DEPARTMENT OF ORTHOPAEDICS

B.J. MEDICAL COLLEGE & SASSOON GENERAL
HOSPITALS, PUNE.

"MANAGEMENT OF FRACTURE OF SHAFT OF HUMERUS BY THE INTRAMEDULLARY INTERLOCKING NAIL"

A Dissertation submitted to the University of Seychelles, in partial fulfillment of the requirements for the award of M.Ch in the subject of Orthopedics.

INTRODUCTION

Trauma has been the leading cause of mobidity and mortality is on the rise in the present age. The victim of bony injury faces prolionged immobilisation and loss of wages and it's a tough time for the entire family. Besides, the patients often may have to live with the sequelae of stiff joints and functional disablity (the fracture disease). Fractures of the shaft of humarus have been teated conservatively since ages, with good results. **Sir John Charnley** in his treatise " The closed treatment of common fractures " even states " it is perhaps one of the easiest major long bone fractures to treat by conservative methods."

However, conservation treatment cannot be recommended in every case. Prolonged limb immobilisation, the need for constant cooperation and respeated hospital visits are the obvious demerits. More ever, unstable(spiral / long oblique) fractures, comminuted fractures, segmental fractures, pathological fractures, open fractures, fractures with delayed or non union and fractures associated with redial nerve injury or major vascular injury are essentially to be treated operatively.

Early restoration of joint motion return to normal physiologic function and minimal morbidity is now regarded as ideal fracture treatment.Though plate fixation has given high rates of union, it requires extensive surgery, with stripping of the soft tissues from bone, increase chances of infection or nerve damages, less secure fixation in ostepenic bone and delayed mobilisation of shoulder and elbow. Further, these is stress shielding of bone by the plate and reducted strength of union due to primary osteal healing compared to callus healing seen otherwise.

Intramedullary nailing with a conventional "V" nail of Kuntscher, rods of Rush, Enter or Hackethal have been used with varied results. These devices however, act merely as internal splints and do not provide rotational stability, so that unrestricted movenments cannot be allowed in every patient and external protaction in some from or other is needed. Rigid intramedullary nailing techmically avoids these problems. Surgeons are now trying to balance the dis-advantage of conservation and operative management by minimal surgical intervention (biological fixation by closed intramedllary nailing). Rotatorty and torsional stavbility and alingment are most reliably achieved by transverse locking screws at each end, thus allowing early mobilization and its obvious advantages.

Even shaft fractures with servere comminution, bone loss and pseudoarthrosis can be effectively treated by this method.The availabilty of image intensifier control has made closed interlocking nailing easily possible in most centers, thus permitting the advantage of closed over open techniques. Ultimetely, the best treatment should be determined by thoughtful analysis of the morphology of the fracture, the amount of energy imparted to the extremity by the trauma, the mechanical characteristics of the bone and age of the patient.

The present study attempts to highlight the use of unreamed interlocking intramendullary nailing of the humerus and evaluate the results and complications related to the procedure.

AIMS AND OBJECTIVES

1. To review the relevent literature
2. To study the results of fixation of the shaft of humerus by rigid interlocking intramendullary nailing.
3. To determine whether it is a safe, simple and reliable method in the management of these fractures.
4. To study the effect of this method on shoulder and elbow joint fuction.
5. To study the operative difficulties encountered.
6. To study the incidence of complication with this method.

ABSTRACT & CONCLUSION

Charaka and **Sushruta** (1000 BC) in the Charaka Samhitas and other writing had mentioned how to deal with the diagnosis and management of various types of fractures and dislocations.

Hippocrates (460 - 335 BC) known as the father of modern medicines, put for the concept that broken bones be treated by immobilization and splintage. Reinforced by Galen99 (131 - 201 AD) much later the concept has remained unchanged till today.

Caldwell (1933) described the hanging arm cast , a method which uses dependancy traction provided by the weight of the cast and the limb, to effect fracture reduction. The coaptation **Splint** also known as gutter splint or sugar tong splint was first described in 1939 by **McMurray**. This was modified to allow movements at shoulder joint by **Rowlay**in 1942. who called it a splint. It basically uses a plaster of Paris or other moldable splinting material to hold the fracture in allingment. It was named coaptation splint by **Sir Reginald Watson Jones** (1955) who propaged this technique widely after decrying the hanging cast method.

This “U” shaped splint with collar and cuff sling is indicated for treatment of acute humeral fractures with minimal overrriding. It has the same disadvantage as the hanging cast, besides causing axillary irrtation andpatient discomfort and the risk of slippage of the reduction within the splint.A recent modification (1991) by **S S Shantaram**of Madras, includes an extended part over the acromion through which an additional sling can be tied across the chest wall for added stability. The **Shoulder Spica** was recommended by some for fractures which require significant abduction and external rotation (upper third fractures) in order to be reducted. The abduction splint (aeroplane splint) was advocated by **Stewart et al** in 1955

Cave (1958) described a stockinette body swathe and sling as a good method for elderly patients. A similar stockinette Valpeau shoulder bandage was **Gilchrist’s** method around the same time for un displaced / minimally displaced fractures in children or the elderly unable to tolerate other methods of managment.

Sarmiento et al since 1977 have published good results with fuctional cast brancing for fractures shaft humerus. “Functional bracing for the treatment of fractures of the humeral diaphysis are associated with a high rate of union, particularly when used for closed fractures. The residual angular deformities are usually functionally and aesthtically acceptable.”

In **summary** - conservative treatment may be effecitve and achieve good union, but the dis advantage must not be dis regarded,like stiffness of joint, muscle wasting and a longer rehabilitation period , risk of malunions and nonunions. Some conditions, where operative treatment is indicated includes:

1. Failed conservative treatment.
2. Polytrauma patients with multiple injuries.
3. Associated injuries in the same extremity e.g. Floating elbow.
4. Segmental fractures.
5. Pathological fractures.

6. Fractures associated with major vascular injury.
7. Holstein Lewis fractures/spiral fractures of lower third humerus shaft.
8. Open fractures.
9. Obesity.

EVOLUTION OF INTRAMEDULLARY NAILING**:**

The history of orthopaedies is replete with writing about various inventors who tried different materials of internal splintage in the medullary canal, notable among these are:**Stimson** in 1883 was the first to be successful in uniting fractures by jamming lvory pegs in the medullary cancel. Others who tried this method before him, including Brutcher and king, were largly unsuccessful. **Hey Groves** in 1912 probably inserted the first metallic intramedullary device in a gunshot wound of the femur during the first world war. He was defeated by inadequcy of metal quality, rediogtaphs and instruments. The **Rush Brothers** between 1936 and 1939 introduced flexible intrmedullary nails of special design and the principal of three point fixation. Intramedullary nailing gained worldwide acceptance only after it was popularised by **Gerhard B. Kuntscher** who in femus, tibia and humerus. In his first publication, in 1940, Kuntscher laid down the principles of intramecullary nailing, which have stood the test of time, they are :

1. Nailing should be done closed, with the incision as far as possible from the frature site.
2. The nail should be strong enough to resist the stresses of muscle contaction joint movement and weight bearing to prevent bending of breakage of the nail.
3. The nail should have suffficiant elasticity to be compressed during insertion and re-expend in the medullary canal.

Ender and Hackethal respectively in 1961, introduced flexible intramedullary nails for long bone fracturs and achieved stabiltity by stacking. In 1968, **Kumtscher** improved on the original nail named after him and introduced what he called "detensor nail" the fore runner of the present interlocking nail, it had transversely threaded bolts passed through prefabricted holes in the nails anchoring the implant directly to bone and controlling length, rotation and alingment. **Grosse and Kempf** in 1981 introduced their modification of the interlocking nail for femur and tibia, named after them, which was first available in France and then the rest of the world. It gained wide acceptance. In 1992 **Russel** and **Taylor** introduced their interlocking intramedully nailing system. including the Humerus nail and reported excellent results in treating traumatic and pathological fractures.This is the nailing system that will be researched in this study.The advantages of closed intermeduallary nailing of diaphyseal fracture include: (Source: Rockwood & Green fractures in adults fourth edition 1994).

1. Preservation of fracture exudate : The exudate produced at the fracture site is very important for healing. It contains prostaglandins. various growth factors, bone morphogenetic proeins (BMP) and hyaluronates. All these and manu unknown factors take part in the stimulation, formation and matruration of the callus to normal bone. This is all lost once the fracture site is opened and the exudate drained.
2. Stability of fracture reduction: The medullary canal is closer to the

mechanical axis than the usual late position on the external surface of bone.Thus intramedullary nails are subjected to smaller bending loads than plates and are less likely to fail by fatique. Further, stabilisation leads to increased vasculatisation of the fracture ends and faster healing.

3. Preservation of vascularity : The periosteal blood supply is undistrubed and endosteal circulation recovers at the earliest. In comminuted fractures, it provides a biological fixation by preserving the soft tissue attachments of bone.
4. Minimal risk of infection due to the shortened operative time and minimal incision, the risk of infection is much less compared to open procedures.
5. Allows early mobilisation of the limb with advantages of improvef blood supply to the limb, aiding in faster fracture healing with a negligible risk of joint stiffness and muscle wasting.
6. Refracture after implant removal is rare with the use of intramedullary nails, secondary to the lack of cortical osteopenia and since fewer stress risers are created.

SPECIAL INDICATIONS FOR INTERLOCKED HUMERUS NAIL:

1. Nonunion of Humerus shaft fractures:

(Source : Rockwood & Green textbook of fractures and joint injuries)

- Site : Proximal and distal thirds of humerus shaft are at increased risk.
- Fracture pattern: Transverse fractures are predisposed, due ro the risk of distraction at the fracture site.
- Soft tissue interposition.
- Inadequate immobilisation.
- Medical factors like old age, poor nutritional status, obesity, diabetes mellitius, use of corticosteroids, anticoagulants, and fractures underlying burns..The treatment objectives for patients with humerus shat nonunions are to establish union, limb length, allignment and function and when necessary,to eliminate infection, Compression plating with bone grafting and reamed intramedullary nailing are probebly the most effective methods for the treatment of established nonunions. With the use of either device, some basic principles must be followed.

1. Obtain osseous stability
2. Eliminate the nonunion gap
3. Maintain or restore osseous vascularity
4. Eradicate infectionServal of the reported studies presented earlier, include the treatment of nonunions of humerus by the humerus interlocked nail. Three recent studies deal specifically with the treatment of nonunions of humerus and nonunions after treatment with the interlocked nail. They are included here.

Lin, Hou and Hang in April 1999, Mc Kee and Miranda in 1996 Raschke et al66 of the University of Berlin

2. Pathological fractures of humerus shaft:

(Source : Orthopaedic clinics of North America, Oct.2003)

Rigid intramedullary nailing of impending or completed pathologic fractures is a covenient and effective means of stabillisation. The aim of the fixing pathological fractures is to provide a pain free functional limb so that the patient can have a

reasonable quality of life. Most reported studies on the use of the interlocking humerus nails include cases of pathological fractures stabilised with the interlocking nail. Few authors have worked only on pathological fracture fixation with the locked humeral nail. These include, **Redmond, Blasier and Biermann** of The University of Michigan USA , **Dijkstra et al** at Rotterdam, Netherlands, in 1997, **Damron** and Associates of the Mayo Clinic USA,
Tom, Carsi et al of Madrid, Spain.

MATERIALS AND METHODS

25 cases of fracture shaft humerus, were stabilised with the interlocking intramedullary nail of Russel - Taylor type by the antegrade approach.These nails were available in the diameters of 6,7 and 8 mm and inthe lengths ranging from 18 to 28 cms. The 6 mm and 7 mm nails were nonconnulated solid nails, 2 holes, for distal lcoking and 1 hole for proximal locking were availableon the nail.These holes were 4 mm in diameter in the 7 and 8 mmnails, accepting interlocking blolts with a thread diameter of 3.9mm and 3mm in diameter in the 6 mm nails, accepting interlocking bolts with a threaddiameter of 2.9 mm. The design of the distal locking holes varied with themanufacturers and were available with an antero - posterior and a mediolateralorientation.The nail, by design, had a proximal bend (apex medical bend) of 5 degrees to accommodate the off set of the insertion portal with the medullary canal.

Pre - Oprative estimation of nail size :Canal diameter at norrowest point look for it in the pre-operative roentgenograms in both antero-posterior and lateral view radiograms. Required length of the nail was assessed as the distance from the tip of the greater tebe-rosity to3 cms from the uppter limit of the olecranon fossa.

ANAESTHESIA: Operative procedure was performed undergeneral anaesthesia.

APPROACH : All cases in this series were operated by the antegrade approach using the proximal entry portal.

PROCEDURE -

1. Positioning of patient -

In supine position ,the head was turned to the opposite side to increase exposure of the shoulder. A cloth roll or ring pillow was placed under the scapula so as to achieve 300 extension of the shoulder, & the image intensifier was placed on the opposite side of the table and positioned prependicular to the table.

2. Patient Prepartion -

Preoperative scrubbing and Draping was done with sterile sheets.

3. Incision and entry point -

A longitudinal skin incision was made from the most lateral point of the acromion and extended 5 cms distally, centering over the tip of the greater tuberosity. The entry portal was made at a point just medial to the tip of greater tuberosity and 0.5 cms posterior to the bicipetal groove using a small curved bone awl & its position was confirmed to be in the center of the canal on image intensifier.

4. Insertion of guide rod and intraoperative assessment of nail length

A guide rod of 500 mm was used in every case**,** after withdrawing the curved awl, the 2.4 mm nonbeaded (all cases were done without reaming) guide rod was inserted and advanced down the canal, after achieving reduction until the tip was 2 cms proximal to the olecranon fossa, confirmed on the image intensifier. The nail length was estimated by overlapping a second guide rod of same length, proximally from the humeral entry point and subtracting the calculated length of overlapping from 500 mm to determine the precise nail length.

5. Nail insertion -

Cannulated nails were passed over the guide rod. Non connulated nails

were inserted only after removing the guide rod.The jig was held pointing away from the patient (laterally) so the apex of the proximal bend in the nail faced medially.The nail was then gently passed across the fracture to avoid comminution and advanced distally after confirming nail position in the distal canal in both AP andlateral views under the image intensifier.The distal limit of the was confirmed under the image intansifier to be 2cms proximal to the olecranon fossa and proximally the nail was confirmed to be flush with the entry portal or countersunk.

6. Proximal locking :

* The drill barrel was passed through the proximal drill guide along with the trocar and where the skin was dimpled by the trocar, a small 8 mm incision was made and the trocar passed upto bone.

* The trocar was exchanged for a drill sleeve and using 2.7 or 3.5 mm drill bits respectively, the proximal screw hole was drilled from laterial tomedical cortex, while keeping the arm abducted toavoid damage to the brachial artery.

* The screw depth guage was then inserted through the drill barrel and the required bolt length estimated. The appropriate sized bolt was selected and inserted using the hexagonal screw driver. A washer was used in osteporotic bone to prevent the screw from being countesunk.

7. Distal interlocking :

Two techniques were used :

1. The free hand technique (used in 22 cases)
2. Using a distal jig/aiming device (used in 4 cases)

8. Post operative managment -

Rehabilitation of the patient began immediately. On the 1st post -op day, the operated extermity was elevated on a Thomas arm splint or by suspension with abduction and external rotation at shoulder.From the 2nd post-op day, active assisted and passive movenents are begun, including pendulum exercises and assited full forward flexion within the limites of the pain. From the 7 th post-op day, overhead abduction, external ratation and internal rotation exercises were begun.

9. Follow up Protocol

The patient was called back for follow up on the 6th, 10th and 16th post operative week, thereafter depending on the the X ray picture at 10 and16 weeks, and functional status of the upper limb further follow up, visitswere advised.Advise regarding lifting of weights and heavy work was given based on the X ray picture and not before 6 post operative months.A clinical proforma was used to evaluate the patient and keep an accurate follow up record. This proforma has been attached in the annexures (Annexurel). A scoring system was used to evaluate shoulder function as devised by Constant and Murley16 (used by the European society for shoulder and elbow surgery) they scores such as the U.C.L.A. and Neer's score are available fore evaluating shoulder function but the constant - Murley scoring system was chosenfor its preciseness and reproducibility. Functional status of the upper limb as a whole was assessed using the A.S.E.S. 69 (American Shoulder and Elbow Surgeons) score. This score was chosen for its focus on functional status of the whole upper limb and for its ease of application.

STATISTICS

The present study consists of 25 cases of fracture shaft humerus operated at B.J.M.C., Pune. 1 case was lost to follow up. Of the remaining, 24 cases, there were 15 fresh fractures, 4 nonunions, 3 delayed unions and 2 pathological fractures. Observations noted in these 24 patients have been included. The data of these cases has been complied and condensed as a master chart (Appendix IV) Analysis of the data is presented here.

Table 1 : Age Distribution of patients :

Age group (years)	No of patients	%
18-20	1	4%
21-30	9	38%
31-40	4	16%
41-50	3	13%
51-60	4	16%
61-70	1	4%
71-80	2	9%
TOTAL	24	100%

Table 2 : Sex Distribution :

	Male	Female	Total
No. of Patients	16	8	24
%	67%	33%	100%

Table 3 : Mode of Injury :

Mode of Injury	No Of Patients	%
Rode traffic accidents	12	50%
Fall from height	6	25%
Blunt trauma / assault	4	17%
Minimal trauma	2	8%
Fire Arm Injury	--	--
Sports Injury	--	--
Total	24	100%

Table 4 SITE :

Anatomical level	No of Patients	%
Upper Third	3	13%
Middle Third	13	54%
Upper 1/3 Middle 1/3 Junction	5	20%
Middle 1/3 – lower 1/3rd	3	13%
Total	24	100%

Table 5 : Indication for surgery :

INDICATION FOR SURGURIES	No of Patients	%
Multiple Injuries	9	38%
Nonunion	4	17%
Delayed union	3	13%
Ipsilateral forearm fracture	2	8%
Unstable closed reduction	2	8%
Pathological fracture	2	8%
Obesity	1	4%
Elderly patients	1	4%
Total	24	100%

Table 6 : Redial nerve injuries :

Radial nurve palsy	On admission	After CMR	TOTAL
No of patients	3	1	4
%	13%	4%	

16% of patients had radial nerve injuries at admission and all 4 patients re-normal function within 6 months with appropriate physiotherapy in a dynamic cock up splint after the fracture was stabilised with rigit fixation. All injuries were neuropraxia of radial nerve.

Table 7 : Nail diameter used :

Nail diameter	Nos	%
8mm	4	17
7mm	13	54
6mm	7	29
TOTAL	24	100%

Table 8 : Time taken for Union :

Time of week	No of patients	%
Less than 10 weeks	6	24
10 – 16	13	55
16 – 20	2	9
20 – 24	1	4
24 – 30	0	0
30 – 36	1	4
TOTAL	23	96%

. 2 cases of patho-logical fractures, Heamangioma and fibrous dysplasia were

(29%).

united with bone grafting during nailing in speculated time.

Table 9 : Functional assessment of shoulder function :

Constant score	No. of patients	%
55 – 66	6	30
50 – 54	8	33
45 – 49	7	23
40 – 44	3	14
< 40	0	0
TOTAL	24	100%

Using the constant Murley scoring system of shoulder function 63% patients had a score between 50 - 60 implying good to excellent shoulder function and no patient had a score less than 40 implying poor shoulder function.

Table 10 : Complications :

Complication encountered	No of cases	%
Shoulder stiffness	5	20.84
Infection – superficial	2	8
Infection – deep	0	0
Delayed union	2	8
Impingement syndrome	2	8
Nonunion due to implant failure	1	4
Osteolysis around implant	1	4
Introgenic radial nerve palsy	1	4
Elbow stiffness	1	4

OBSERVATION & OUTCOMES

The basic goal of management of diaphyseal fractures of humerus is to achieve union and restore good function. While assessing results of this study. more stress was given to functional recovery and early return to the prefracture state. Union of the fracture was judged clinically by the lack of pain or tenderness at the fracture site and by assessing serial readiograms for presence and consolidation of the bridging callus. Upper limb function was assessed on the whole,using the scoring system of the American Shoulder and Elbow Surgeons.In most cases, assessment of shoulder and upper limb function was done at the end of 6 months. Patient Assessment was done as follows during follow up-shoulder and elbow function was assessed using the score of Constant- Murley, which takes into consideration range of motion and strengh of adjacent muscle.

The results have been graded on the basis of :

Time to fracture Union :	**Points**
< 10 weeks	10
10 - 16 weeks	8
17 - 20 weeks	6
20 - 30 weeks	4
> 30 weeks	2
Non union	0
A.S.E.S. score of upper limb function	
52 – 47	10
46 – 42	8
41 – 36	6
34 – 31	4
< 30	2
Constant - Murlay score of shoulder function	
60 – 55	10
54 – 50	6
49 – 45	6
44 – 40	4
< 40	2

A maximum score of 30 points is possible and grading is as follows :

	< 15
Statisfactory	15 – 19
Good	20 – 24
Excellent	25 – 30

The results were as follows :

Excellent	14	42%
Good	7	46%
Satisfactory	2	8%
Poor	1	4%
TOTAL	24	100%

OUTCOMES:

* Excellent to good results were seen in 88% patients.
* Out of 24 cases followed up, 2 patients had pain in the shoulder on abduction and forward flexion, symptoms of the impingement syn drome, which were relived after removal of the implant in bothcases.
* A single case of implant failure due to breakage of the nail at the unused proximal of 2 distal screw holes ended up with nonunion and is currently Under treatment.
* 1 case of autolysis around the implant causing pain and limitation of upper limb function required removal of the implant.
* All 6 cases of radial nerve palsy had excellent functional return at the end of the 6 months.

DISCUSSION

A series of 25 cases of fracture shaft humerus treated by interlocked intramedullary nailing were studied, which included 16 fresh fractures,4 nonunions, 2 pathological fractures and 3 delayed unions.The youngest patient was 18 years old and oldest was 79 years old.Most of the patients were adults between the ages 20 to 40 years (58%).The commonest mode of injury was road traffic accidents (50%).The antegrade approach was used in all 25 cases, and all nails were inserted without reaming. 13 of the patients had associated injuries involviing the axial and ap-pendicular skeleton, other organs and viscera.

4 cases had a radial nerve palsy at admission, in all these cases, there was complete recovery of nerve function within 6 months. 1 case had superficial infection which healed with sterile dressing and antibiotics after culture and sensitivity. 5 patients had a significant restriction of shoulder movements while 4% had elbow stiffness with no functional loss. In short, 25 fracture of the shaft humerus treated with unreamed antergrade interlocked intramedullary nails in this study have shown 96% union rates with the time of union ranging from 8 to 32 weeks. Only indi-cated fracture were operated upon the most important indication being pres-ence of associated multiple injuries, stable and early internal fixation in the patient's with multiple injuries not only hastens recovery, but relives pain, protects adjecent soft tissue from further injury, prevents the "fracture dis-ease" and facilitates nursing care and rehabilitation. In the presence of other injuries in the same extremely, stabilisation of the humeral fracture may have similar beneficial effects.Although the technique has a high learning curve and is best in expe-rienced hands, it is much less technically demanding than open reduction and fixation with plate and screws. The final fuctional outcome is good to exc-ellent in majority(88%) of patients, with a relatively low complication rate compared to other methods of intenal fixation. The results of the present study indicates that in the presence of proper indications, unreamed antegrade intramedullary interlocked nailing appears to be one of the best modes of the treatment among the available methods today.

CONCLUSIONS

1. When indicated, internal fixation of fractures of the shaft of humerus with unreamed interlocked intramedullary nail gives goods results.
2. The raliable secure fixation provided enables early post operative rehabilitation both physically and psychologically.
3. It appears to be the method of choice for internal fixation of osteoporotic and pathologic fractures.
4. Early exploration of the radial nerve is unnecessary and a wait and watch approach, gives the best results.
5. The antegrade approach produces shoulder stiffness in few patients but is technically less demanding than the retrograde technique, shoul der stiffness recovers in due course of time with physiotherapy and rehabilitation.
6. There are some obvious dis-advantages including a high learnig curve.The risk of violating the rotator cuff with the antegrade procedure and damaging neurovascular structures unless due care is taken, the necessity of the use of image intensifier thereby increasing the risk of radiation exposure to the surgeon, and the cost of equipments. However, the advantages of a closed over an open procedure, short operative time, immediate post operative mobilisation of patients, the biomechanical advantages and low complication rate of the interlocking nail make it a preferred procedure for fixing fracture of the shaft of the humerus.

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