

# Stack Nailing For Management of Diaphyseal Fractures of Humerus: Analysis of 65 Cases

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## ABSTRACT

**Introduction:** Stack nailing(multiple rush nails) is jamming of nails in the waist of medullary cavity through a single cortical window, spreading the bunch of nails in the metaphysis and filling up the conus to the medullary cavity of humerus with short nails. In present study we evaluated results of this technique for management of fractures of shaft humerus prospectively.

**Material and Methods:** Study was conducted in the department of Orthopaedics S.N. Medical College and Hospital, Agra. Stack nailing of humerus was done only if the fracture was > 2 cm distal to the surgical neck to 3 cm proximal to olecranon fossa of the humerus. In close fracture of shaft of the humerus was immobilized by well padded plaster of Paris "U" slab application. Patients were followed regularly and functional results were assessed on the criteria propose by magrel.

**Results:** 65 patients having diaphyseal fracture of humerus were managed by close intramedullary multiple flexible rush nailing. Out of those, 54 fractures (83.08%) united within 12 weeks, 6(9.23%) between 12 – 16 weeks, 3(4.62%) between 16 – 20 week, 2(3.0%) took more than 20 weeks to unite. Excellent results were achieved in 42(64.62%) cases, good results in 18(27.70%) cases and fair results in 5(7.69%) cases.

**Conclusion:** Closed reduction and stack nailing of diaphyseal fractures of humerus is a good alternative of open reduction and plating. It has advantage of biological fixation, less infection, early mobilization and lesser chances of joint stiffness.

**Keywords:** Stack Nailing, Diaphyseal Fractures, Humerus

## INTRODUCTION

Trauma to the upper extremity often presents a real challenge to the orthopaedic surgeons. The humerus fractures account for 3%-5% of the skeletal injuries. These fractures result from direct and indirect trauma e.g. fall on anti-stretched and, motor vehicle accident (RTA), fire arm injury, assault etc.

Over the year a number of methods have evolved for the management of humeral shaft fractures.<sup>1</sup> There have been proponents of closed reduction and casting claiming equally good functional results over the operative means. However with the advent tools, implants and techniques the armamentarium of a trauma surgeon is enriched with a wide array of implants such as nails and plates.<sup>2-4</sup> Open reduction and internal fixation with plate gives good radiological reduction but are fraught with complications like infection and radial nerve palsy.

In today's era of closed technique of fracture fixation various nails are described with very promising results and early recovery. Stack nailing(multiple rush nails) is jamming of nails in the waist of medullary cavity through a single cortical window, spreading the bunch of nails in the metaphysis and filling up the conus to the medullary cavity with short nails (Rush nails).<sup>5,6</sup> It provides better axial, angulatory, and rotational stability, preserves periosteal and endosteal blood supply as reaming it not

required and Early joint motions are permitted thus decreasing the chances of joint stiffness. Generally it is done by closed method and only one portal of entry. Stack nailing of humerus are used to stabilize from 2 cm. distal to surgical neck to 3 cm. proximal to olecranon fossa of humerus. The present study was carried out with the aim to achieve the above pre-requisites of treatment of humeral shaft fractures with perfection and to evaluate the results of Stack nail fixation in the humeral shaft fractures, and the simple, cost effective, closed intramedullary technique of rush nails capable of being undertaken at a district level hospital without expensive instrumentation and providing results comparable to the standard existing interlocking systems.

## MATERIAL AND METHODS

Present study was conducted in the department of Orthopaedics S.N. Medical College and Hospital, Agra. The 65 cases for the present study were selected from the patients attending the emergency as well as out patient department of Orthopaedics based on following inclusion and exclusion criteria. It was an open ended study, sample size was decided according to inclusion exclusion criteria. Ethical clearance and informed consent was taken for the study.

Patients after skeleton maturity having diaphyseal fractures of humerus from 2 cm distal to the surgical neck to 3 cm proximal to olecranon fossa of the humerus.

Transverse, oblique, spiral and comminuted anatomical variants of fracture in above diaphyseal area. Closed fractures and open grade 1 and grade 2 fractures. Open fractures of grade 3 and 4 and patients not giving consent were excluded from study. Written informed consent were taken from patients for participation in study.

After stack nailing shaft of the humerus was immobilized by well padded plaster of Paris "U" slab application. Limb is kept elevated and anti-inflammatory analgesics to be prescribed. In case of open fracture, anti-tetanus globulin, tetvac, broad spectrum antibiotics started and debridement and surgical toilet routinely done as earliest as possible. The day before the operation the part was prepared by shaving and cleaning. The patient fasted 4-6 hour prior to the operation. Intravenous antibiotic to be given an hour before the operation. Two techniques have been described for stack nail insertion antegrade and retrograde, Antegrade technique for fracture of middle and lower third of humeral shaft and retrograde for proximal 3<sup>rd</sup> humerus fractures.

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Here nailing done by antegrade technique. Surgery was done either under supraclavicular (brachial plexus) block or general anaesthesia. Close reduction was carried out and ascertained by image intensifier on anteroposterior and lateral views. A longitudinal skin incision was given made from the most lateral point of the acromian and extended distally centered over the tip of the greater tuberosity. Incision should not be extended more than 1 – 3 cm in the deltoid muscle to avoid damage to the axillary nerve. Fascia of deltoid muscle was incised and palpate the greater tuberosity was palpated. Using the awl, establish the entry portal site just medial to the tip of the greater tuberosity, approximately 0.5 cm posterior to bicipital groove and just lateral to the biceps tendon (to minimize damage to rotator cuff). Advance the awl until it is seated within the humeral head, rotate the humerus internally and externally and confirm containment of the awl by image intensifier. The entry portal should be centered on AP and lateral view to ensure that the nail will be in the midline of the humerus. Assemble the rush nail of appropriate size in Rush nail holder. After removal of awl, the medullary cavity was filled with Rush nails of calculated length in the sizes ranging from 2 mm to 4mm. rush nail inserted. Minimum of two and maximum of four Rush nails could be negotiated within the medullary cavity. Limb was kept in “U” plaster slab for 2-3 weeks, but with gross osteoporosis and comminution (unstable fractures) “U” POP cast was given for 3-6 weeks.

Patients were asked for regular follow up, first time after three weeks then every fifteen days for first two months then every month for one year.

Patients were assessed radiologically and a thorough clinical examination was done. Assessment was done during follow up –

- Shoulder joint movements
- Elbow joint movement
- Assessment of neurological status if any present at the time of injury or during surgery.

Physiotherapy of shoulder and elbow joints started as early as possible after removal plaster slab. Functional results were assessed on the criteria propose by Magrel et al (1979) and were labeled as -

**Excellent:** Has full functional and anatomical restoration

Site of fracture	No. of cases	Percentage
Upper third	8	12.30
Junction of upper and middle third	9	13.84
Middle third	28	43.07
Junction of middle and lower third	6	9.23
Lower third	14	21.54
Total	65	100

**Table-1:** Distribution according to the site of fracture

Shoulder abduction (in degrees)	At the time of stitch removal		At 6 weeks		At the end of follow up	
	No.	%	No.	%	No.	%
0 – 45	36	55.38	-	-	-	-
45 – 90	29	44.62	17	26.16	2	3.06
90 – 135	-	-	28	43.07	8	12.30
135 – 180	-	-	20	30.77	55	84.64
Total	65	100	5	100	5	<b>100</b>

**Table-2:** Degree of abduction at shoulder joint

without any pain.

**Good:** May have occasional mild intermittent discomfort (Chiefly on weather change). Strength and endurance are normal. Elbow and shoulder movements are restricted less than 10 degrees. Shortening is 1 cm. or less.

**Fair:** May have moderate intermittent pain, but does not limit normal activity or require medicine. Maximal performance might be impaired.

Shoulder and elbow movement are restricted less than 20 degrees. Shortening is 1.5 cm or less.

**Poor:** Include an finding outside the acceptable limits listed for a grade of fair.

**STATISTICAL ANALYSIS**

Microsoft office 2007 was used to make tables. Descriptive statistics like mean and percentages were used to interpret results.

**RESULTS**

The present study consists of close intramedullary multiple flexible rush nailing in 65 fracture shaft of humerus of 65 patients. All these patients were treated in the Department of Orthopaedics, S.N. Medical College, Agra. Most of the fractures (59.99%) occurred in young adults that are from 21–40 years of age. Patient below 18 years of age were not included in this study. There was no patient above the age of 75 years of age. There was predominance of male patients (78.47% males and 21.53% females).

Fracture of shaft of humerus was defined as those occurring below surgical neck of humerus and above the supracondylar ridge. Incidence of fracture in upper, middle, lower third, at the junction of upper and middle third and at the junction of middle and lower third is shown in table-1. Most of the fractures were located in the middle third of the shaft of humerus (43.07%).

Shoulder abduction was studied in follow up visits (Table-2). At the time of stitch remove, 29 (44.62%) cases had range of motion between 45 – 90 degrees but in 36 (55.38%) cases it was between 0 – 45 degrees.

At 6 weeks 28 (43.07%) cases had shoulder abduction between 90 – 135 degrees, in 17 (26.16%) cases should abduction was between 45 – 90 degrees and in 20 (30.77%) cases it was between 135 – 180 degrees.

At the end of follow up 55 (84.64%) cases were having full range of motion i.e. between 135 to 180 degrees. In 8 (12.30%) cases it was between 90 – 135 degrees and in 2 (3.06%) cases it was between 45 – 90 degrees.

Most of the patients at the time of stitch removal were having internal and external rotation movements between 15 – 30 degrees i.e. internal rotation in 43 (66.15%) cases and external

rotation in 39 (60%) movement between 15 – 30 degrees.

At six weeks 26 (40%) cases regained internal rotation between 45 – 60 degrees, while 19 (29.23%) cases regained internal rotation between 30 – 45 degrees. In 7 (10.76%) cases regained internal rotation was recovered > 60 degrees and in 13 (20%) cases between 15 – 30 degrees.

At six weeks external rotation in 24 (36.92%) cases was between 30 – 45 degrees, while in other 21 (32.31%) cases it was between 45 – 60 degrees and in 14 (21.54%) cases it was between 15 – 30 degrees and in 6(9.23%) cases it was between more then 60 days.

At the end of follow up internal rotation in 48 (73.85%) cases were having > 60 degrees, 11 (16.92%) cases were having 45 – 60 degrees and in 6 (9.23%) cases were having 30 – 45 degrees.

At the end of follow up external rotation in 45 (69.24%) cases were having > 60 degrees, in 13 (20%) cases were having 45 – 60 degrees and in 7 (10.26%) cases were having 30 – 45 degrees.

At the time of stitch removal the degree of flexion at elbow joint in 9(13.84%) cases was between 60 – 90 degrees, in 41(63.07%) cases between 90 – 120 degrees and 15(23.07%) cases it was between 120 – 160 degrees and the degree of extension in 10 (15.38%) cases was between 60 – 90 degrees, in 42(64.58%) cases was between 90 – 120 degrees and in 13 (20.0%) cases was between 120 – 160 degrees.

At 6 weeks the degree of flexion at elbow joint in 4 (6.15%) cases was between 60 – 90 degrees, in 35 (53.85%) cases between 90 – 120 degrees and 26 (40.0%) cases it was between 120 – 160 degrees and the degree of extension in 3 (4.62%) cases was between 60 – 90 degrees, in 36(55.38%) cases was between 90 – 120 degrees and in 26 (40.0%) cases was between 120 – 160 degrees.

At the end of follow up the degree of flexion at elbow joint in 52 (80.0%) cases was between 120 – 160 degrees, in 12 (18.47%) cases between 90 – 120 degrees and 1 (1.53%) cases it was between 60 – 90 degrees and the degree of extension in 52 (80.0%) cases was between 120 – 160 degrees, in 11(16.92%) cases was between 90 – 120 degrees and in 2 (3.06%) cases was between 60 – 90 degrees.

In the present study period of healing of fracture of the shaft of humerus is shown in table-3. Union of facture was considered when Rotatory / angulatory strain painless and bridging callus present

Duration of follow up radiological assessment was done monthly. In our series, 54 fractures (83.08%) united within 12 weeks, 6 (9.23%) between 12 – 16 weeks, 3 (4.62%) between 16 – 20 week, 2(3.0%) took more than 20 weeks to unite.

Complications were also studied simultaneously as shown in table-4. Out of 65 cases, only 2(3.06%) cases had superficial infection which was cured by antibiotics, 2 (3.06%) cases had non union, 3 (4.62%) cases had delayed union, 1 (1.53%) case had angulation, 3 (4.62%) cases had elbow stiffness, 5 (7.69%) cases had shoulder stiffness and 8 (12.30%) impingement syndrome. In our series non union and delayed union case bone grafting was done, in both cases later on fracture united. Elbow stiffness and shoulder stiffness is due to poor compliance which later on improved with proper physiotherapy. Impingement of rush pin to acromian was later on improve by impaction of rush pins.

The grading of final result is based on functional and anatomical

criteria given by Magrel et al<sup>4</sup> Complication which have been satisfactorily resolved were not considered in grading and results (Table-5).

At present study excellent results were achieved in 42 (64.62%) cases, good results in 18 (27.70%) cases and fair results in 5 (7.69%) cases. There is no any case had poor results.

The time between surgery and return to original or gainful employment was recorded in the present study (Table-6). Out of 65 cases 8 case could return to work within two weeks, twelve cases could return to work within three week and 40 cases within four weeks and rest 5 cases with in five weeks

Concepts in the management of trauma in orthopaedics are very rapidly changing to keep pace with the increasing severity and complexities of the fractures.

The management of humeral shaft fracture is always a challenging problem to a orthopaedics surgeon, as they are very frequently associated with multiple injuries, leading to complications like shortening, malunion, infection, delayed union and non union etc.<sup>6,7</sup>

Duration of Union (in weeks)	No. of cases	Percentage
Within 12	54	83.08
12 – 16	6	9.23
16 – 20	3	4.62
> 20	2	3.06
Total	65	100

**Table-3:** Time of Union

Complications	No. of cases	Percentage
Superficial infection	2	3.06
Deep infection	-	-
Shortening	3	4.62
Non union	2	3.06
Delayed union	3	4.62
Implant failure	-	-
Neurological deficit	-	-
Angulation	1	1.53
Elbow stiffness	2	3.06
Shoulder stiffness	5	7.69
Impingement	8	12.30
Total	26	40.0

**Table-4:** Complications

Type of Fracture	Excellent	Good	Fair	Poor
Transverse	26	8	2	-
Oblique	10	4	1	-
Spiral	5	2	1	-
Comminuted	1	4	1	-
Total	42	18	5	-
Percentage	64.62	27.70	7.69	-

**Table-5:** Evaluation of result on the basis of Magrel et al (1979)

Time Interval	No. of cases	Percentage
Within 2 weeks	8	12.30
Within 3 weeks	12	18.45
Within 4 weeks	40	61.54
Within 5 weeks	5	7.69
Total	65	100

**Table-6:** Time between surgery and return to work

The treatment modalities are varies time to time. There have been proponents of closed reduction and casting claiming superiority over the operative means. The functional cast bracing yields good results. But conservative treatment for the obese patients and females with large breast pose difficulty for conservative management can these fracture. Patients who are not compliant with the conservative treatment also be managed with surgery. The successful treatment of humeral shaft fractures depends on many factors; the age of the patient, the patients general health, the time from fractures to treatment, the adequacy of treatment, concurrent medical treatment, the adequacy of treatment and stability of fixation.

The aim of treatment in these fracture is to achieve anatomical reduction, restoration of alignment and to produce favourable environment for bone and soft tissue healing. The classical method of treatment of humeral shaft fractures has been the use of U-plaster cast. Although satisfactory result can be obtained with this method but residual angulation, malrotation and limb length inequality is well documented.

Operative treatment may be considered to avoid complications such as, malunion, delayed union, rotational deformity, shoulder and elbow stiffness, limb length discrepancy, psychological problems and long hospital stay.

Intramedullary nailing is a favoured modality of treatment for these fractures, which allows early mobility and decrease dependency.<sup>6-8</sup> Infection rate is also decreased with the evolution of closed Intramedullary techniques.

However conventional kuntscher nailing gives poor fixation in unstable fractures, especially of upper and lower third of shaft, and in comminuted fractures where rotation and telescoping are common problems.

To reduce these problems the concepts of interlocking intramedullary nailing has evolved, which has not only increased the stability but has also extended the indications of nailing but chances of infection, delayed union and nonunion is their.

Plating in fracture shaft humerus also gives good anatomical reduction and stability but chances of infection and radial nerve palsy more.

To overcome these problems the concepts of close intramedullary rush nailing has evolved, which has not only increased the axial and rotational stability but also minimises chances infection and radial nerve palsy.<sup>6,8,9</sup>

Successful stack nailing requires preoperative reduction, appropriate rush nails sizes, image intensifier control In the present study there were sixty five cases of fractures of humeral shaft treated surgically with stack (Multiple rush nail) nailing.

In our study, out of sixty five fractures of humeral shaft, most of the fractures were in age group of 21-40 years (48.73%). This is due to the fact that persons of this age group are more exposed to road traffic accidents and other trauma which are commonest cause of humeral shaft fractures. In study of Lin J. and Hou SM. et al<sup>10</sup> the average age of patients was 5.8 years. In Kelsh, Deffner et al<sup>11</sup> series most of fracture were in the age group of more than 60 years.

In our series males were 78.47% and female were 21.53%. In Kelsch et al<sup>11</sup> series males were 60% and female were 40%.

On examination in the present study, fracture was transverse in 53.38% of cases, oblique in 23.07%, spiral in 12.30% of cases, and comminuted in 9.23% of cases. This is in agreement with

the study of finding of Kempf and Grosse.<sup>12</sup>

In 43.07% cases fractures were located in middle third of shaft, in 21.54% cases the fractures were at the lower third, in 13.84% cases the fractures were at junction of the upper and middle third and in 12.30% cases the fractures were at the upper third. In Lin J. and Hou SM et al<sup>10</sup> series, fractures in 60.4% cases were located in middle third of the shaft and in 39.58% cases in distal third of the shaft.

In the present study out of 65 fractures, 62 were fresh fractures and 3 were non unions. In Lin J. and Hou SM et al<sup>10</sup> series, out of 48 fractures 39 were acute fractures non-unions and 3 pathological fractures.

In the present study 60% cases were of polytrauma, most of these resulted from road traffic accident. Frequency of associated head injury was 9.23%, both bone fracture of forearm was 1.53%, fracture clavicle was 3.06%, fracture both bone leg 3.06%, radial nerve injury was 3.06% and of chest injury was 3.0%.

In our series time interval between injury and operation, at the minimum was 4 days and maximum was 5 months. 41 cases (63.08%) were operated within one week, 10(15.38%) cases within two weeks, 4(6.15%) cases within three weeks and 2(3.06%) cases within four weeks and 8(12.30%) cases were operated after four months. Bone grafting with stack nailing was done in these two cases of non-union and both the fractures united well.

Post operative stability was assessed and categorized as good, fair and poor depending upon, the clinical and radiological features such as comfort of patient, pain on angulatory and rotational strains impaction and degree of comminution on x-ray. Fracture were assessed to be having good stability in 86.15 cases, fair in 12.30% cases and poor in 1.53% cases.

External immobilization in the form of "U" plaster slab was given for 3 weeks in all the cases having good stability. In Kempf and Grosse et al<sup>12</sup> series post operative immobilization was given for an average of 13 days.

In our series post operative hospitalization varied from 21 days. 81.54% cases were discharged between 6 - 12 days. 26.66% cases up to 5 days and 13.33% cases between 11 - 15 days after operation. Duration of follow-up in our series varied from 4 months to 18 months. In Kempf et al (1986) series the mean duration of follow up was 14 months. In Lin J. and Hou SM. et al<sup>10</sup> series average follow-up time was 12 months.

Different authors used different criteria to label union. Healing or union has been variously defined as the presence of bridging callus on x-ray, the absence of pain on deformation at fracture site, the ability of the patient to bear full weight without external support or a combination of these.

We have found that the X-ray criteria of bridging callus is the most effective and reproducible when stack nail is used. We have considered a fracture to have united when there was no pain on angulatory / rotatory strain, no pain on full unsupported function of upper limb and external callus bridging across fractures.

In our series 54 fractures (83.78%) were united within 12 weeks, (9.23%) between 12 - 16 weeks, 3 (4.62%) between 16 - 20 weeks and 2(3.06%) was united in more than 20 weeks.

In our series, there occurred 3 delayed union and 2 non-union. Union occurred in both of these cases also, after bone grafting and stack nailing.

In Kempf and Grosse et al<sup>12</sup> series consolidation. Occurred in all cases within an average time of 10.5 weeks. There were no delayed union or non unions. In Blum and Rommens et al<sup>13</sup> series, bone healing occurred in 70 cases, five non-union (6.7%) were reported.

In the post operative period in 2 of the cases (3.06%) wound infection occurred. It was a superficial infection. It was treated with daily dressing and specific antibiotics after culture and sensitivity. The infection resolved within a week. In Kempf et al<sup>12</sup> series infection occurred in one case out of 48 cases. It was no deep infection. Implant had to be removed leaving no persisting osteomyelitis. Kelsch and Deffner et al<sup>11</sup> reported infection in 2 cases, which disappeared after removal of the nail and introduction of antibiotic loaded beads.

In the present study there was no cases of radial nerve palsy occurred. There was no permanent radial nerve palsy in present series. In Blum and Rommens et al<sup>13</sup> series radial nerve palsy occurred in 3.9% of the cases. In Kempf et al<sup>12</sup> series 1 cases developed radio circumflex paralysis. Other complications like chest infection, pulmonary embolism, fat embolism, deep vein thrombosis were not observed in our series. The absence of these complications can be said to be because of early mobilization.

In our series of 61 (93.84%) cases all patients got full shoulder movements at the end of follow-up. In Lin J and Hou SM. et al<sup>10</sup> series recovery of shoulder function was complete. In Blum and Rommens et al<sup>13</sup> series, at the end of treatment 89.4% of the patients had excellent shoulder function.

In our series all the 63 (96.4%) cases got the full elbow movements. In Lin J. and Hou SM. et al<sup>10</sup> series elbow movements were excellent in all but one non-union. Blum and Rommens et al<sup>13</sup> reported that at the end of treatment 88% of the cases had excellent elbow function.

The time between surgery and return to original or gainfull employment was recorded in our series. Out of 65 cases, 8 (12.30%) cases could return to work within two weeks, 12 (18.46%) cases within three weeks, 40 (61.53%) cases within four weeks and the rest 5 (7.68%) cases with five weeks.

At the end of follow up the patients were evaluated according to criteria proposed by Magrel<sup>4</sup> and the functional results were classified into excellent, good, fair and poor.

In our series results were excellent in 73.84% cases, good in 18.4% case and fair in 7.68% cases. No poor result was noted in our series. In Kempf et al<sup>12</sup> series, results were excellent in 64%, good in 23% and fair in 13% cases. In Kelsh and Deffner et al<sup>11</sup> series 84% of the cases had an excellent or satisfactory results. Analysing the technical difficulties while performing this study we suggest the following points for the betterment of this stack nailing technique:-

- Rash nail should be prebent.
- While introducing or hammering the nail into medullary canal, angulation and rotation of distal fragement should be checked.
- The proximal end of rush nail should be buried into the humeral head by gentle hammering which prevents the proximal migration of the nails.
- Hammering of rush nail should not be done at any stage.
- Care should be taken to avoid distraction at the fracture site.
- Distally the nail should be fan out in different directions

and gain anchorage in the distal metaphyseal region.

- The shoulder should be moved in all the direction to check the possible obstruction by rush nails.

The suggestion made by us were implemented by us while performing the operation of stack nailing and found to be successful.

## CONCLUSION

Stack nailing for fractures of shaft of humerus is a good alternative of open reduction and plating. It should be performed for the diaphyseal fractures of humerus in young adults having fracture line 3 cm proximal to the olecranon fossa and at least 2 cm distal to the surgical neck of humerus. It is a kind of biological fixation and have less chances of infection, early mobilization and lesser chances of joint stiffness.

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