ORIGINAL RESEARCH PAPER

Volume - 14 | Issue - 06 | June - 2025 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

A COMPARATIVE STUDY OF SINGLE BONE VERSUS BOTH BONE PLATING IN PEDIATRIC DIAPHYSEA FOREARM FRACTURES- A NON RANDOMIZED CONTROLLED TRIAL

Orthopaedics

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ABSTRACT

Introduction: Paediatric diaphyseal fractures of the radius and ulna, which are both bone forearm fractures, are the third most frequent form of fracture in children, accounting for 13–40% of all paediatric fractures.Common reasons include falls, accidents, and reduced bone health due to inactivity, poor nutrition, and vitamin D insufficiency.Rotational forces cause varying degrees of fracture, with falls onto an outstretched hand accounting for the majority of fractures. To evaluate radiological, functional, and cosmetic results of single-bone (ulna) plating with both-bone (radius and ulna) plating in paediatric diaphyseal forearm fractures. **Materials And Methods:** Non-randomized controlled trial is the study design.Location: Regional Institute of Medical Sciences (RIMS), Imphal, Department of Orthopaedics.Two years, from May 2022 to June 2024.Children (9–14 years old) who have mid-shaft forearm fractures that are closed, displaced, and unstable within seven days after injury are eligible.Open fractures, pathological fractures, neurovascular deficits, polytrauma, and other particular disorders are excluded.56 individuals, 28 in each group.Ulna plating (single bone fixation) is group A.Group B: Bone fixation in the ulna and radius plating. Functional (range of motion, price criterion grading) and radiographic (union time, angulation).Ulna plating can be done subcutaneously and fixed with a one-third tubular plate or a 3.5mm locking compression plate (LCP) **Results:** Populations: The single-bone group's mean age was 13.1 years, whereas the both-bone group's was 10.6 years.The ratio of men to women is 2.03:1 for single-boned people and 1.08:1 for both-boned people.Operation Time frame:42.5 ± 4.95 minutes, single-bone.89.9 ± 4.56 minutes for both bones.Time of Union: Weeks 6.6 ± 0.62 for single-bone.7.13 ± 0.63 weeks (statistically significant, p=0.003) for both bones.Practical Results:Single-bone ROM loss was 10.06 ± 4.3°, whereas both-bone ROM recovery was complete. This difference was statistically significant (p=0.001).The single-bone group had a mean of 5.3 ± 2.21° for radial re-angulation, while the two-bone group had none (statistically significant, p=0.001).Price Grading: The both-bone group had a higher frequency of excellent results. **Conclusion:** Compared to single-bone plating, both-bone plating yields better functional and radiographic results. On the other hand, single-bone plating offers benefits including shorter recovery times and fewer problems. It is advised to provide individualised care depending on the patient's demands and fracture stability.

KEYWORDS

Pediatric Diaphysea, Forearm Fractures, Bone Plating, Imphal.

INTRODUCTION

Paediatric diaphyseal fractures of the radius and ulna, sometimes referred to as both bone forearm fractures, account for 13–40% of all paediatric fractures and are the third most common fracture in children.OneForearm fractures account for 41.1% of all paediatric fractures, making it a common injury1. Roughly one-eighth of forearm fractures are caused by diaphyseal fractures of the radius and ulna.2. Common kid activities that raise the risk of falls and accidents frequently result in paediatric fractures. However, there are other variables that raise the risk of fracture, such as children's compromised bone health. According to recent studies, the risk of fractures may be increased by decreased bone mineralisation brought on by things like inactivity, poor diet, and certain risks for vitamin D insufficiency, such little sun exposure.3.

A fall onto an outstretched hand is usually the main cause of injury for radial and ulnar shaft fractures, transferring indirect stress to the forearm bones. Particularly vulnerable to fracture is the point where the middle and distal thirds of the radius meet a sizable section of the ulnar shaft. Rotational forces during the fall frequently cause fractures in the radius and ulna at various levels. Lower torsional forces are suggested by fractures that occur close to the same level in both bones, whereas comminution suggests higher-energy damage may be present.4. Significant hyperpronation forces are frequently linked to dislocations of the proximal or distal radioulnar joints (DRUJ and PRUJ), as well as isolated shaft fractures of the radius or ulna.5.

A well-established method for treating forearm fractures in both paediatric and adult patients is open reduction and internal fixation (ORIF) using plates and screws.

Compared to noncontoured intramedullary rods, it offers better anatomical and stable treatment of abnormalities and restoration of radial bow. Rigid fixation does not need postoperative immobilisation; nonetheless, it might result in significant problems such as muscle fibrosis that impairs mobility and unattractive scars.6.Although it is debatable in adults, intramedullary fixation is recommended for paediatric forearm fractures.7.The intramedullary nail has a low risk of infection while maintaining length and alignment. Smaller incisions, less soft tissue dissection, and maybe a lesser chance of stiffness are some of its benefits.8. However, its rotational stability has been questioned. Intramedullary implants work as stress shearing devices, lead to periosteal callus formation, and help in the vital union at the fracture site.9

Biomechanical studies indicate sufficient, stable fixation in paediatric diaphyseal fractures, and fixation of the ulna alone has demonstrated encouraging outcomes.10. If the radius is properly positioned, ulnar plating by itself can produce satisfactory results in unstable diaphyseal fractures of both bones in the forearm.11. Compared to both bone fixation, single bone fixation minimises soft tissue damage and

 PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

associated problems.12The majority of paediatric ulnar and radial fractures are treatable without surgery. A suitable above-elbow cast can immobilise low energy, undisplaced, and mildly displaced forearm fractures right away (3-point mould idea of Charnley). Greenstick fractures, undisplaced complete fractures, comminuted fractures, and traumatic bending or plastic deformation are all frequently treated non-operatively.

There is still debate, nonetheless, over whether single bone fixation affects radiographic and functional results and offers enough stability in bone forearm fractures.13.

In this study, I evaluate the radiological and functional results of bone plating and ulna plating for closed diaphyseal forearm fractures in paediatric patients (9–14 years old).

MATERIALS AND METHODS

Study Design

A non-randomized controlled trial was conducted among the patients with closed diaphyseal both bone forearm fractures in paediatric age (9-14 years) groups attending out-patient department or admitted to the Department of Orthopaedics at Regional Institute of Medical Sciences (RIMS), Imphal.

Study Setting

The present study was conducted in the Department of Orthopaedics, RIMS Imphal. The institution caters to the needs of the North Eastern region in medical education by providing undergraduate and postgraduate courses in all important branches of medical specialities. The hospital typically provides services to more than 2.4 lakh outdoor patients and admits around 31 thousand patients annually. This hospital also receives referrals from different parts of Manipur and neighbouring states. The Orthopedics department offers a wide range of services, including knee and hip replacement. Operation theatres are well equipped. According to the register maintained by the medical records section, every year, on average, 80 closed paediatric bone diaphyseal fractures are being operated on.

Duration Of Study: The study was conducted for a period of two years, from May 2022 to June 2024.

Study Population:

The patients (children) who attended the Orthopaedics department of RIMS, Imphal, both in OPD and the emergency casualty, were included in a consecutive manner.

Inclusion Criteria

1. Patients with closed displaced bone fractures aged between 9-14 years
2. Unilateral or bilateral unstable mid-shaft both bone forearm fracture
3. Closed fractures within seven days from the date of injury
4. Irreducible fracture after close manipulation

Exclusion Criteria:

1. Open fractures
2. Patient medically unfit
3. Associated neurovascular impairment following fractures
4. Comminuted ipsilateral fracture of distal humerus or elbow joint
5. Ipsilateral upper limb fractures and dislocation
6. Stable fractures
7. Pathological fractures
8. Polytrauma patients
9. Monteggia and Galeazzi fracture dislocations
10. Metabolic bone disease
11. Previous ipsilateral upper limb surgery
12. Associated radial head fracture
13. Patients whose parents or legal guardians declined to participate

Sample Size:

In a study conducted by Bhaskar et al.,11 the sample size was calculated using the formula

$$n = \frac{(u+v)^2(s_1^2+s_2^2)}{(m_1-m_2)^2}$$

Where,

s1 (standard deviation union time in single bone fixation groups) = 2.25 s2 (standard deviation of union time in both bone fixation groups) = 2 m1 (mean of union time in single bone ulna fixation) = 11.5 m2 (mean of union time in both bone fixation) = 9.8 u (Type 1 error) = 1.96

v (Type 2 error/Power of study) =0.84 Confidence interval=95%

The calculated sample size is 25 in each group

A minimum of 56 patients (28 each for single bone fixation and both bone fixation groups) who fulfilled the criteria were taken as samples during the study period, considering a 10% loss to follow-up.

Ethical Issues:

Ethical approval was taken from the Research Ethics Board, RIMS Imphal, Manipur. Written informed consent was taken from all the participants. The socio- demographic profile of the participants and data were kept secure, password protected, and only accessible to my guide and me.

Recruitment And Allocation Into Two Groups:

Participants were taken from the OPD and casualty. All participants were allocated to the ulna and double bone plating groups. Participants were recruited in an alternative manner. The first case underwent ulna bone plating, and subsequent cases were taken up in an alternate manner for both bone diaphyseal fractures. Single bone plate fixation was done in 28 patients, and the remaining 28 patients underwent both bone fixation with LCP plate or one-third tubular plate.

Outcome Measures

Diaphyseal fractures were defined as shaft fractures between the distal and proximal metaphysis.Unstable fractures were defined as fractures with an angulation of>10°, and/or malrotation of>30°, and/or displacement>10 mm after attempted closed reduction.43,44 Fracture union was defined as the absence of tenderness on palpation and subjective complaint of pain, painless range of motion (ROM) of forearm rotation, and appearance of bridging callus on follow-up x-ray.45The reduction was considered unacceptable when there was an angular deformity of the radius or ulna of > 10 degrees or > 50% translation at the fracture site, plus angulation.46 ROM of the forearm, wrist, and elbow was measured using a universal, transparent goniometer. In the examination of pronation and supination, the patients were sitting, adducting arms with the elbows in 90° of flexion. The forearms were in a neutral position, thumbs upwards, and progressively active and passive rotation movement followed by Goniometer measurement. Wrist and elbow ROM were compared with those on the contralateral side.47Radiographic parameters were angulation, rotation, and displacement. Clinical and radiological measures were correlated with Price criteria for both groups of patients in this study.48

Study Tools

Predesigned Proforma Will Be Used For The Following:

1. Socio-demographic profile
2. Surgical history
3. Postoperative follow up

Intervention:

Group A: Closed, displaced, both bone diaphyseal fractures of the forearm will be operated with ulna bone plating by LCP or locking one-third tubular plate.

Group B: Closed, displaced bone diaphyseal fractures of the forearm will be operated with both radius and ulna plating by LCP or locking one-third tubular plate.

Procedure

After admission, patients were examined by a senior consultant. They were allocated into a group. The first group underwent ulna bone plating, and the other group underwent bone plating by 3.5mm LCP or locking one-third of the tubular plate. Comparisons were made between the two groups on the basis of radiological, functional, and cosmetic outcomes after each procedure. The following procedures were followed-

1. Informed written consent was taken accordingly (Annexure III).
2. All details of participating individuals were recorded (Annexure I).
3. The fractures were assessed by anteroposterior and lateral view X-rays.
4. All routine investigations (blood routine examination, urine routine examination, electrocardiograph, bleeding time, chest x-rays, blood sugar, liver function test, kidney function test, and

serum electrolytes) were done on all patients.
5. Patients were prepared for an operative procedure of ulna bone or both bone plating.
6. Operation was done under General Anaesthesia (GA)

Operative Techniques
All the patients underwent open reduction and internal fixation (ORIF) with LCP under the control of a tourniquet.Two standard approaches, anterior (Henry) or posterolateral (Thompson), were used for the shaft of the radius, and standard subcutaneous approaches between the flexor and extensor muscle compartments were used for the shaft of the ulna.

Positioning
The patient lay down in a supine position, and the affected limb was extended on the radiolucent hand table.

Draping
The skin over the arm and forearm was prepared by application of the povidone- iodine 10% solution. The operative field was draped with sterile sheets, and the towel clips were placed

Approach To Shaft Of Radius
1. Henry's Approach:
Henry uses an extensile surgical technique. A portion of this is utilised to repair fractures of the bottom third of the radius. It entails a longitudinal incision that begins close to the tendon of the bicep and runs along the brachioradialis' medial border in the direction of the radial styloid. The superficial radial nerve is retracted laterally, and the radial artery and its corresponding veins are located and retracted medially. When the forearm is completely pronated, the lateral border of the pronator teres muscle is visible.

2. Thompson's Approach:
It is used for the proximal two-thirds radius. The incision for this approach is along the line joining the lateral epicondyle and styloid process of the radius, with its length varying based on required exposure. The incision goes through the skin, subcutaneous tissue, and fascia. Deep dissection begins at the abductor pollicis longus, oblique crossing over the radius, retracting it to access the radius. Dissection continues between the extensor carpi radialis brevis and extensor digitorum communis, retracting them to expose the supinator and posterior interosseous nerve, which is moved away by fully supinating the arm.

Approach To The Shaft Of Ulna Standard Subcutaneous Approach:
The arm was positioned on a side table. The forearm was held vertically, and the elbow was resting on the side table. The skin incision was followed along the subcutaneous border of the ulna, along a line drawn between the tip of the olecranon process and the ulnar styloid process. The deep dissection was carried out at intervals between the flexor carpi ulnaris and the extensor carpi ulnaris muscles. Sharp dissection of the periosteum was limited to the level of fracture, and irrigation of the fracture hematoma and anatomy reduction with a reduction clamp was done. The aim was to restore length, alignment, and rotation. A 3.5 mm LCP or locking one-third tubular plate with enough length for a purchase of at least six cortices on each side was used. After final fixation, overall alignment and implant position were checked with an image intensifier in two planes. Clinical assessment of the overall stability and the arc of movement of the forearm should be carried out before closure. If LCP was bulky for the patient, then locking one-third of the tubular plate was used. If the reduction of the radius was not accepted by close manipulation under an image intensifier after fixation of the ulna, then the radius was also fixed with the plate.

Wound Closure
Release of the tourniquet and hemostasis was recommended before closure. The subcutaneous layer is closed with interrupted 2-0 vicryl suture. After wound closure, the limb was kept in a well-padded long arm posterior slab covering 2/3 of the forearm circumference with the elbow in 90° flexion and the wrist in a neutral position. The slab was kept for the third week from the date of injury.

Post-operative Management
Postoperatively, a second-generation cephalosporin antibiotic would be administered prior to the operation and then 12 hourly for two days after surgery. The patients were discharged from the hospital between 5-7 days after the operation.

Postoperative Follow-up
During follow-up in the OPD, clinic-radiological evaluation would be performed for maintenance of reduction (at first follow-up) and functional outcome, which includes a range of wrist and elbow motion, supination, pronation, radial re- angulation and any complications including neurovascular status, superficial and deep infection. Suture removal was done on the 10th-day post-operative day during the follow-up in OPD. The follow-up schedule was the 3rd, 4th, 6th, and 12th weeks, and at six months. In single bone plating, the POP slab was removed on the 3rd week from the date of injury and the 3rd postoperative day in both bone plating.The radiological evaluation was performed on the day after surgery, at three weeks, six weeks, three months, and finally at six months with AP and lateral views. At the 3- and 6-month follow-ups, children were evaluated for full function, minor limitation of function, and major loss of function. The final results were graded as excellent, good, fair, and poor, according to the loss of forearm rotation and clinical, functional limitation (symptoms), using the criteria of Price et al.

Statistical Analysis:
Data was checked for completeness and consistency. Informed written consent was taken. All details of participating individuals were recorded. Data was entered and analysed using SPSS V. 21 for the window. Descriptive data was presented using percentage and frequency for variables like sex, fracture side, mode of injury, complications and mean with standard deviation for time of union, duration of surgery, duration of hospital stay, time of fracture union, loss of range of motion of forearm (supination/pronation), ROM at elbow and wrist, duration of surgery in minutes and complications (infection, re-fracture, neurovascular injury, scarring, delayed union or non-union). The chi-square test was used to collect categorical data such as functional outcomes. A p-value <0.05 was taken as significant.

RESULTS
Patients with both bone forearm diaphyseal fractures in paediatric were prospectively recruited during the study period. A total of 56 patients who met the criteria for inclusion were included in the study, of which 28 patients were operated for single bone plating and 28 patients with both bone plating. Three patients were lost to follow-up. The study was done in the Department of Orthopaedics, Regional Institute of Medical Sciences, Imphal. The following results and observations were made at the end of the study. The data collected were then analyzed.The mean age of all patients in the double bone plating group was 10.6 ± 1.47 years with a range of 9 to 14 years, while that of the single bone plating group was 13.1 ± 1.1 years with a range of 9 to 14 years. The age group of 10-13 years comprised the highest number of patients (52.5%). There were 19 (67%) males and 9 (33%) females in the ulna plating group with a male- to-female ratio of 2.03:1, whereas in the single plating group, there were 13 males (52%) and 12 females (48%) with a male to female ratio of 1.08:1 in our study.

Side Of Injury
The right forearm was predominantly involved in both groups. 12 (42%) patients with left-side forearm fractures underwent single bone plating, while 16 (57%) patients with right-side fractures also received single bone plating. 11 (44%) patients with left-side forearm fractures and 14 (56%) patients with right-side fractures were involved in both bone forearm plating.

Mode Of Injury
In both the groups (single bone plating and double bone plating in forearm fracture), maximum fractures occurred due to falls while playing, and it was the most common mode of injury. Among these, 22 (78%) cases underwent single bone forearm plating, and 17 (68%) cases underwent both bone forearm plating.

Duration Of Surgery
The mean duration of surgery was 42.5 ± 4.95 minutes in single bone plating, whereas in the case of both bone plating, the mean time was 89.9 ± 4.56 minutes.

Union Time
The mean time of union was 6.6 ± 0.62 weeks in single bone plating and 7.13 ± 0.63 weeks in both bone plating groups. The difference between them was statistically significant ($p= 0.003$).

 PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

Loss Of Forearm ROM

There was a mean loss of range of motion in supination or pronation of the forearm of 10.06 ± 4.3 degrees in single bone plating. In contrast, all the patients of both bone- plating groups regained their full range of motion. The difference between the two groups was statistically significant(p=0.001).

Radial Re-angulation

Radial re-angulation was observed in the single bone forearm plating group with a mean of 5.3 ± 2.21 degrees. In contrast, none of the patients in the both bone forearm plating group exhibited radial re-angulation. This difference was found to be statistically significant (p=0.001).

Price Grading For Functional Outcome

In this study, the functional outcome as per the Price grading system who underwent the ulna plating group was as follows: 82% of cases were rated as excellent, 14% were considered to have a good, and 4% had a fair outcome. Conversely, in both bone forearm plating groups, 85% of cases achieved an excellent outcome, and 16% were rated as good outcomes.

DISCUSSION

The best course of action for children with both bone forearm fractures is still up for debate. However, in order to enable early mobilisation and avoid complications, surgical therapy is necessary. Different surgical techniques are recommended as treatments in various sources, with differing degrees of success and problems such infection, scarring, and non-union.One bone is biomechanically stable in children with diaphyseal forearm fractures. It results in reduced blood loss, less soft tissue injury, shorter hospital stays, and quicker operating times.In order to compare the outcomes in terms of perioperative measurements, such as surgical duration, fracture union, functional outcomes, and complications, we have attempted to survey, evaluate, document, and quantify the results in the management of unstable both bone forearm fractures by treating them with ulna plating.

From May 2022 to April 2024, 53 patients with unstable two-bone forearm fractures in children aged 9 to 14 years—28 with single bone plating and 25 with both bone plating—were studied in the Orthopaedics Department of the Regional Institute of Medical Sciences in Imphal, Manipur. For every example in both groups, open reductions were performed. Two groups of patients were created: one for ulna bone plating and one for both bone plating. The ulna was fastened with a plate and screws in ulna bone plating only, whereas the radius and ulna were fixed with a plate and screws in both bone plating groups.

The results were studied by comparing both groups. The following variables of each patient were analyzed: age, sex, mode of injury, side of forearm affected, the time interval between trauma and surgery, time of union, radial re-angulation, ROM of the forearm, Price grading, and complications. Patients in group A and group B in this study were 10.6 ± 1.47 and 13.1 ± 1.1 years old, respectively. Nine women (33%) and nine men (67%) made up group A in this study. We saw 48% girls and 52% men in group B. Within group A of this investigation, it was shown that 42% of patients had fractures on their left side and 57% on their right. In contrast, group B experienced 56% right-side fractures and 44% left-side fractures.In this study, the majority of patients sustained fractures due to falls while playing, accounting for 78% in group A and 68% in group B. In the present study, the functional outcome as per the Price grading system for those who underwent the ulna plating group was as follows: 82% of cases were rated as excellent, 14% were considered to have a good, and 4% had a fair outcome. Conversely, in both bone forearm plating groups, 85% of cases achieved an excellent outcome, and 16% were rated as good outcomes. In group A, 3 (10%) and in group B, 4(16%) scars were seen, and no cases of infection and nonunion were seen in the group.

CONCLUSION

Based on this investigation, the following conclusion may be made: Single bone plating required less operating time.In single-bone plating, the fracture union time was shorter.84% of patients with both bone plating got good price grades, compared to 82% of patients with single bone plating.The forearm (supination/pronation) was significantly lost in single bone plating.and radial re-angulation (ROM). Diaphyseal both bone fractures of the forearm in children aged 9 to 14 years can be treated with single bone plating since the overall results are similar to those of two bone plating.

TABLES

Table 1: Age In Years

VARIABLE	SINGLE BONE PLATING		BOTH BONE PLATING		P-VALUE
	MEAN	±SD	MEAN	±SD	
AGE DISTRIBUTION (in years)	10.6	1.47	13.1	1.1	0.006

Table 2: Gender- Frequency Distribution In Two Groups Of Patients Studied.

GENDER	SINGLE BONE PLATING		BOTH BONE PLATING	
	NUMBER	PERCENTAGE	NUMBER	PERCENTAGE
MALE	19	67	13	52
FEMALE	9	33	12	48
TOTAL	28	100	25	100

Table 3: Side Of Injury

THE SIDE OF THE FOREARM AFFECTED	SINGLE BONE PLATING		BOTH BONE PLATING	
	NUMBER	PERCENTAGE	NUMBER	PERCENTAGE
LEFT	12	42	11	44
RIGHT	16	58	14	56
TOTAL	28	100	25	100

Table 4: Mode Of Injury- Frequency Distribution In Two Groups Of Patients Studied

MODE OF INJURY	SINGLE BONE PLATING		BOTH BONE PLATING	
	NUMBER	PERCENTAGE	NUMBER	PERCENTAGE
FALL WHILE PLAYING	22	78	17	68
RTA	3	11	5	20
HEAVY OBJECT	3	11	3	12
TOTAL	28	100	25	100

Table 5: Duration Of Surgery

VARIABLE	SINGLE BONE PLATING		BOTH BONE PLATING		P-VALUE
	MEAN	±SD	MEAN	±SD	
DURATION OF SURGERY (in minutes)	42.5	4.95	92.9	5.33	0.05

Table 6: Union Time- Frequency Distribution In Two Groups Of Patients Studied

VARIABLE	SINGLE BONE PLATING		BOTH BONE PLATING		P-VALUE
	MEAN	±SD	MEAN	±SD	
TIME OF UNION (in weeks)	6.6	0.62	7.13	0.63	0.003

Table 7: Loss Of Forearm Rom- Frequency Distribution In Two Groups

VARIABLE	SINGLE BONE PLATING		BOTH BONE PLATING		P-VALUE
	MEAN	±SD	MEAN	±SD	
MEAN LOSS OF RANGE OF MOTION IN PRONATION OR SUPINATION (in degree)	10.06	4.3	0	0.0	0.001

Table 9: Radial Re-angulation In Both The Groups

VARIABLE	SINGLE BONE PLATING		BOTH BONE PLATING		P-VALUE
	MEAN	±SD	MEAN	±SD	
RADIAL RE-ANGULATION (in degree)	5.3	2.21	0	0.0	0.01

Table 8: Price Grading For Functional Outcome

PRICE GRADING	SINGLE BONE PLATING	BOTH BONE PLATING
EXCELLENT	23	21
GOOD	4	4
FAIR	1	0
POOR	0	0
TOTAL	28	25

Table 7: Showing Complication

Complication	Single bone plating		Both bone plating		p- value
	Number	Percentage	Number	Percentage	0.04
Scar	3	10	4	16	
Infection	0	0	0	0	
Non union	0	0	0	0	

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