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## Surgically treated open fractures: Study of their characteristics and outcome

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### Abstract

Open fractures are a well described entity in the literature of Orthopaedics. However review of literature and patients attending fracture clinics and hospitals around the world indicates that the fracture epidemiology (in general) is changing very quickly [2, 3, 4, 5, 6, 7, 8, 9]. The same is true for open fractures as well. Worldwide literature is deficient in determining the changing characteristics, pattern and outcome of open fractures. With the intention of improving our hospital approach towards open fractures, we felt the need to audit our current management and outcome of such injuries. This study was conducted to assess the characteristics and outcome of surgically treated open fractures in our set-up.

**Aims and Objective:** To study the clinical profile and outcome of open fractures treated surgically with reference to general health, limitations of activities, physical health problems and social activities and upper and lower limb involved. Also assess the union (by x-ray) and health of patient at the end of 6 month by SF-36 questionnaire.

**Methods:** This observational prospective cohort study was carried out at the Department of Orthopedics, at a state run 1500 bedded tertiary care hospital attached to post-graduate teaching institute located in central Gujarat, from July, 2019 to November, 2020 with due permission from Institutional Ethics Committee. During this period, 60 patients with open fractures were treated surgically under one unit.

This study being a surveillance, all patients included were closely observed for a period of 6 months from the date of presentation, while they were being treated. No study specific alteration was done in the management which was decided on individual merits by the treating surgeon. All subjects were evaluated with respect to the demographic data, history of fracture being treated, presenting symptoms and signs, current management and outcome as outlined in the Performa (see Annexure). The outcome was considered favorable if the fracture united at final follow up and unfavorable if otherwise and also assessed according to SF - 36 questionnaire.

**Results:** Out of 57 fractures in our study, 41 open fractures showed union at final follow up and the remaining 16 ended in non-union. 76% of Open Grade I fractures united at final follow up where as 38.8% of Open Grade II fractures united at final follow up and 90% of Open Grade IIIA fractures united at final follow up. Among OG IIIA fractures 50% of fractures were small bones of Hand and Feet. All those fractures showed full union at final follow up. 33.33% of Open Grade IIIB fractures united at final follow up. In our study all upper limb fractures showed union compared to lower limb fractures of which 60% showed union at final follow up. In our study, Patella fractures showed 60% of non-union at final follow up. Average age of patients was 40 years. Male to female ratio was 4:1. Most patients (66.6%) were from the active phase of their life. Most patients were operated within 5 days of admission. A statistically significant association was seen between grade of open fractures and duration of Hospital stay. As grade of open fracture increased duration of Hospital stay also increased. Tibia was the most common bone fractured (43.85%) followed by Radius-Ulna (15.78%), Small bone of Hand and Feet (14.03%), Femur (12.28%), Patella (8.77%) and Humerus (5.88%). In our study 50% of Open Grade III fractures had complications like infection, failure of fixation and limb length discrepancy.

In our study 50% of patients with Open Grade III fractures showed less than 65 score of SF-36 questionnaire at final follow up and 51.16% of patients with Open Grade I & II fractures showed more than 80 score of SF-36 questionnaire at final follow up. However no statistically significant association between score of SF-36 and grade of open fractures was elicited.

**Conclusion:** We justified from our results that we should continue surgical fixation of open fractures as per our Hospital protocol so as to decrease the duration of Hospital stay and improve the outcome in relation to activities of daily living. However, more intensive treatment is advocated for open fractures of lower limb especially the severe variety. Bone grafting as a adjuvant to fracture healing may timely improve the outcome in such fractures.

**Keywords:** Open grade fracture, high velocity trauma, soft tissue

### Introduction

Open fractures, previously known as compound fractures are those in which there is a break in the soft tissue envelope over or near the fractures such that the underlying bone communicates with the external environment [1].

Open fractures are a well described entity in the literature of Orthopaedics. However review of

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literature and patients attending fracture clinics and hospitals around the world indicates that the fracture epidemiology (in general) is changing very quickly [23, 4, 5, 6, 7, 8, 9]. The same is true for open fractures as well. Worldwide literature is deficient in determining the changing characteristics, pattern and outcome of open fractures. Open fractures are common with an incidence of 30 open fractures for every 100,000 people every year in general population, with an average age of 45 years [10]. Road traffic accidents are the main mechanisms of injury in these fractures.

Open fractures are challenging due to several reasons. First of all, it is a complicated situation because of the generation of a bone defect or the presence of complex fracture patterns; second, soft tissue coverage, and in some cases, restoring the blood flow to the extremity.

In the case of multiple trauma patients, open fractures should be individually addressed in order to minimize the general complications of a prolonged reconstructive procedure, minimizing the second-hit phenomenon in unstable patients [11, 12, 13]. The decision of limb salvage can be difficult to achieve, but in these situations, if we follow a validated protocol, we can optimize the chances of a favorable outcome. With the intention of improving our hospital approach towards open fractures, we felt the

need to audit our current management and outcome of such injuries. This study was conducted to assess the characteristics and outcome of surgically treated open fractures in our set-up.

## Aims and objectives of the study

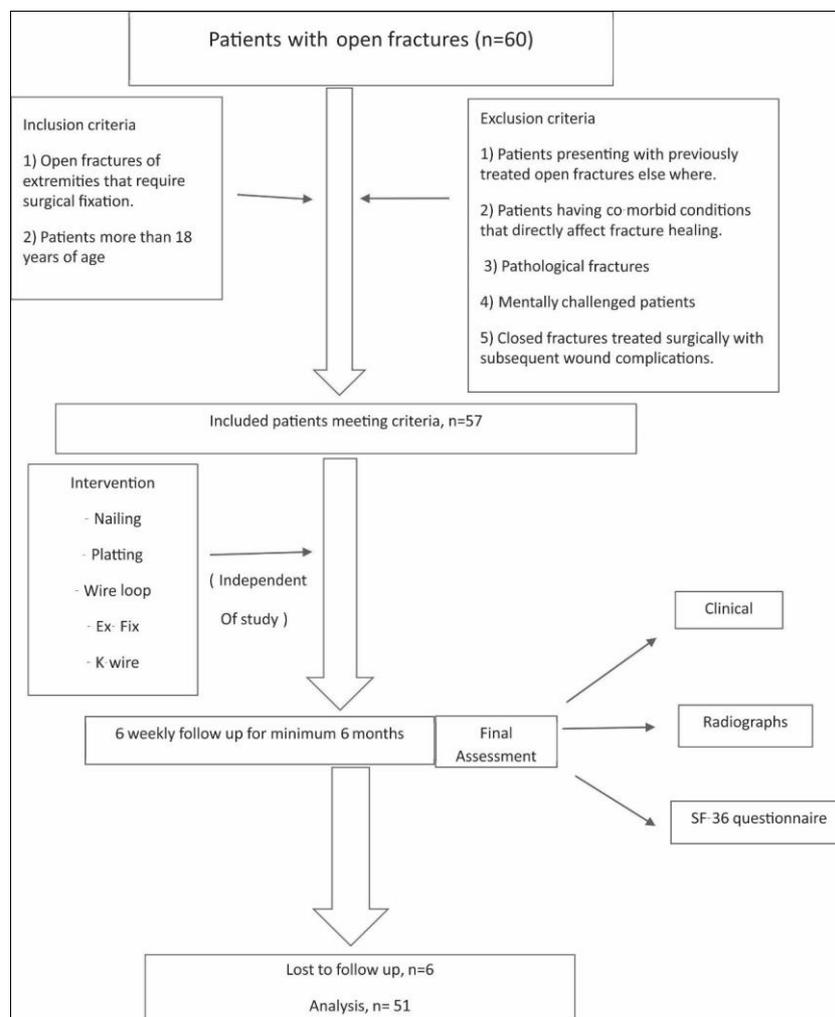
### (A) Aims

1. To study the clinical profile of open fractures treated surgically.
2. To study the outcome of open fractures treated surgically with reference to general health limitations of activities, physical health problems and social activities.

### (B) Objectives

1. To assess the union in surgically treated open fractures (by x-rays).
2. To study the current pattern of microbiological growth seen in different open fractures.
3. To analyse the outcome with reference to upper and lower limbs involved.
4. To assess the health of patients at the end of the 6 month by SF 36 questionnaire.

## Materials and Methods



**Fig 1:** Flowchart showing basic methodology

## Introduction

This observational prospective cohort study was carried out at the Department of Orthopedics, at a state run 1500 bedded tertiary care hospital attached to post-graduate teaching institute located in central Gujarat, from July, 2019 to

November, 2020 with due permission from Institutional Ethics Committee. During this period, 60 patients with open fractures were treated surgically under one unit.

This study being a surveillance, all patients included were closely observed for a period of 6 months from the date of

presentation, while they were being treated. No study specific alteration was done in the management which was decided on individual merits by the treating surgeon. All subjects were evaluated with respect to the demographic data, history of fracture being treated, presenting symptoms and signs, current management and outcome as outlined in the Performa (see Annexure). The outcome was considered favorable if the fracture united at final follow up and unfavorable if otherwise and also assessed according to SF - 36 questionnaire.

### Study setting

This study was carried out at the department of Orthopaedics, SSG Hospital and Medical College, Vadodara.

### Study population

All patients presenting with open fractures being surgically treated in one unit of Orthopaedics at SSG Hospital and consenting to participate in the study defined by inclusion and exclusion criteria were enrolled in this study.

### Study duration

We included all surgically treated open fractures in SSG Hospital Vadodara from August 2019 to May 2020.

### Study design

Prospective observational study.

### Sample size

Sixty open fractures were surgically treated at the study setting defined. Of these 3 patients were excluded as they did not fulfill the study criteria and 6 patients were lost before completing 6 months observational follow up. Hence, we had 51 patients with 57 open fractures that were surgically treated for final assessment.

### Inclusion criteria

All of the following criteria were required to be satisfied to be included in this study

1. Open fractures of extremities that required surgical treatment.
2. Patients more than 18 years of age.

### Exclusion criteria

1. Patients presenting with previously treated open fractures elsewhere.
2. Patients having co-morbid conditions that directly affect fracture healing.
3. Pathological fractures.
4. Mentally challenged patients.
5. Closed fractures treated surgically with subsequent wound complications.

### Study method

All Patients justified to be included in the study were closely monitored and data entered as per case record sheet. Surgical procedures done were noted. Outcome assessment was done on basis of status of union and SF - 36 questionnaire at final follow up.

### Follow Up

We followed up the patient for a minimum of six months at every six weekly interval. At every follow-up patients were assessed clinically for pain, swelling, mobility at fracture site, joint stiffness, signs of infection, wound status etc, radiologically for union status, alignment, and implant status

and functionally for activities of daily living. We considered a fracture united when plain radiographs showed bridging bone across the fracture in both orthogonal views and the patient could bear full weight without pain. We considered outcome as favorable when fracture union was achieved in both planes on plane radiograph. Failure to unite with or without hardware problems and non-return to activities involving daily living using the involved limb due to the fracture under study was considered as unfavorable outcome.

### Observations and Analysis

This Prospective observational cohort study was carried out at the department of Orthopaedics, at a state run 1500 bedded tertiary care hospital attached to a Post Graduate teaching institute in central Gujarat, from August 2019 to May 2020 with due permission from the Institutional Ethics Committee. In this study, 60 patients were identified, out of which 3 patients were excluded as they did not fulfill the study criteria and 6 patients were lost to follow up, so our study comprised of 51 patients with 57 surgically treated open fractures for final follow up and analysis.

#### 1. Demographic details

**Table 1a:** Distribution according to age of patients

Age in years	No. of patients	Percentage
18-35	22	43.13
36-50	14	27.45
>50	15	29.41

Average age of patients was 40 years (18 - 65 years). Majority of patients belonged to the younger age group.

**Table 1b:** Distribution according to gender of patients

Gender	No. of patients	Percentage
Male	40	78.43
Female	11	21.56

Among 51 patients, 40 were male and rest 11 were female. Male to female ratio M: F = 4:1

**Table 1c:** Distribution according to life style of patients

Life style	Male	Female	Total	Percentage
Active	28	6	34	66.66
Sedentary	12	5	17	33.33
Total	40	11	51	100

Among 40 male patients, 28 had active lifestyle and out of 11 female patients, 6 had active life style. So in a total of 51 patients, 66% had active life style in younger age group.

#### 2. Chronological details

**Table 2a:** Distribution of patients according to duration of injury - surgery interval

Injury-surgery interval (days)	No. of patients	Percentage (%)
0	11	21.56
<5	32	62.74
5 to 10	8	15.68

Average interval between injury and surgery was 2.5 days. 21.56% of total patients were operated on same day of injury. Majority of patients (62.74%) were operated within 5 days of Injury.

**Table 2b:** Distribution of patients according to duration of admission - surgery interval

Admission-surgery interval (days)	No. of patients	Percentage (%)
0	12	23.52
<5	36	68.62
5 to 10	4	7.84

Average interval between admission and surgery was 2.3 days. Among 51 patients, 23.56% of patients were operated on same day of admission and 92% of patients were operated within 5 days of admission.

**Table 2c:** Distribution of open fractures according to duration of Hospital stay

Duration of Hospital stay (days)	Open Grade I	Open Grade II	Open Grade IIIA	Open Grade IIIB
≤10	24	15	5	1
>10	1	3	6	2
Total	25	18	11	3

Average duration of Hospital stay was 8.9 days. Chi square = 10.49 and P value = 0.01. There is statistical significance between duration of Hospital stay and grade of open fracture. As grade of open fracture increases, duration of Hospital stay also increases.

### 3. Anatomical Area Involved

**Table 3:** Distribution of open fractures according to anatomical area involved

Anatomical Area Involved	OG-I	OG-II	OG-III A	OG-III B	Total	Percentage (%)
Tibia/fibula	13	8	3	1	25	43.85
Femur	2	3	1	1	7	12.28
Patella	0	2	2	1	5	8.77
Radius-ulna	7	1	1	0	9	15.78
Humerus	3	0	0	0	3	5.88
Small bone of Hand and Feet	0	4	4	0	8	14.03
Total (n)	25	18	11	3	57	
Percentage (%)	43.8	31.5	19.2	5.26		100

Total number of patients were 51 who had 57 open fractures which were treated surgically. According to anatomical area most common involved bone was Tibia-Fibula (43.85%). According to Gustilo Anderson's classification, maximum patients belonged to Open Grade I category (43.85%). More severe variety of injuries were seen in lower limbs, 9 in lower limbs as compared to 5 in upper limbs.

### 4. Method of Surgical Fixation

**Table 4:** Distribution of open fractures according to method of surgical fixation

Method of surgical fixation	OG I	OG II	OG IIIA	OG IIIB	Total	P value
Internal fixator	Nail	9	3	0	0	36
	Plate	15	4	0	0	
	K-wire/wire loop	0	2	2	1	
External Fixator	Ex-Fix	1	5	4	2	21
	K wire	0	4	5	0	
Total		25	18	11	3	57

Chi square=19.004; p value=0.0002

There is a statistically significant relationship between operative implant and grade of open fracture. As grade of open fracture increased, use of external fixation as a treatment of choice also increased.

### 5. Grade of Open Fracture Vs Complications

**Table 5:** Distribution of open fractures according to complications. Chi square = 2.445, P value = 0.117

Grade of open fracture	Complications		Total
	Present	Absent	
<III	10	33	43
III	7	7	14
Total	17	40	57

There is no significant relationship between grade of open fractures and occurrence of complications.

### 6. Outcome analysis

**Table 6a:** Anatomical area involved versus final outcome. Chi square=7.63; p value=0.18

Anatomical area involved	Union	Non union	Total
Tibia-Fibula	16	9	25
Femur	3	4	7
Radius-Ulna	9	0	9
Humerus	3	0	3
Small bones of Hand and Feet	8	0	8
Patella	2	3	5
Total	41	16	57

There is no statistically significant association between outcome at final follow up and anatomical area involved.

**Table 6b:** Final outcome versus limb involved. Chi square=6.85; p value=0.009

Affected Limb	Union	Non union	Total
Upper	16	0	16
Lower	25	16	41
Total	41	16	57

There is a statistically significant association between limb involved and final outcome of fractures. Open fractures of lower limb are more prone to undergo non-union as compared to those of upper limb.

**Table 6c:** Grade of open fractures versus final outcome. Chi square=2.49, p value=0.49

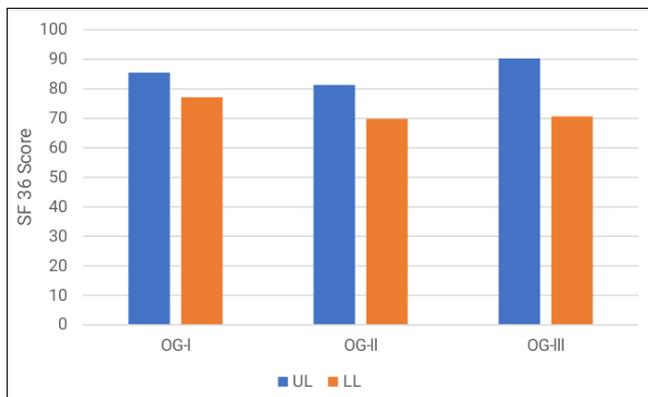
Final Follow up	OG-I	OG-II	OG-III A	OG-III B	Total
Union	19	11	10	1	41
Non union	6	7	1	2	16
Total	25	18	11	3	57

There is no statistically significant association between outcome at final follow up and grade of open fracture.

**Table 6d:** SF36 Questionnaire score (Maximum score =100 points)

Study minimum value	44
Study maximum value	96

Grade	OG-I	OG-II	OG-III	Total	Upper limb	Lower limb
Average SF-36 score	80.5	71.7	74.89	76.34	85.62	72.73



**Fig 2:** SF-36 Score with reference to limb involvement and severity of injury

**Table 6e:** Grade of open fractures versus SF 36 score Chi square=5.84; p value=0.21

Score	OG-I	OG-II	OG-III	Total
<50	2	3	1	6
50-80	9	7	11	13
>80	14	8	2	24
Total	25	18	14	57

There is no statistically significant association between SF 36 score and grade of open fracture. Hence return to daily activities seem to be less dependent on severity of injury.



**Fig 3:** OG-I fracture and it's outcome with SF-36 Score



**Fig 4:** OG-II fracture and it's outcome with SF-36 Score



**Fig 5:** OG-III fracture and it's outcome with SF-36 Score

## Discussion

Open fractures are well described entity in the literature of Orthopaedics. However review of literature and of patients attending fracture clinics and hospitals around the world indicates that the fracture epidemiology (in general) is changing very quickly [2, 3, 4, 5, 6, 7, 8, 9]. The same is true for open fractures as well. Worldwide literature is deficient in determining the changing characteristics, pattern and outcome of open fractures.

In our study high velocity trauma was the main mechanism of injury in these fractures. Several classifications have been used to classify open fractures. We used the Gustilo Anderson's classification for open fractures. Our group of 51 patients had 57 open fractures including all those variety of fractures that are regularly seen in clinical practice. In our study 43.85% of patients had fractures of Tibia-Fibula 15.78% of patients had fractures of Radius and Ulna where as 14.03% of patients had fracture of small bones of Hand and Feet 12.28% of patients had fracture of shaft Femur and 8.77% of patients had fracture of Patella 5.88% of Patients had fractures of Humerus.

We expect that our group is a reflection of the population in general. However there was a predominance of males in the group under study, probably because of high velocity injury which is more common in males. All fractures included in study were fresh open fractures operated within 10 days of trauma. This reduced the Hospital stay of patients and limiting the incidence of Hospital acquired infection and also financial burden of the Hospital. Lower limb open fractures outnumbered those of upper limb with maximum weightage of tibia fractures.

Our study which focused on assessment of fracture characteristics and union did not dictate the intervention which was individualized by the treating Orthopaedic surgeon. Hence, fractures were managed as per existing protocol of the department. 36 cases were operated using open reduction and internal fixation using nailing, rush Pin, k- wire and plating and wire loop. While rest 21 cases were operated by closed reduction using External fixator and Percutaneous K wires. 96% Open Grade I fractures were operated by open reduction plating /nailing. 50% of Open Grade II fractures were operated by open reduction and 84.61% of Open Grade III fractures were operated by External Fixation. External Fixation offers several advantages in the management of open fractures. They offer acceptable stability for fractures, minimal operative trauma, less operative time and good access to the soft tissue. 50% of small bones of Hand and Feet fractures were Open Grade III injuries while most of long bone fractures were Open Grade I and II. As grade of open fractures increased duration of Hospital stay also increased. All patients were periodically followed up for assessment of progression of union at 6 weeks follow up interval. Assessment was made based on complaints regarding function of affected limb, X- ray, status of open and surgical wound. We considered a fracture united when plain radiographs showed bridging callus across the fracture in both orthogonal views and patient could bear full weight or did activity involving upper limb without pain at final follow up. Absence of bridging callus with or without hardware problems was considered failure of union.

Out of 57 fractures in our study, 41 open fractures showed union at final follow up and the remaining 16 ended in non-union. 76% of Open Grade I fractures united at final follow up where as 38.8% of Open Grade II fractures united at final follow up and 90% of Open Grade IIIA fractures united at

final follow up. Among OG IIIA fractures 50% of fractures were small bones of Hand and Feet. All those fractures showed full union at final follow up. 33.33% of Open Grade IIIB fractures united at final follow up. In our study all upper limb fractures showed union compared to lower limb fractures of which 60% showed union at final follow up. In our study, Patella fractures showed 60% of non-union at final follow up. Functional outcome was assessed using score against a self-reported questionnaire. We used SF-36 questionnaire in our study. The major disadvantage of SF-36 questionnaire is that it is subjective. Also it contains more questions about lower limb activities so less reproducible for upper limb injuries. Analysis done in relation to type of bone affected, grade of open fractures, SF-36 questionnaire, and presence of complications did not show any statistical significance. However statistically significant association was seen in open fractures analyzed in relation to duration of Hospital stay, method of reduction and limb involvement. In our study 50% of OG III fractures had complications like infection, failure of fixation and limb length discrepancy. In our study 50% of Open Grade III fractures showed less than 65 score of SF-36 questionnaire at final follow up and 51.16% of Open Grade I & II fractures showed more than 80 score of SF-36 questionnaire at final follow up which suggested that OG I & II fractures patients were living a better life with less limitations of daily and social activities.

We justified from our results that we should continue surgical fixation of open fractures as per our Hospital protocol so as to decrease the duration of Hospital stay and improve the outcome in relation to activities of daily living. However, more intensive treatment is advocated for open fractures of lower limb especially the severe variety. Bone grafting as a adjuvant to fracture healing may timely improve the outcome in such fractures.

## Summary

The aim of this study was to comprehend the clinical profile and study the outcome of open fractures treated surgically with reference to general health, limitation of physical health problems and social activities. This prospective observational cohort study was carried out at the department of Orthopaedics at a state run 1500 bedded tertiary care hospital attached to Post-Graduate teaching institute located in central Gujarat, from August 2019 to May 2020 with due to permission from the Institutional Ethics Committee. In this study, 60 patients were enrolled, of which 3 patients were excluded based on the study criteria and 6 patients were lost to follow up, so we had 51 patients with 57 surgically treated open fractures for final follow up and analysis.

Average age of patients was 40 years. Male to female ratio was 4:1. Most patients (66.6%) were from the active phase of their life. Most patients were operated within 5 days of admission. A statistically significant association was seen between grade of open fractures and duration of Hospital stay. As grade of open fracture increased duration of Hospital stay also increased. Tibia was the most common bone fractured (43.85%) followed by Radius-Ulna (15.78%), Small bone of Hand and Feet (14.03%), Femur (12.28%), Patella (8.77%) and Humerus (5.88%).

We considered a fracture united when plain radiograph showed bridging callus across the fracture in both orthogonal views and patient could bear full weight or did activity involving upper limb without pain at final follow up. Absence of bridging callus with or without hardware problems was considered failure of union. Out of 57 open fractures 41

united and 16 resulted in non-united at final follow up. As grade of open fracture increased, use of external fixator as a treatment of choice also increased. The grade of open fractures did not show any statistically significant effect on outcome. Small bones of Hand and Feet Radius-Ulna, Humerus united earlier than Tibia-Fibula, Femur and Patella. Open fractures of Patella showed 60% rate of non-union and shaft Femur showed 57% non-union. There is more chance of non-union in lower limb as compared to upper limb. In our study 50% of Open Grade III fractures had complications like infection, failure of fixation and limb length discrepancy. In our study 50% of patients with Open Grade III fractures showed less than 65 score of SF-36 questionnaire at final follow up and 51.16% of patients with Open Grade I & II fractures showed more than 80 score of SF-36 questionnaire at final follow up. However no statistically significant association between score of SF-36 and grade of open fractures was elicited. Hence return to daily activities seem to be less dependent on severity of injury.

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