1 patient each. None of them were on medications such as steroids, post organ transplant immunosuppressive agents, anticancer therapy etc. which are known to cause immunosuppression. [Shown in table 2]

The preoperative hospital stay ranged from 2-21 days with average being 8.11 days in. 15 (83.33%) of them had pre-operative hospital stay for more than one week (1-2 weeks in 11 and more than 2 weeks in 4). [Shown in table 2]

The total hospital stay from hospital admission to discharge was 8 days to 40 days with average being 22.16 days. The hospital stay extended to more than 2 weeks in 17 (94.44%) patients. 5 of them (27.77%) were hospitalised for more than 3 weeks, 3 of them (16.67%) for more than 4 weeks and 2 of them (11.11%) for almost 6 weeks.[Shown in table 2]

The duration of surgery starting from skin incision to the closure range from 49 minutes to 135 minutes, average being 94.11 minutes in post-operative infected patients of our series. The duration of surgery was more than 120 minutes in 3 (16.66%) patients, between 90 to 120 minutes in 8 (44.44%) patients and between 60 to 90 minutes in 5 (27.77%) patients. This suggests that in 16 of the infected cases duration of surgery exceeded more than 60 minutes. [Shown in table 2]

Table 2: Detail of infected cases

Sl. No.	Patient particulars	Diagnosis	Procedure	Comorbid factors	Pre-operative hospital stay (days)	Duration of surgery (minutes)	Total hospital stay (days)	Early/ Delayed /Late	Superficial/ Deep	Florid/ Low grade	Organism	Sensitive Antibiotic
1	SK,10yr female	Subtrochanteric #	ORIF with PHLCP (SA)	Nil	8	103	21	Delayed	Superficial	Low grade	Pseudomonas aeruginosa	Imipenem Colistin Aztreonam
2	ND,13yr female	Sub trochanteric # right femur	ORIF with PHLCP (SA)	Anaemia (Hb=9.6 gm %)	16	72	31	Delayed	Superficial	Low grade	Staphylococcus aureus	Ciprofloxacin Cefoxitim Co-trimoxazole Tetracycline Vancomycin
3	MG,27yr male	#Shaft Of Femur left	ORIF with Interlock IM Nail (SA)	Nil	8	118	17	Late	Superficial	Low grade	MRSA	Ciprofloxacin Co-trimoxazole Linezolid Vancomycin Clindamycin
4	SS,65yr male	Proximal humerus # left -1 month old on presentation	ORIF with PHLCP(Block)	Smoking for 3 years – 5 Cig/day	2	107	15	Early	Superficial	Low grade	Pseudomonas aeruginosa	Imipenem Colistin Meropenem Aztreonam
5	SD,53yr male	#Both bone right leg distal third extra-articular	CRIF with InterlockIM Nail (SA)	1.Smoking for 7 years – 8 ig/day 2. Lower Prothrombin Time(PT=11)	8	113	16	Late	Superficial	Low grade	Proteus vulgaris	Ciprofloxacin Imipenem Piperacillin/tazobactum Gentamycin
6	DP,41yr male	Neglected #Neck Of Femur left	CRIF with Cannulated Cancellous Screw & Autogenous ipsilateral fibular graft (SA)	1.Alcoholic 8 years 2. Eosinophilia (E=15%)	11	67	18	Late	Superficial	Low grade	Staph aureus	Ciprofloxacin Cefoxitim Linezolid Vancomycin
7	DG,45yr male	#Right tibial proximal 1/3 rd. comminuted	CRIF with PTLCP by MIPO (SA)	Anaemia (Hb=8.2 gm %), Eosinophilia (E=14%)	8	92	21	Late	Superficial	Low grade	Klebsiella pneumonae	Imipenem
8	PG,52yr male	Comminuted Sub-trochanteric # right side	CRIF with Long PFN (SA)	Anaemia (Hb=7.6 gm %)	8	58	15	Late	Superficial	Low grade	Citrobactor species	Imipenem Ciprofloxacin
9	HG,54yr male	Proximal humerus # left side	ORIF with PHILCP(Block)	Hypertension for 3 years	2	96	8	Late	Superficial	Low grade	E.coli	Imipenem Aztreonam
10	NG,45yr female	Distal humerus # right side	ORIF with bicoloumnar plating (SA)	Hypertension for 5 years	8	135	23	Late	Superficial	Florid	Klebsiella pneumonae	Ciprofloxacin Imipenem Aztreonam
11	MB,45yr male	#Right tibial shaft	ORIF with narrow DCP (SA)	Nil	8	74	15	Late	Deep	Low grade	Staph aureus	Ciprofloxacin Co-trimoxazole Clindamycin Erythromycin Linezolid Vancomycin cefoxitim
12	HD, 86yr	#Patella right side -	ORIF with modified	1.Hypertension for	2	49	15	Delayed	Deep	Low	Klebsiella	Imipenem

	male	1 month old	TBW (SA)	10 years 2. COPD for 2 years 3. Anaemia (Hb=8.6 gm %)						grade	pneumonae	Gentamycin Piperacillin/taz obactum Cefepime
13	SS,72yr female	Trochanteric # left	CRIF with TFN (SA)	1.T2DM for 4 years 2.Hypertension for 6 years	8	63	43	Late	Deep	Low grade	Klebsiella pneumonae	Imipenem
14	DH,21yr male	#Shaft Of Femur left side	ORIF with K nail (SA)	1. Anaemia (Hb-8.4gm %) 2. Smoking for 1.5 years, 2 cig/day	8	72	21	Delayed	Superficial	Low grade	Staph aureus	Co-trimoxazole Linezolid Vancomycin Cefoxitim
15	MB,40 yrs male	Sub-trochanteric # left femur	ORIF with PFLCP (SA)	1.Alcoholic for 2 years 2.Hepatic parenchymal disease	15	109	31	Early	Deep	Florid	Klebsiella pneumonae	Tetracycline
16	BD,36yr male	Bicondylar tibial platue # left side	ORIF with dual plating (SA),	Hypertension for 5 years	8	121	43	Early	Deep	Florid	Klebsiella oxytoca	Ciprofloxacin
17	MA, 30yr male	Tibial platue # right side with posteromedial fragment	ORIF with posteromedial buttress plate with L plate & 6.5 mm locking cancellous screw for lateral side (SA)	Alcoholic for 5 years	21	128	21	Early	Deep	Florid	Citrobactor species	Imipenem
18	ND,65yr male	#Neck Of Femur left side	Hemiarthroplasty (Bipolar) (SA)	1. Anaemia (Hb-9.6 gm %) 2. Hypoalbuminemia (Alb-2.4 gm)	15	117	38	Early	Deep	Low grade	CONS	Co-trimoxazole Vancomycin Cefoxitim

Discussion

Post-operative wound infection is an unresolved problem in the development of orthopaedic surgery. Infections occur even though orthopaedists perform thoroughly aseptic procedures during surgery & patients are strictly managed before and after surgery [23]. Probable sources of infection are the hospital environment, other patients, staff, infected surgical instruments, dressings and even drugs and injections [24]. In public hospitals of developing countries, the infection rate is still high [25].

The diagnosis of implant infection can be done by clinical examination, laboratory investigation, microbiology, radiograph, ultrasonography, Computerized Tomography (CT), Magnetic Resonance Imaging (MRI), three phase Technetium99 Indium111 and Gallium67 bone scan, [1, 26]. And Positron Emission Tomography (PET) or PET-CT [1, 26]. Biopsy can also be done for undiagnosed infection but it is rarely done [27, 28].

The surgical site infection after orthopaedic implant surgery is a disaster both for the patient and surgeon. This may lead to increased antibiotic use, prolonged hospital stay, repeated debridement, prolong rehabilitation, morbidity and mortality [29].

The accepted standard for postoperative infection should be less than 1% [29]. Various authors have reported different rates of post-operative infection. It is reported from 0.5-5% by Tachdjian & Compere 1957, Henderson & Kornblum 1961, Schonholtz *et al.* 1962, Raf 1964, Stevens 1964, Maguire 1964, Annals of Surgery 1964, Towers 1965, Dencker 1965,Derian and Green 1966, Jeljaszewicz & Bobr 1968 (0.7%), Jeffrey & Sklaroff 1968,Zifko & Vlasich 1968,Bruun 1970 Plaue & Hinz 1971, Charnley 1972 and Lidgren & Lindberg 1974 (3.6%) [13].The frequency of infection was of 3.1 to 12.0 per cent after osteosynthesis [5]. in series reported by Boyd *et al.* 1973, Salvati & Wilson 1973, Kavlie & Sundal 1974, Jepsen 1973, Jamali A R *et al.* [30]. (3.97%), Tago I a *et al.* [31]. (5%), Khan M S *et al.* [29]. (5.76%), Iqbal M Z *et al.* [25]. (7.8%), Ibtesam K Afifi and Ehssan A Baghagho [32]. (8.264%) and O'Riordan *et al.* 1972 (8.8%) [13]. However, significantly higher infection rates were reported by Jain B K *et al.* [33]. (22.58%) and Jadranka Maksimovic *et al.* [34]. (22.7%). The difference in incidence of post-operative infection in different studies may be related to difference in inclusion criteria, surgical set ups and facilities available [33].

Raahave D [5] did not find sex and age to significantly influence the frequency of post-operative infection. Lidgren & Lindberg 1974 [13] reported that the age corrected incidence of infection was the same in males and females (X* = 5.3, 4, P > 0.05).

Higher rate of post-operative infection was reported by Khosravi. A.D *et al.* [7]. In the age group of 41-60 years, Jain B K *et al.* [29].above the age of 45 years and Kumar S *et al.* [35] above the age of 40 years. Khan M S *et al.* [29] reported more than 50% of their cases in patients of more than 60 years of age. The frequency of postoperative infections increased significantly with age ($P < 0.001$) from less than 0.5 per cent belowage of 25 years to close to 9 per cent above age of 75 years [13]. Tago IA *et al.* [31]. &Burnett J W *et al.* [36].reported advanced age as a risk factor. Some other studies [29, 36]. also reported advanced age as risk factor for development of post-operative infection. In our study also, post-operative infections were more common in patients above 40 years of age (61.11%). It can be due to multiple factors like a low healing rate, malnutrition, mal-absorption, increased catabolic processes and a low immunity [37].

The incidence of post-operative infection was more common in males (77.78%) in our study. This finding is similar to studies by Khosravi. A.D *et al.* [7] Stevens 1964 [5] JainBK *et al.* [33] Kumar S *et al.* [35] and Nazri M Y *et al.* [38]. However, the studies by Raf 1964, Davidson *et al.* 1971, Lidgren & Lindberg 1974 [5] showed either sexes can develop infection equally.

Femur (50%) especially proximal end followed by tibia were the most common post-operative infected bone in our study. Similar results were reported by Khosravi. A.D *et al.* [7]. Kumar S *et al.* [35]. And Nazri M Y *et al.* [38]. Raahave D [5] found higher post-operative infection rate in the lower extremity (6.6%) than in the upper extremity (3.1%); hip and ankle regions were most often involved. Tachdjian Compere 1957, Raf 1964, Salvati & Wilson 1973 [5]. Found a significantly higher infection rate after operation in the hip region. Lidgren & Lindberg 1974 [13] found the hip region ($P < 0.001$) to be a high-risk location and the spine ($P < 0.05$) and the knee joint ($P < 0.01$) were low-risk locations. They also reported that the severity of post-operative infection leading to spoiled results occurred more commonly in lower limb specially hip and proximal femur. Haf 1965 reported a significantly higher frequency after operation in the spine, hip and thigh region [13]. Stevens 1964 compared different regions but found no difference [13].

Khan MS *et al.* [29] reported increased rate of infection following open interlocking nailing. Lidgren & Lindberg 1974 [13] reported higher rate of post-operative infection following open reduction of fractures. But no such definitive observation was found in our study in terms of method of fracture reduction. However, our results of higher rate of infection in plate fixation was similar to Nazri M Y *et al.* [38] who reported infection in 22 patients following plating and 8 cases following intramedullary nailing.

Whereas most prevalent infection was late onset infection (50%) in our study, Khan M S *et al.* [29]. reported equal number of early, delayed and late infection in their study. Like our study, Khan M S *et al.* [29] reported superficial infection rate twice higher than that of deep infection. Nazri M Y *et al.* [38] reported higher rate of low grade infection than florid infection in their series; a finding similar to our study.

Our study found that the rate of infection is more (83.33%) in patients having longer preoperative stay (more than 1 week) in the hospital ward. Jain B K *et al.* [33] reported that the rate of infection increases with increase in preoperative hospital stay and infection rate in patients having preoperative hospital stay of 10 or more days had infection rate of 75% in their series. Kumar S *et al.* [35] reported highest rate of post-operative infection in their study when preoperative hospital stay was between 8-21 days. Long preoperative hospital stay leads to colonization with antimicrobial resistant microorganisms and affects patients' susceptibility to infection by lowering host immunity or by providing increased opportunities for bacterial colonization [39].

In our study, prolonged surgery time (more than 60 minutes) was responsible for increase rate of infections as reported in other studies as well [29, 31, 36,]. Sawyer R G *et al.* [40].reported that the rate of infection is directly proportional to the length of the procedure; cases lasting one hour or less had a infection rate of 1.3% while those lasting for 3 hours or more it was 4 %. Chowdhury MAM *et al.* [41] reported that infection rates were 5.3%, 10.5%, 26.1 % for durations less than 60 minutes, 60- 120 minutes, more than 120 minutes respectively. The association between the two may be the result of more complicated operations being of longer duration and increased damage to the tissue due to long exposure of the wound [24].

The SSI prolongs hospital stay on average for2 weeks, doubles re-hospitalization rates and costs can increase by over 300% [1]. Such similar observations of SSI resulting in prolonged hospital stay were made in our study.

Lancet 1960, Henderson& Kornblum 1961, Annals of Surgery 1964, Riif 1964, Stevens 1964, Gill Quist 1967, Jeljaszewicz & Bobr 1968, Bruun1970 [13]. reported that an increase of postoperative infections has been shown with age, duration of preoperative hospitalisation, co-existing infection elsewhere (e.g. of the nose, skin, urinary tract), type of preoperative washing, duration of operation, length of incision, drainage, the number of persons present in the operating theatre, the time of the day the operations are performed. Annals of Surgery 1964 reported a significant increase of postoperative infections in patients with malnutrition, overweight, diabetes and patients undergoing steroid treatment while Stevens 1964 and Bruun 1970found no increase for these factors [13]. Khosravi A.D *et al.* [7] reported smoking (33.3%), diabetes (20.6%) and drug addiction (1.8%) as risk factors. Nazri M Y *et al.* [38] reported hypertension in one patient and a combination of hypertension, DM and ischemic heart disease in another patient as medical comorbidity in their series. Khan M S *et al.* [29] reported history of smoking as a risk factor. Jain B K *et al.* [33]. Reported anaemia and DM as risk factors. Awan MS [42]. and Birendra K Jain *et al.* [33]. Reported anaemia to be the most common comorbid condition associated with post-operative infection. Patel Sachin *et al.* [39]. Reported DM as high risk. Similar correlation with some of these comorbid conditions were observed in our study.

Khosravi A.D *et al.* [7] reported that the most prevalent isolated bacteria were gram negative bacilli including Pseudomonas aeruginosa and Klebsiella ozaenae and among gram positive cocci recovered, Staph aureus was most common. Multiple factors including cross infection in postoperative hospital ward stay could have contributed to the high proportion of infections due to gram negative pathogens in this study [29]. A recent review has reported that hands of health care workers and patients can play a role in transfer of gram negative bacteria during cross infection [42, 43].This was in contrast with Gomez *et al.* 2003 [7]. study where the most prevalent organisms were gram positive and aerobes. This was probably due to different nosocomial pathogens present in their operating rooms.

The most common organism found in our study was Staph aureus (including MRSA & Coagulase Negative Staph Aureus) followed by Klebsiella pneumonae & Pseudomonas aeruginosa which is similar to Kumar S *et al.* [35]. However, the prevalence of MRSA among the Staphylococcus aureus isolates was 16.66% in our study as compared to 75 % by Kumar S *et al.* [35]. Arciola *et al.* 2005 [44]. Reported Staphylococci as the most prevalent organism & Mousa 2001 [45] reported Pseudomonas aeruginosa as the significant isolated organism. Nazri M Y *et al.* [38] reported Staph aureus as the commonest organism (80%), of which 54 % were MRSA. Staphylococcus aureus was reported as commonest organism in various studies by Patzaki *et al.* [46]. (28%), Jain B K *et al.* [33]. (39.27%) Court-Brown *et al.* [47]. (50%), Khan M S *et al.* [29]. (50%), Lidgren & Lindberg 1974 [7]. (67%), Tago IA *et al.* [31]. (67.30%) and Zych and Hutson [48]. (68%). However, they didn't mention whether the organisms were MRSA or not. Raahave D [5] reported Staph aureus and Staph albus as predominant organism among the gram positive infections and gram negative infections occurred remarkably frequently; E.coli being the most common followed by Proteus species and Pseudomonas aeruginosa. He reported that isolation of gram negative bacteria indicate the patient's own indigenous biota as the source, keeping in mind the nearness of urethra and anus to operation wounds of lower extremity. These studies are in contrast to a study in India by Agrawal *et al.* which found that the most common infecting organism was E. coli (34.4%) followed by Pseudomonas spp. and then S. aureus. However, their study was regarding all sorts of orthopaedic infections including bedsores, osteomyelitis and open fractures [29].

Overall, Staphylococcus aureus remained the commonest organism in infection around the bone [49]. Contributing factors to this include its predilection for this tissue, presence of the surface receptor for the human intracellular proteins and the Staphylococcal toxins [38]. S. aureus adheres to such host-tissue ligands via genetically defined microbial surface proteins, commonly referred to as "microbial surface components recognizing adhesive matrix molecules" (MSCRAMM) [50-51]. The most important MSCRAMMs include FnbpA and FnbpB, which bind to fibronectin; clumping factor, which binds to fibrinogen; and collagen adhesins, which binds to collagen [50-51]. The role of MSCRAMM in the pathogenesis of device associated infections, however, is not clear and, at least in the case of orthopaedic device infection, have been controversial [52].In addition, this organism commonly colonise the skin and the nares, hence a ready source of infection [48].

In our study, the most common organism found in early onset post-operative infection was *klebsiella species*, in delayed onset infection was *Staph aureus*and in late onset infections were*Klebsiella pneumonae* and *Staph aureus* including *MRSA*. Arciola *et al.* reported *Staphylococci* as the most prevalent organism in delayed and late onset infections [31].

Antibiotic sensitivity test in our study revealed that most of the organisms were sensitive to imipenem followed by ciprofloxacin & vancomycin. Similar results were reported by Khosravi. A.D *et al.* [7]. The gram negative organisms showed sensitivity to imipenem in our study which is similar to Kumar S *et al.* [35]. Showing 100% sensitivity to imipenem and 86.4% sensitivity to meropenem.Tunney *et al.*, 1998 reported vancomycin and ciprofloxacin as most effective antibiotics against isolated bacteria [53]. Vancomycin and linezolid exhibit potent clinical and microbiological activity in MRSA infection [54]. In our study, Staph*species* showed high sensitivity to vancomycin and linezolid which is similar to studies by Khosravi. A.D *et al.* [7] and Kumar S *et al.* [35]. The results of our study were contradictory to that of Thool *et al.* [55]. in which they had found that 12 out of 51 isolated *Staphylococcus* were resistant to linezolid.

The retrospective design, small sample size and short duration of follow up were limitations of our study. Our study criteria did not allow us to compare post-operative infection rate following internal fixation in emergency surgery versus elective surgery and open fracture versus closed fracture. A prospective study with larger sample size and longer duration is needed to arrive at more conclusive evidence.

Conclusion

Surgical site infections are inevitable in different orthopaedic procedures although all aseptic precautions are taken. Knowledge of patient related clinical factors and commonly isolated organisms and their antimicrobial susceptibility patterns within a given hospital assists in prophylaxis and treatment of post-operative infection. Advancing age, male sex, femur, plate osteosynthesis, prolonged preoperative hospital stay, increased duration of surgery and certain comorbid conditions like anaemia, hypertension, smoking, and alcoholism are risk factors. Late onset, superficial and low grade post-operative infections are more common and *Staph. aureus* is the most common organism. Combination of vancomycin & imipenem would be effective in empirical treatment of post-operative infections following internal fixation of closed fractures till culture and sensitivity reports are awaited or when cultures are negative.

Abbreviations

DHS: Dynamic hip screw
ORIF: Open reduction internal fixation
CRIF: Closed reduction internal fixation
PFN: Proximal femoral nail
TFN: Trochanteric fixation nail
PFLCP: Proximal femoral locking compression plate
IM: Intramedullary
TBW: Tension band wiring
MIPO: Minimally invasive plate osteosynthesis
DFLCP: Distal femoral locking compression plate
PHLCP: Proximal humeral locking compression plate
K wire: Kirschner wire
AC dislocation: Acromio clavicular dislocation
K nail: Kuntscher nail
SA: Spinal anaesthesia
DCP: Dynamic compression plate
PFN: Proximal femoral nail
PTLCP: Proximal tibia locking compression plate
Hb: Haemoglobin
PT: Prothrombin time
COPD: Chronic obstructive pulmonary disease
DM: Diabetes mellitus
MRSA: Methicillin resistant Staphylococcus aureus
CONS: Coagulase negative Staphylococcus aureus
E.coli: Escherichia coli

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