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Dr. Manjunatha A
Assistant Professor, Department of Orthopedics, Kodagu Institute of Medical Sciences, Madikeri, Karnataka, India

Dr. Santhosha JB
Senior Resident, Department of Orthopedics, Kodagu Institute of Medical Sciences, Madikeri, Karnataka, India

Corresponding Author:
Dr Santhosha JB
Senior Resident, Department of Orthopedics, Kodagu Institute of Medical Sciences, Madikeri, Karnataka, India

Evaluation of results after dynamization of interlocking nail in diaphyseal fractures of femur and tibia

Dr. Manjunatha A and Dr. Santhosha JB

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Abstract
Dynamization could be achieved by provision of oblong slots in the intramedullary nails called as dynamic holes, along with the circular slots. Thereafter the process of dynamization was done that included removal of the screw in the circular slot (static hole) after 6-12 weeks of surgery when the soft callus had already formed that allowed the interlocking screw in the dynamic hole to move about in the axial direction thus conferring a dynamic compression at the fracture site during weight bearing. Patients were examined, haemodynamically stabilised, 1st aid administered in the form of splintage/ traction/ POP slab along with analgesics followed by radiological evaluation. Relevant data was recorded in pre-prepared proforma. Patients were evaluated clinically for fitness for anesthesia and surgery. Relevant investigations were done. Out of 77 femoral interlocking nailing procedures, in 6 cases, the fracture got impacted on table itself and thus nailing was done in dynamic mode since the very beginning, while another 8 cases underwent dynamization subsequently between 6-12 weeks post-op.
Patients were followed up and when 2 consecutive x-rays did not show progress of union, were subjected to dynamization.

Keywords: Dynamization, Interlocking nail, Diaphyseal fractures of femur and tibia

Introduction

As science advanced, the technology also evolved. The biomechanics of human gait and weight bearing patterns were better understood and hence, newer implants more conducive to the the human anatomy were developed.

Along with this, the materials used for manufacture of such implants were also put under the microscope for detailed evaluation and newer metals and their alloys came forward, possessing an ever increasing level of strength, pliability along with anatomical and physiological compatibility.

Earlier nails were solid or hollow cylindrical columns of wood, ivory or metal that were simply introduced into the medullary cavity, thus providing the most elementary form of internal splintage. These implants however were highly reactive and accompanied with the poor understanding and implementation of sterilization procedures, led to a very high rate of infection and non-union [1].

To address these problems, metallic implants in the form of solid metallic rods were developed. After much research, alloys that were minimally reactive to the human body and possessed greater strength and elasticity were developed and used for manufacture for implants. Simultaneous improvements in sterilization facilities also contributed to a marked decrease in rate of complications. However unsatisfactory fracture stability leading to a high rate of non union of fractures still posed a major challenge to orthopaedicians world over.

By introducing simple changes in the structure and shape of the nail, rendering it hollow and modifying the cross section from round to a clover-leaf shape, appreciable improvements in fixation stability were seen [2].

Many means of improving the fixation were advocated. With the advent of the Kuntscher nail**,** the concept of 3 point fixation of a nail was brought into light that received immediate and widespread recognition across the orthopaedic community.

Though the K-nail provided axial stability as well as 3-point fixation and thus, improved stability of the fracture but it could not provide rotatory stability except in transverse or short oblique fractures in the isthmic region of femur [3]. To improve rotatory stability surgeons came up with the idea of putting screws just anterior or posterior to the nail to obliterate the space and later to put screws into the slot of the nail to restrict the rotatory mobility at the fracture**.** These methods of rotatory stability provision were closely followed up and it was observed that they were associated with a very high rate of nonunion. To overcome this problem, the concept of interocking nails came where the screw was passed from Though the K-nail provided axial stability as well as 3-point fixation and thus, improved the cortex of the bone into the hole of the nail and into the opposite cortex at both ends of the nail. But again a high rate of non union was seen and hence surgeons recommended dynamization in each and every case of interlocking after 6 to 12 weeks of surgery. Dynamization could be achieved by provision of oblong slots in the intramedullary nailscalled as dynamic holes, along with the circular slots. Thereafter the process of dynamization was done that included removal of the screw in the circular slot (static hole) after 6-12 weeks of surgery when the soft callus had already formed**,** that allowed the interlocking screw in the dynamic hole to move about in the axial direction thus conferring a dynamic compression at the fracture site during weight bearing [4]. There are however advantages and disadvantages of both methods of fixation. Static nailing provides rigid fixation thus helps in maintaining length and alignment specially in comminuted and segmental fractures where dynamic nailing from the beginning may lead to loss of reduction and shortening specially in comminuted fractures. Today the debate for nailing in static mode and dynamization later on or nailing in a dynamic mode since beginning is going on. This study has been undertaken to study the role and timing of dynamization after interlocking nailing in diaphyseal fractures of femur and tibia.

Methodology

Patients of diaphyseal fractures of femur and tibia attending the emergency and outpatient department of Medical College Hospital, were selected for the. Patients were examined, haemodynamically stabilised, 1st aid administered in the form of splintage/ traction/ POP slab along with analgesics followed by radiological evaluation. Relevant data was recorded in pre-prepared proforma. Patients were evaluated clinically for fitness for anesthesia and surgery. Relevant investigations were done.

Inclusion Criteria

1. All diaphyseal fractures of femur and tibia including Gustillo’s type 1 and 2 compound fractures.

Exclusion Criteria

1. Fresh Gustillo’s grade 3 compound fracture
2. Already infected fracture
3. Sclerotic disease of bone with inadequate marrow cavity
4. Periarticular fractures
5. Young patients below 8 years of age
6. Patients with non-functional limbs prior to injury due to pre-existing condition
7. Polytrauma patients
8. Patients medically unfit for surgery / anaesthesia

Having attained surgical and anaesthetic fitness, patients were posted for the procedure.

Patient was mounted on an orthopaedic fracture table for femur interlocking while for tibia interlocking the leg was hanged along the side of the table for the procedure.

Femur Interlocking Procedure

- Incision was made over the lateral aspect of the thigh starting at the level of tip of greater trochanter, extending 4-5 cm proximally.
- The iliotibial tract was incised in line with the skin incision and retracted.
- Fascia covering the vastus lateralis muscle was also incised along the same line.
- Fibres of the vastus lateralis were split and retracted.
- Hip abductors attaching onto the greater trochanter were carefully split to expose the region of pyriform fossa.
- Awling was done under fluoroscopic guidance, using either a 4 mm Steinman pin or a curved bone awl, until the medullary cavity was reached
- Awl was withdrawn and a ball tipped guide wire introduced into the entry made.
- Reduction was achieved at the fracture site by means of traction and manipulation and guide wire passed across the fracture, its position thus confirmed under fluoroscopy.
- Reaming was done with reamers of progressively increasing sizes from 8mm upto a maximum of 12mm, depending on the diameter of medullary cavity.
- Ball tipped guide wire was exchanged with a simple wire after inserting an exchange sleeve.
- Nail size was determined by measuring the length of the guide wire inserted into the medullary cavity and diameter corresponding to 1mm smaller than the widest reamer used, was chosen.
- Nail was inserted using a proximal jig and passed into the distal fragment while maintaining reduction.
- Distal locking was done using the free hand technique, under fluoroscopic guidance, after predrilling pilot holes through the distal locking holes of the nail using 4.00 mm drill bit.
- Locking was done using 4.9mm cortical screws of appropriate sizes.
- Fracture reduction was confirmed under C arm visualization and reverse hammering was done if residual gap was seen
- Proximal locking was done using the proximal jig after predrilling with 4.00mm drill bit and using 4.9mm cortical screws of appropriate sizes.
- Jig was removed, all wounds debrided thoroughly and closed in layers.
- Occlusive dressings were placed and patients were shifted to post op room under all due spinal precautions.
- Post-op care was administered to all patients including continuation of spinal precautions for 6 hours, antibiotic prophylaxis, post-op check dressings followed by active quadriceps exercises

Results

The average time from initial trauma to operation was 3.85 days for tibia and 4.34 days for femur. Closed reduction was achieved in 79.2 % cases of femoral and 82.9 % of tibial interlocking procedures. All 141 fractures of tibial diaphysis, treated by interlocking nailing, were interlocked in static mode in the beginning. But in 24 of these cases, the nails were dynamized at 6-12 weeks after the initial surgery. Out of 77 femoral interlocking nailing procedures, in 6 cases, the fracture got impacted on table itself and thus nailing was done in dynamic mode since the very beginning, while another 8 cases underwent dynamization subsequently between 6-12 weeks post-op. Patients were followed up and when 2 consecutive x-rays did not show progress of union, were subjected to dynamization. In femur interlocking nailing, the average union time was 22.4 weeks for non-dynamized and 21.6 weeks for dynamized nails. For tibial interlocking nails, it was observed to be 22.5 weeks for non-dynamized and 20.1 weeks for dynamized cases. Early dynamization between 6-12 weeks post operative helps in faster healing of tibial and femoral diaphyseal fractures.

Table 1: type of Compounding

S. No.	Gustillo-Anderson Grade	Tibia	Femur	Total
1	Grade 1	47	13	60
2	Grade 2	22	5	27
3	Grade 3	Excluded	Excluded	---
Total		69	18	87

Table 2: X-Ray Grading

S. No.	Type	Tibia	Femur	Total
1	Transverse	67	42	109
2	Spiral	40	4	44
3	Comminuted	30	29	59
4	Segmental	4	2	6
Total		141	77	218

Table 3: Associated Injuries

S. No.	Injuries	Tibia	Femur	Total
1	Head Injury	19	11	30
2	Ipsilateral Femur	3	NA	3
3	Contralateral Femur	1	2	3
4	Ipsilateral Tibia	NA	4	4
5	Contralateral Tibia	2	1	3
6	Patella	2	3	5
7	Humerus	1	0	1
8	Radius	6	2	8
9	Ulna	3	1	4
10	Clavicle	4	5	9
Total		41	29	70

Table 4: Time Lapse From trauma To Surgery

S. No.	time	Tibia	Femur	Total
1	<6 hrs	1	0	1
2	6-24 hrs	14	2	16
3	24-48 hrs	19	15	34
4	2-7 days	97	42	139
5	7-15 days	8	13	21
6	>15 days	2	5	7
Total		141	77	218

Table 5: Procedure Done

Procedure Type	Tibia	Femur	Total
crif	118	61	179
Orif	23	16	39
Total	141	77	218

Table 6: Implant Used

S. No.	Implant	Tibia	Femur	Total
1	Pfn	--	1	1
2	Expert Femur	--	2	2
3	femur I/L	--	74	7r
4	Expert Tibia I/L	3	--	3
5	Tibia I/L	121	--	121
6	Tiplock Tibia I/L	17	--	17
Total		141	77	218

Table 7: Operative Time

S. No.	Time (minutes)	Tibia	Femur	Total
1	<30	17	1	18
2	30-40	34	3	37
3	40-50	28	17	45
4	50-60	25	15	40
5	>60	37	41	78
Total		141	77	218

Table 8: Mode of Locking

Mode	Tibia	femur	total
Static	141	71	212
dynamic	--	6	6
Total	141	77	218

Table 9: Healing of Wound

Healing	Tibia	femur	Total
Primary Intention	66	17	83
Secondary Intention	3	1	4
Total	69	18	87

Table 10: Incidence of Infection

Site of Infection	Tibia	Femur	Total
Superficial	5	4	9
Deep	1	0	1
Total	6	4	10

Table 11: Weight Bearing – Tibia

S. No.	Weight Bearing- Tibia	weeks			
		6	8	12	>12
1	Toe-Tip Touch	17	--	--	--
2	Partial	124	14	--	--
3	Full With Walker	--	60	14	--
4	Unsupported	--	67	127	--

Table 12: Time Duration; Weight Bearing – Femur (Weeks)

S. No.	Weight Bearing Femur	weeks			
		6	8	10-12	>12
1	Toe-Tip Touch	35	--	--	--
2	Partial	42	35	--	--
3	full with walker	--	32	45	--
4	Unsupported	--	10	26	7

Table 13: Dynamization

Dynamization	Tibia	Femur	Total
Done	24	14	38
Not Done	117	63	180
Total	141	77	218

Table 14: Timing of Dynamization (weeks)

Bone	Dynamic Locking	6-8	8-12	12-16	Total
Tibia	0	9	15	0	24
Femur	6	1	7	0	14
Total	6	10	22	0	38

Table 15: Union Time-(Tibia)

S. No.	Time (Weeks)	Non Dynamized	Dynamized	Total
1	12 - 16	0	0	0
2	16 - 20	12	12	24
3	20 - 24	78	8	86
4	> 24	27	3	30
5	Non Union	0	1	1
Total		117	24	141

Table 16: Union Time-(Femur)

S. No.	Time (Weeks)	Non Dynamized	Dynamized	Total
1	12-16	0	0	0
2	16-20	4	4	8
3	20-24	49	6	55
4	>24	10	3	13
5	Non Union	0	1	1
Total		63	14	77

Discussion

The compounding status of the injuries was classified using the Gustillo-Anderson system of classification, according to which, 72.2% of open femoral and 68.1% open tibial diaphyseal fractures were Compound Grade 1 while the remaining were Compound Grade 2 (with Grade 3 having been excluded from our study). Similar incidence was observed by Marco, Sertorio and Murilo Antonio in 2002 [5], who reported the incidence of Grade 1 compounding to be 67.2% in tibial and 61.8% in femoral fractures. The x-ray grading of the tibial diaphyseal fractures under study revealed 47.5% transverse and short oblique, 28.3% spiral, 21.2% comminuted and remaining 2% to be segmental fractures. The femoral fractures on the other hand were classified as 54.5% transverse and short oblique, 5 % spiral, 37% comminuted and 2% segmental fractures. The study by Marco, Sertorio and Murilo Antonio in 2002 [5], yielded similar observation with 56.8% of the tibial fractures being transverse or short oblique, 16.2% spiral, 17.8% comminuted and 0.08% tibial fractures being segmental. These figures show the greater incidence of the transverse and short oblique morphology among other types. Closed reduction could be achieved in 79.2 % femur interlocking and 82.9 % of tibia interlocking procedures. This can be compared to variable data recorded in different studies. A study on femoral shaft fractures by Meena, Kundnani and Hussain in 2006 [6], reported 53.4% of the total 108 femur interlocking procedures performed to have involved closed reduction. Another study by Court-Brown, Christie and McQueen in 1987 [7] on tibial diaphyseal fractures reported 82.6% procedures to have employed closed reduction. The mean operative time observed in our study was 47.19 minutes for tibia interlocking and 56.7 minutes for femur interlocking nailing. Similar observation were obtained from studies by Court-Brown, Christie and McQueen in 1987 [7] and Basumallick and Bandopadhyay in 2011 [8], who reported mean times of 62 minutes and 71 minutes for tibia and femur interlocking nailing procedures respectively. The mode of locking employed during the interlocking procedures in our study was static locking in 93 % femoral and 100 % tibial interlocking nailings. Observations from studies by S. Solooki and Misbahi [9] in 2011 also shows 100% static locking employment for tibial interlocking while Siddharth Sharma and Gopalan in 2011[39] did static locking in only 55% of the 87 femoral fractures that they studied. Weight bearing during our study was started at 6 weeks post-operation, in case of femoral fractures in the form of toe-tip touching in 46% and partial weight bearing with support in the rest 54% cases. While for patients with tibia interlocking, partial weight bearing with support was started in 47.5% cases at 6 weeks, restricted to toe tip touching in 37.8% cases while 14.7% fractures were kept non-weight bearing until 10 weeks post operation. Other studies reveal earlier weight bearing, as in studies by S. Solooki and Misbahi in 2011 [9] and Kamruzzamman and Islam in 2002 [10] who allowed toe-tip touch weight bearing in stable fractures, as early as 2nd post operative day followed by partial weight bearing starting at around 1-2 weeks post operation.

Patients were evaluated at regular intervals and when two consecutive x-rays did not show any progression of union, dynamization was done in 14 cases of femoral fractures and 28 cases of tibial fractures. Hao Ming in 1997 [11] however, dynamized all 28 cases of femoral interlocking nailing at around 6 months post operation, irrespective of the union healing status while Carlton, Hick and Trevors [12] chose to dynamize only 75 out of the 179 femoral interlocking procedures they performed.

The timing of dynamization, which continues to be a debatable topic till date, was performed in our study,in case of femur interlocking, at 8-12 weeks post operation in 7 cases while 1 nail was dynamized before 8 weeks. The remaining 6 cases had been locked in dynamic mode since the beginning. As for tibial interlocking, 9 nails were dynamized at 6-8 weeks post operation while the remaining 15 cases were dynamized at 8-12 weeks post operation. Finally, the average union time observed in our study was 22.4 weeks for non-dynamized and 21.6 weeks for dynamized femoral interlocking nails. For tibial interlocking nails, it was observed to be 22.5 weeks for non-dynamized and 20.2 weeks for dynamized cases. Similar data was recorded in the study by Basumallick and Bandopadhyay in 2011 [8], who reported a union time of 19.2 weeks in dynamized cases and 23.5 weeks in non-dynamized cases of femoral fractures, highlighting a beneficial role of dynamization on union time. However, Carlton, Hick and Trevors, in 2005[52], observed a faster healing rate in the static group of femoral nails (103 days) as compared to the dynamized group (126 days). Thus our study arrived at a clearly beneficial effect of dynamization on accelerating the time to union in tibial diaphyseal fractures but an equivocal effect on the healing rate of femoral diaphyseal fractures. The timing of dynamization was also studied. While we observed an average union time of 21.6 weeks for dynamized femoral interlocking nails and 19.2 weeks in dynamized tibial interlocking nails, having performed all dynamization procedures between 6-12 weeks post operation, similar study by Subhramaniam in 1988 [13], who performed dynamization after 24 weeks post operation, observed an average union time of 22.8 weeks and 21.4 weeks for femoral and tibial interlocking nails respectively, denoting a greater efficacy of an early versus a delayed dynamization. Winquist, 1984 [14], achieved 99.1% union rate in femoral diaphyseal fractures, having performed dynamization in 171 of his cases and thus arrived at results favouring dynamization. Hao Ming, 1997 achieved 85.4% union rate in his study on 28 dynamized femoral nails and supported this concept. Basumallick and Bandopadhyay in 2002[2], studied 50 patients of femoral shaft fractures of which 26 were dynamized and 24 not and concluded that dynamization had a favourable effect on mean time to union. Charles and Hansen, 2002 [15] also reported a beneficial role of dynamization in treating non-union of femoral shaft fractures.

At the same time, there were surgeons who came up with results against dynamization. These included works by Carlton, Hick and Trevors, 2005 [12], who observed a faster healing rate in the static group, Brumback, Reilly, Poka and Lakatos, who achieved satisfactory union in 99% cases without the need for dynamization and Brumback, Uwagi, Lakatos, Bathon and Burges, who also came up with data going against dynamization. The rate of non-union encountered in our study was 1.4% for tibial and 1.2% for femoral diaphyseal fractures. S.Salooki and SAR Misbah, 2011 [9], studied 173 patients of tibial and femoral fractures and reported 0.8% non-union in femoral fractures while all tibial fractures united well. Brumback, Uwagi, Lakatos, Bathon and Burges [16] observed a 2% non-union rate among the 98 femoral shaft fractures studied.

Conclusion

The progress of union and the average time to union was noted in dynamized versus non-dynamized cases and it was observed that dynamization had a definite role in enhancing tibial diaphyseal fracture union while having an equivocal effect on femoral diaphyseal fractures, as compared to non-dynamized cases.

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