

**A STUDY OF MANAGEMENT OF  
HUMERAL SHAFT FRACTURES  
WITH CLOSED  
INTRAMEDULLARY  
INTERLOCKING NAIL**

*A dissertation submitted for the M.Ch. Certification  
Program In Orthopaedic Surgery  
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# **CERTIFICATE BY THE CANDIDATE**

I certify that this dissertation is the result of my five years of study, record and follow up of the cases during private practice carried out at Khemka Orthopedic Hospital, Raipur and prepared in fulfillment to the requirement of M.Ch. Certification Program In Orthopaedic Surgery in accordance with standards and guidelines set by the University of Seychelles, American Institute of Medicine (USAIM) and Boolean Education.

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**Date: 25/02/2011**

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# INTRODUCTION

Humeral shaft fractures are uncommon injuries and are most commonly caused by high energy trauma and most commonly occurs in middle third of the shaft.

Traditionally humeral shaft fractures have been treated non-operatively with hanging cast or brace. Sarmento et al reported use of plastic sleeve with early introduction of functional activity. In a review of 51 fractures, there were no non-union among 49 non-pathological fractures and there was good restoration of joint motion. But non-operative treatment has disadvantages of prolonged immobilization in cast or brace which sometimes may be required as long as 6 months resulting in huge morbidity. Moreover, not all fracture shaft humerus can be treated conservatively.

Bandi in 1964 first defined clear indication of operative treatment including:

1. Open fractures
2. Pseudoarthrosis
3. Transverse fractures
4. Comminuted fractures with radial nerve palsy
5. Diaphyseal fracture in an unacceptable position after conservative treatment.

Bandi advised anatomical reduction and stable internal fixation in accordance with AO principle. Plate and screws osteosynthesis seemed to be the most appropriate choice. (Bandi,1964, Bell et.al. 1985, Foster et al 1985, Van der Griend, Tomasin & Ward 1986, Nast Kolb, Knoefel & Schweiberer 1991).

Open reduction and internal fixation causes extensive soft tissue damage, insertion of plate may injure radial nerve. Risk of infection and nonunion due to opening of fracture hematoma, periosteal stripping and contamination of fracture site is also present. It also provide less secure fixation especially in osteoporotic bone and if crutch walking is required.

Stabilization of humeral fractures with rods placed in the medullary canal was introduced by Kuntscher (1940), Rush (1950) & Hackethal (1961). Kuntscher proposed the slotted elastic nail with the classical self fitting technique. He used both the proximal and the distal entry to the medullar canal. Rush proposed two elastic rods with three point fixation. He preferred the proximal entrance. Hackethal used a bundle of elastic rods and preferred the proximal approach.

But the operative treatment of humeral fractures has been dominated by the plating technique after AO group of Muller, Allgower, Schneider and Willenegger (1977).

Analysis of Kuntscher's technique has shown that complications like proximal instability with distraction or telescoping, rotation instability, pseudoarthrosis, malalignment and protrusion of the nail on the top of the shoulder joint are common. The advantage of this technique was the closed procedure and the Biological callus consolidation of the fracture.

The humeral locking nail was first proposed by Seidel (1985). The entrance is at the proximal end of the humerus and penetrates the rotator cuff. With this nail the proximal fragments can be stabilized with locking screws guided through the nail. The rotator cuff is protected because the nail is safely fixed with the locking screws below the level of the rotator cuff.

Advantages of closed intramedullary nailing are well established.

- (1) It does not disturb the fracture hematoma
- (2) Avoid dissection at fracture site thereby reducing contamination of fracture site:

Although closed intramedullary nailing with interlocking is a good treatment for fracture shaft humerus, it has some disadvantages including infection, radial nerve palsy, restriction and painful shoulder movements in antegrade and that of elbow in retrograde nailing.

## **AIMS AND OBJECTIVES**

1. To find out which fractures of the shaft of humerus should be treated by interlocking intramedullary nailing.
2. To study its efficiency, ease of treatment, comfort and end results
3. To find out the advantages and disadvantages of nailing and interlocking.
4. To streamline the indications of closed humerus interlocking nailing .

## **MATERIALS AND METHODS**

This study of management of humeral shaft fractures by humeral interlocking nailing was carried out at Khemka Orthopedic Hospital, Raipur from February 2001 to March 2006. Total of 127 patients were treated in this period and were followed up. Our 11 cases were lost in follow up and hence were excluded from the study.

The age of patients ranged from 19 to 68 years. Of the total 116 patients, 14 were female and 102 were males. 111 fractures were closed and 5 were open. 7 had radial nerve palsy, 5 of which recovered between 1 to 9 month postoperatively. Of the 116 fractures 98 patients had fractures because of road side accident, 13 patients had fall and 5 patients had direct trauma by assault.

### **Selection Criteria:**

1. Patient with polytrauma where early mobilisation is needed
2. Diaphyseal fractures of humerus (Transverse, oblique, comminuted)
3. Segmental fractures
4. Compound fractures (Gustilo & Anderson Grade I & II)
5. Fractures shaft humerus associated with radial nerve palsy.
6. Adult patients over 16 years of age

### **Exclusion criteria:**

1. Patients with previous osteomyelitis of shaft of humerus
2. Patients with recent infections
3. Immunosuppressive therapy
4. Proximal fractures within 2 cm of surgical neck and those within 5 cm of junction of diaphyses and metaphyses on both AP and lateral radiographs.
5. Compound grade-III fractures.
6. Pathological fractures
7. Pseudoarthrosis
8. Implant failure

**Choice of Nails:**

Universal humerus nails are available in diameters ranging from 6 to 8 mm. 6 mm nail is usually solid while 7 & 8 mm nails are cannulated. These have double proximal locking hole in medio-lateral plane and two distal locking holes in antero-posterior plane. All are made up of 316L stainless steel.

**Preoperative Protocol:**

1. Routine preoperative investigations like proper Antero-posterior & lateral X-rays, routine blood investigations, pre-anaesthetic checkup etc.
2. Analgesics, Immobilisation & prophylactic antibiotics as indicated.
3. Adequate local debridement and proper antibiotics in case of compound wound.

**Operative Technique:**

## 1) Patients position and preparation:

With the patient supine, the head is turned to the contralateral side to increase the exposure of shoulder and a sand bag is placed below the scapula to raise the shoulder off the table. Proper prepping and draping is done.

## 2) Approach and entry portal:

A longitudinal incision is made from the most lateral part of acromian and is extended distally centered over the tip of greater tuberosity. The fascia of deltoid is incised in the line of skin incision. Care is taken not to extend the incision more than 4 to 5 cms in deltoid muscle to avoid injury to the axillary nerve. Using a small Kuntscher diamond shaped awl, entry portal is established just medial to the tip of greater tuberosity and is confirmed with the Image Intensifier. The awl is gently advanced into the medullary cannal by gentle hammering.

## 3) Guide wire insertion:

The awl is removed and a guide wire is inserted through the entry portal up to the distal end of proximal fracture fragment. Reduction is done by closed means under Image Intensifier guidance and guide wire is then advanced into the distal fracture fragment up to the distal humeral shaft. Position of the guide wire is checked under image intensifier in both antero-posterior and lateral planes. Next, reaming of the shaft is done by cannulated reamers starting from 6mm reamer and advancing gradually by 0.5 mm.

## 4) Nail insertion:

Appropriate sized nail as determined by measuring with another guide wire of same length is attached to the jig with the conical bolt in such a way that bend of the nail is pointed medially. The nail is then inserted into the entry portal and gently hammered up to fracture site and then up to 1 to 2 cm proximal to the olecranon fossa to avoid supracondylar fracture. The alignment and rotation of the fracture site is checked under image intensifier. The nail is hammered into the head so that proximal end of nail is beneath the bone to avoid subacromial impingement.

## 4) Proximal and distal interlocking:

For proximal interlocking proximal aiming device is used. For distal interlocking we used free-hand technique using image intensifier. The wound is irrigated with adequate amount of

normal saline and closed layer by layer. A bulky dressing with cuff and collar was given to the patient for initial 2 to 3 days. In all the patients we started pendulum exercises from 2<sup>nd</sup> postoperative day.

**Follow up:**

The cases were followed up clinically and radiologically at 3 wk, 6 wk, 3 mth, 6 mth and 1yr.

**Radiologic and clinical evidence of union:**

A fracture was considered healed when callus with a density similar to cortical bone has bridged most of the fracture in two radiographic views with no tenderness over fracture site.

**Assessment of results:**

In this study we have assessed the results according to the modification of the rating system of Neer et al and of Cofield i.e. we have measured the motion of involved shoulder in terms of degrees rather than comparing the motion with that of opposite side. Also we did not incorporate scale to assess ability to perform activities of daily living as necessary information was not available for all patients. The results were considered excellent, satisfactory and unsatisfactory depending upon pain, movement of shoulder and satisfaction of the patient.

Modified Neer & Cofield classification of assessment of shoulder function:

Assessment	Excellent	Satisfactory	Unsatisfactory
External rotation	At least 45°	At least 20°	If any of the criteria is not met
Active abduction	At least 140°	At least 90°	
Shoulder pain	No or slight pain	No, slight or moderate pain with vigorous exercise	
Satisfaction of Patient	Satisfied with results	Satisfied with procedure	

## OUTCOME AND ANALYSIS

From February 2001 to March 2006, 116 patients of fracture shaft Humerus treated with interlocked nailing were followed up at Khemka Orthopedic Hospital, Raipur. Observations of the study are as follows:

**Age & Sex Distribution:**

Age in years	Males	Females	Total
16-20	3	0	3
21-30	26	8	34
31-40	37	8	45
41-50	19	4	23
51-60	8	1	9
61 & above	2	0	2
Total	95	21	116

There were 95 male and 21 female patients. Out of the total 116 patients, youngest patient was 19 years old and eldest was 68 years. Majority of patients were between 21 to 40 yrs age group. (79 patients)

**Mechanism of Injury:**

Mechanism of Injury	No of cases	Percentage
Road traffic accident	98	84.5
Fall from height	13	11.2
Direct trauma	5	4.3
Total	116	100

Of the total 116 patients, maximum i.e. 84.5 % were of road traffic accidents followed by fall from height (11.2 %) and direct trauma (4.3 %)

**Level of fracture:**

Level of fracture	No of cases	Percentage
Upper third	19	16.4
Middle third	61	52.6
Lower third	36	31
Total	116	100

Of the total 116 patients, 61 cases were of fracture of middle third (52.6 %) and 36 patients were of lower third (31 %).

**Side of injury:**

Side of injury	No of cases	Percentage
Right side	66	56.9
Left side	50	43.1
Total	116	100

Of the total 116 patients 56.9 % cases were of right side and 43.1 % were of left side.

**Type of Fracture:**

Type of Fracture	No of cases	Percentage
Transverse	33	28.4
Oblique	53	45.7
Comminuted	19	16.4
Segmental	11	9.5
Total	116	100

The commonest type of fracture in our series were oblique fractures in 53 patients (45.7 %) followed by Transverse (28.4 %), comminuted (16.4 %) and segmental (9.5 %)

**Mode of reduction:**

Mode of reduction	No of cases	Percentage
Close	102	88
Open	14	12
Total	116	100

Closed reduction was successful in about 88 % patients while about 12 % patients required open reduction. This was mostly seen in old cases which failed to reduce by closed means.

**Diameter of nail:**

Diameter	No of cases	Percentage
6 mm	13	11.2
7 mm	64	55.2
8 mm	39	33.6
Total	116	100

The commonest diameter of nail use was 7 mm (55.2 %) followed by 8 mm (33.6 %) and 6 mm (11.2 %)

**Length of nail:**

Length	No of cases	Percentage
20 cm	2	1.7
22 cm	6	5.2
24 cm	27	23.3
26 cm	43	37
28 cm	38	32.8
30 cm	0	0
Total	116	100

Nail size 26 cm was most commonly used (37 %) followed by 28 cm (32.8 %), 24 cm (23.3 %), 22 cm (5.2 %) and 20 cm (1.7 %)

**Duration between Trauma and Surgery:**

Duration in days	No of cases	Percentage
0-10	107	92.2
11-20	8	6.9
21-30	1	0.9
>30	0	0
Total	116	100

In majority of cases, the fracture was fixed within 10 days (92.2 %). The earliest was within 1 day and the longest was after 23 days of trauma. Average duration was around 3 days.

**Time for bridging soft callus:**

Time in weeks	No of cases	Percentage
4	30	25.8
6	59	50.9
8	22	19
10	5	4.3
12	0	0
Total	116	100

Most of the patient had Callus by 8 weeks (95.7 %) with only 5 patients (4.3 %) requiring more than 8 weeks.

**Time required for radiologic and clinical union:**

Time in weeks	No of cases	Percentage
6	0	0
8	2	1.7
10	17	14.7

12	34	29.3
14	24	20.7
16	39	33.6
24	0	0
Total	116	100

Majority of fractures united by 16 weeks with consolidation, average for union was found to be 13.8 weeks.

#### **Range of shoulder abduction:**

Degrees	No of cases	Percentage
Less than 90°	14	12
90°-140°	26	22.4
More than 140°	76	65.6
Total	116	100

Almost all of the patients regained a good range of shoulder abduction of more than 90° (88 %). Only in 14 patients (12 %) abduction was less than 90 ° which was mainly due to impingement of nail on the acromian in 7 cases, 5 of which was due to inadequate insertion and two were due to proximal migration of the nail. This proximal migration was seen only in osteoporotic bone with severe comminution. No elbow problems were recorded in our series.

#### **Range of shoulder external rotation:**

Degrees	No of cases	Percentage
>45°	98	84.5
20°-45°	18	15.5
<20°	0	0
Total	116	100

84.5 % of our patients had excellent external rotation. None of the patients in our series had external rotation less than 20°

#### **Complications:**

Complications	No of cases	Percentage
Shoulder pain	Mild	18
	Moderate	4
	Severe	0
Impingement	7	6
Radial nerve palsy (Post operative)	2	1.7
Infection	9	7.8
Non-union	0	0
Increased comminution	7	6
Fracture greater tuberosity	0	0
Total	47	40.5

Of the total 116 patients, 18 patients (15.5%) had mild and 4 patients (3.5 %) had moderate shoulder pain. Impingement and increased comminution was found in 7 patients (6 %), Post operative radial nerve palsy in 2 patients (1.7 %). Infection was present in 9 patients (7.8 %) all

of which was superficial and responded to oral antibiotics. No non-union or fracture of greater tuberosity was recorded in our series.

**Associated injuries:**

Sl no	Associated injuries	No. of cases
1	Head injury	5
2	Chest injury	4
3	Abdomen injury	1
4	Fracture shaft femur	6
5	Forearm bones fracture	11
6	Supracondylar humerus fracture	2
7	Radial nerve palsy	7
8	Pelvic injuries	0
9	Fracture Tibia-fibula	9
10	Other Fractures	6
11	None	82

Majority i.e. 82 patients (70.7 %) had isolated fractures of shaft of humerus. There were 34 patients (29.3%) with associated injuries and these 34 patients had total of 51 injuries.

**Results:**

Results	No of cases	Percentage
Excellent	76	65.6
Satisfactory	26	22.4
Unsatisfactory	14	12
Total	116	100

Only in 14 patients (12 %), results were unsatisfactory. Rests of the 102 patients had either satisfactory or excellent results and were almost able to reach their pre-injury capacities.

**Period of hospitalization:**

In our series, the period of hospitalization ranged from 3 days to 10 days, average being 5.2 days.

## DISCUSSION

Fractures of humeral shaft have traditionally been regarded as relatively benign injury, with a high percentage of primary healing with conservative methods, using either a U-shaped splint (Bohlers 1966) or a functional brace (Sarmiento et al 1977; Zagorski et al 1988). These methods have been found to give better results than primary plate fixation in closed injuries (Pennsylvania Orthopaedic Society 1959; Steward 1964).

Operative treatment has usually been reserved for the treatment of nonunion (Muller 1965), for poly trauma patients (Bell et al 1985; Van der Griend, Tomasin and Ward 1986) and for those with neurovascular complications (Holstein and Lewis 1963), The results in operated patients have been generally favourable, but there has been a tendency to use fracture union as the major determinant of outcome; few studies have examined function at the shoulder and elbow (Mast et al 1975).

Intramedullary nailing has theoretical advantages over other techniques of internal fixation and has been used to maintain the alignment and length of the humerus (Rush and Rush 1950;

Kuntscher 1967; Durbin, Gottesman and Saunders 1983; Hall and Pankovich 1987). Without static locking, however, fixation was often not sufficiently rigid and external splintage was needed until union occurred (Brumback et al 1986). The recent development of a locking nail for the humerus by Seidel (1989) has created renewed interest and excellent results have been reported in small numbers of patients (Habernek and Orthner 1991).

In view of our satisfaction with the results of closed intramedullary nailing, we report the results of our 116 cases from February 2001 to March 2006.

**Age and Sex:**

Most of the patients in our series belong to the economically productive young age group between 21-40 with an average of 29 years.

Comparison of age with various standard series:

Standard Series	Age range
J.O.Ikpeme (1994)	17-91
H.Seidel (1989)	24-80
C.M.Robinson (1992)	20-84
Present series	19-68

In western countries more consciousness about the health, better economy of patient and country and belief in medical science may be the factors responsible for older patients of above mentioned series as compared to our present series.

Our average age of patient is 29 years with majority of our patients in 21-40 age group i.e. young earning age group as compared to 53 years in Seidel and 59 years in Robinson series

Comparison of sex with standard series:

Standard Series	Sex	Sex ratio
J.O.Ikpeme (1994)	30 females 9 males	3.33: 1
Hartmut Seidel (1989)	11 females 9 males	1.22: 1
C.M.Robinson (1992)	21 females 9 males	2.33.: 1
Present series	21 females 95 males	0.22: 1

Marked variation in age:sex ratio reflects consideration of Indian society in which females are mostly household dwellers and the males the wage earners concerned with outdoor activity.

**Level of fracture:**

C.M.Robinson et al (1992) reported in their series of 30, only one patient had fracture in lower third (3.33%) and majority of fractures in middle third i.e. 19 patients (63 %) and upper third involved in 7 patients (23.33%) remaining 3 had segmental fractures in proximal and middle third .

Hartmut Seidel (1989) reported in their series of 20 patients 13 patients (65%) had fracture in proximal third, 4 cases (20%) in middle third 3 cases (15%) in distal third.

In present series we have majority of fractures in middle third 61 patients (52.6 %) next to it is lower third 36 patients (31 %) and least in upper third i.e. 19 cases (16.4 %).

**Type of fractures:**

Hartmut Seidel (1989) reported 5 transverse fractures (25%), 6 short oblique (30%) and 5 long oblique (25%) and 4 comminuted fractures (20%) total percentage of oblique fractures in this series was 45 %.

C.Garnovs and P.G.Lunn reported 3 transverse fractures (25%), 4 spiral fractures (33.33%) and 4 comminuted and 1 compound grade-II fractures out of their 12 patients.

P.M.Rommens et al in a review of 39 patients reported 14 transverse fractures (35.89 %), 8 spiral fractures (20.51 %), 3 oblique fractures (7.69 %).

In our series there were 33 transverse fractures (28.4%), 53 oblique fractures (45.7%), 19 comminuted fractures (16.4%) and 11 segmental fracture (9.5%).

**Mechanism of injury:**

P.M. Rommens reported in their series reported road traffic accident as a major mechanism of injury in 21 cases (56.75%)

C.Garnovs reported 5 patients (41.66%) with road traffic accident, 5 sustained fracture after fall (41.66%)

In our series we report 98 cases with road traffic accident accounting for 84.5 % of total 116 cases, next to it is fall 13 cases (11.2%) and least is direct trauma.

**Duration between injury and operation:**

C.M.Robinsen et al reported waiting period of 1 week in 23 patients and 7 were treated conservatively and nailed within 6 weeks of fracture since previously undisplaced fractures became displaced.

C,Garnovs & PG.Lunn reported interval between injury and operation in their series of 12 patients as 1-12 days.

In present series majority of fractures were fixed within 10 days i.e. 107 patients (92.2 %) with an average of 3 days after injury.

**Diameter and length of nail used:**

In our series the most commonly used nail is 7 mm used in 55.2 % of patients. We used nail of 8 mm in only 39 patients (33.6 %). 28 cm length nail was used in 32.8 % patients and 26 cm in 37 % patients.

Average Indian bones are thin and small as compared to Western standard. Moreover, over-reaming was avoided in majority of the cases.

**Mean time of union:**

Comparison of mean time of union in different series

Series	Union Time
C.M.Robinsen (1992)	18 weeks
H.Habernek (1991)	8weeks
C.H.Jensen(1992)	6 weeks
Jinn Linn et al	8.2weeks
Present series	13.8 weeks

In our series the mean time of union is 13.8 weeks which is nearly comparable to standard series.

Dynamisation of nail was not done in any case but all fractures united eventually suggesting dynamisation is not mandatory in Humerus interlocked nailing.

**Post-operative Radial nerve palsy:**

Series	Percentage of Radial Nerve Palsy
C.M.Robinsen et al	3.33%
PM.Rommens et al	2.56%
I.A.Ingmann et al	2.43%
Present series	1.7%

C.M. Robinson reported 1 patient of radial nerve palsy in their series of 30 patients (3.33%) P.M.Rommens reported radial nerve palsy in 1 patient of the total 39 patients (2.56%) I.A.Ingmann reported 1 patient of radial nerve palsy of the total 41 patients (2.43%). In our series we had 2 cases of radial nerve injury (1.7%). Both the injuries were neuropraxia and eventually recovered at 5 & 7 mth post-operatively. We had 7 patients with the radial nerve palsy (preoperative), 5 of which were recovered within one to nine month postoperatively

**Impingement:**

Series	Percentage of impingement
Hartmut Seidel	10%
C.H.Jensen	25%
C.M.Robinsen	40%
Present series	6%

Harmut Seidel reported impingement in 2 cases of their total 20 (10%). C.H.Jensen reported impingement in 4 patients of their total 16 patients (25%). C.M.Robinsen reported impingement in 12 patients of their total 30 patients (40%). In our series impingement occurred in 7 patients of our total 116 patients (6 %)

As compared to above standard series percentage of impingement is less in our series. This might be due to the reason that proximal tips of the nails were counter-sunked into the head of humerus. In our series, impingement occurred because of lack of experience with this type of nailing in initial phase and this complication was minimized later on. Proximal nail migration was seen in two cases with severe osteoporosis along with comminution.

**Results:**

Applying modified Neer and Cofield criteria we found unsatisfactory results only in 14 patients (12%), satisfactory in 26 patients (22.4%) and excellent in 76 patients (65.6%). No patients in our series had any elbow problem. All of the patients treated had good range of shoulder movement except in 12% where shoulder abduction was markedly restricted. In majority of the patients with unsatisfactory results the cause of shoulder abduction restriction was impingement.

**Complications:**

In the present study we encountered following complications:

***Intra-operative complications:***

Seven patients had increased comminution at fracture site but this did not add to any instability. These fracture united well within 4 months.

We were unable to countersink the tip of nail in to the head of humerus because of lack of experience initially which had caused impingement in 5 patients.

We had two cases of intra-operative radial nerve palsy probably due to manipulation during reduction. The nerve injury recovered within 5 to 7 mth postoperatively.

***Postoperative complications:***

The most common amongst this is shoulder pain. We noticed mild shoulder pain in 18 patients and moderate in 4 patients. Restriction of shoulder movements especially abduction occurred in 14 patients; major cause of this restriction was impingement which we reported as having unsatisfactory results.

Infection occurred in 9 patients which was mostly superficial and responded to oral antibiotics. We did no experience any case of non-union.

## **CONCLUSIONS AND RECOMMENDATIONS**

Humerus interlocking nail is a satisfactory device for stabilisation of humeral shaft fractures. It is effective in diaphyseal as well as proximal fractures provided greater tuberosity is intact. Antegrade insertion has not caused worrying shoulder discomfort because of minimal surgical trauma in the region of rotator cuff and countersinking of the nail. Countersinking of nail into the head also avoids the problem of sub-acromial impingement. This method of insertion allows the device to be used in comminuted fractures and also in low diaphyseal fractures which would be difficult to fix from below (Retrograde route) and with plating as bone drilling near the fracture could split the bone further. Patients who need crutches or frame for mobilisation were able to walk because humeral fractures were stable.

In conclusion, relatively simple reproducible operative technique with close reduction, security of fixation, least complications, early use of extremity and cost effectiveness of implant make this technique of closed humerus interlocking nailing of humeral shaft fractures an important modality to be considered in the management of humeral shaft fractures.

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