International Journal of Orthopaedics Sciences

ISSN: 2395-1958
IJOS 2017; 3(1): 441-448

www.orthopaper.com
Received: 05-11-2016
Accepted: 06-12-2016

Dr. V Thirunarayanan
Associate Professor of, Orthopaedics, Department of Orthopaedic Surgery, Dharmapuri Medical College, Dharmapuri, Tamil Nadu India

Dr. DR Ramprasath
Department of Orthopaedic Surgery, Coimbatore Medical College, Coimbatore, Tamil Nadu, India

Dr. Arjun Rajan
Resident, Department of Orthopaedic Surgery, Government Royapettah Hospital, Chennai, Tamil Nadu, India

Correspondence
Dr. V Thirunarayanan
Associate Professor of Orthopaedics, Department of Orthopaedic Surgery, Dharmapuri Medical College, Dharmapuri, Tamil Nadu, India

Assessment of bone geometry and its considerations in implant selection for polio affected femoral fractures: An outcome analysis

Dr. V Thirunarayanan, Dr. DR Ramprasath, Dr. Arjun Rajan

DOI: http://dx.doi.org/10.22271/ortho.2017.v3.i1f.65

Abstract
Introduction: Fractures occurring in the femurs of polio affected limbs pose various challenges in their management since they have an altered anatomy. In this study, the bone geometry of femoral fractures in post-polio residual paralysis patients is analysed and compared with standard implants for proper implant selection to provide a stable fixation.
Materials and methods: A total of 20 femoral fractures in adult post-polio residual paralysis patients were included in this study and their bone geometry was assessed. Based on the bone geometry in each case, appropriate implants were used. The mean age was 41.6 years (Range 26 to 58 years). 9 cases out of the 20 required the use of non-standard implants, including a custom-made femoral nail, a humerus nail, proximal humerus LCP, proximal tibial LCP and a modular bipolar hemiarthroplasty prosthesis with DDH stem. Mean duration of follow up was 34.5 months (Range 2 to 5 years).
Results: The mean union time was 4.63 months. The mean duration of surgery was 81min (Range 65-145 mins). Intra-operative blood loss ranged from 80-250ml (Mean 130ml) with no case requiring blood transfusion. Mean hospital stay ranged from 7-9 days. All patients returned to their pre-operative function (assessed according to Vignos scale for lower extremities), except for two cases showing a deterioration of function post-operatively.
Conclusion: No implant is unique for surgical management of femur fractures in post-polio residual paralysis patients. Proper pre-operative evaluation and planning should be individualised for each case according to the measured femoral geometry. The best implant should be chosen and a wide array of implants should be made available during surgery to achieve good results.

Keywords: Femur, fracture, implant, polio, surgery, Vignos

1. Introduction
No case of poliomyelitis ("polio") has been reported for more than 2 years in India and WHO has declared India polio-free on 26-27 March 2014 [1], but there is a prevalence of around 13.45 per 1000 population [2] of post-polio residual paralysis (PPRP) patients. Incidence of fractures in post polio residual paralysis patients is quite high. Although the exact incidence of femoral fractures in these patients is not known, femur is considered the most commonly fractured bone, constituting about one-third of fractures.
Surgical management allows active early mobilisation, prevents complications of long recumbency like mal-union, non-union, worsening joint contractures and permits active rehabilitation. Achieving a stable fixation in these deformed, osteopenic, osteoporotic [3] and hypo vascularized femurs is quite difficult.
Regular implants designed for normal bones may not fit in the altered anatomy of these deformed polio affected femurs, hence managing a deformed bone with normal implants available for use is not always possible. Choice of implants then have to be custom made or implants designed for use in other bones like tibia or humerus may have to be used with the knowledge of how and why it is used for achieving stable fixation.
The aim of this study is to assess the bone geometry of polio affected femoral fractures and to study if stable fixation and good functional outcome can be achieved using suitable implants matching the altered geometry.

2. Materials and methods

Our study was a prospective case series which included 20 cases with a sex ratio of M:F = 14:6 (Fig. 1). All patients with post-polio residual paralysis having fractures of the polio affected femur were included in the study. This included 3 fractures of neck of femur, 4 in the trochanteric region, 5 of the shaft and 8 of the distal femur (Fig. 2)

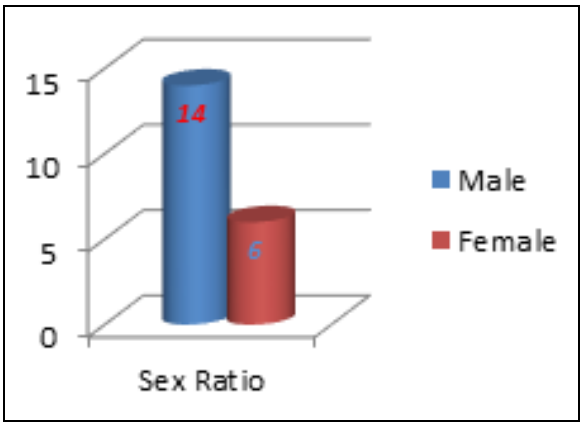

Fig 1: Sex Ratio

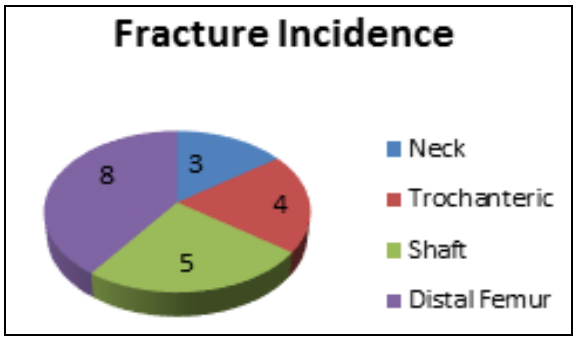

Fig 2: Fracture incidence

Dimensions of standard implants like width of screw and side-plate in DHS, nail diameter in standard antegrade IMIL nail, Proximal Femoral Nail (PFN), width of distal femur LCP, proximal tibia LCP and proximal humerus LCP at the broadest and the narrowest portions were charted out.

The following radiographic measurements for femur were done in all cases (Table 1)-

1. Femur Length- Tip of the greater trochanter to medial knee joint line (By X-rays)
2. Femur Diameter -Measured at the level of the lesser trochanter, 5cm, 10cm, 15cm and 20 cm below it, was done and least diameter was taken into consideration (CT scans and full length X-rays)
3. Neck Diameter- Narrowest was taken into consideration (CT scan)
4. Neck Shaft Angle (CT scan)
5. Anteroposterior and Mediolateral diameter at the level of condyles (CT scan)
6. Anterior bowing- Wherever possible
7. Anteroposterior width of distal femur 5cm and 10cm above the condylar level

Table 1: Radiographic Measurements of Femur

	Neck Shaft Angle (º)	Neck Diameter (mm)	Narrowest shaft diameter (mm)	Femur Length (cm)	Distal femur AP diameter (mm)	Distal femur mediolateral diameter (mm)
Case 1	137	26	7	32	35	55
Case 2	137	22	7	36	36	57
Case 3	138	26	7	32	30	50
Case 4	138	26	7	36	40	65
Case 5	134	24	8	32	28	45
Case 6	135	27	8	35	32	55
Case 7	137	22.5	8	35	34	55
Case 8	130	27	9	38	36	60
Case 9	139	25	8	38	38	55
Case 10	136	25	7	32	40	50
Case 11	137	26	7	35	35	55
Case 12	138	25	9	38	34	55
Case 13	136	25	7	36	28	60
Case 14	132	26	8	34	31	65
Case 15	136	27	7	35	36	60
Case 16	139	28	8	36	32	55
Case 17	130	24	8	37	30	50
Case 18	135	25	9	38	37	55
Case 19	136	26	7	33	31	50
Case 20	137	25	7	37	36	60
MEAN	135.85	25.375	7.65	35.25	33.95	55.6

3. Results

The sex ratio of the 20 patients in our study was M:F= 14:6. The mean age of the patients was 41.6 years (Range 26 to 58 years). The left femur was affected in 12 patients and right femur in 8 patients. Mode of injury was self fall in 11 patients, road traffic accidents in 8 patients and 1 patient had a fall from a height of 10 feet.

The mean duration of surgery in our study was 81 minutes (Range 65 to 145 mins). Intraoperative blood loss ranged from 80-250ml (Mean 130ml) with no case requiring blood transfusion. Mean hospital stay ranged from 7-9 days.

Patients were started on knee mobilisation exercises from the second post-operative day. Patients were followed up regularly and bony bridging callus (in atleast 3 cortices) was seen on plain radiographs by 12 weeks in 11 patients (55%). The mean time for bony union was 4.63 months. One case developed non-union which required bone grafting (Union time 11 months).

Out of 20 cases, the femoral dimensions in 11 cases nearly matched normal bones (non-polio bones) . So in these 11 cases, we did not encounter any difficulty in using routine implants for that fracture type. Two cases were fractures of neck of femur, treated with cancellous screws. Three trochanteric fractures were treated with standard DHS and one case with PFN-A2. Two shaft fractures were treated with standard femoral interlocking intramedullary nail. Three condylar fractures were treated with distal femoral locking compression plates.

Of the remaining 9 cases, one case with fracture neck of femur underwent a bipolar hemiarthroplasty with a DDH stem of Corail. Three cases of fracture shaft of femur were treated with a custom-made femur nail, a humerus nail and a broad DCP (Dynamic Compression Plate) respectively. Of the condylar fractures of femur, 3 cases were fixed with LPHP (Locking proximal humerus plate) and two cases with Proximal tibial LCP (Locking Compression Plate) (Table 2).

Table 2: Master Chart of Results

S. No	Age/Sex	Region #	Non-polio Implant of Choice	Implant Used	Reason	Union Time (Months)	Pre-Op/Post-Op VIGNOS Score	Complications
Case 1	51/F	NOF	CCS/ Hemiarthroplasty	CCS	-	6.5	5/5	-
Case 2	50/M	NOF	Bipolar Hemiarthroplasty Prosthesis	Modular Bipolar with CDH stem	Narrow canal		6 /6	-
Case 3	48/M	NOF	CCS/ Hemiarthroplasty	CCS	-	6.5	5/5	-
Case 4	37/M	Troch	DHS/PFN	DHS	-	3.5	3/3	-
Case 5	41/F	Troch	DHS/PFN	PFN A2	-	4	3/3	-
Case 6	36/M	Troch	DHS/PFN	DHS	-	3.5	2/2	-
Case 7	44/M	Troch	DHS/PFN	DHS	-	3.5	4/4	-
Case 8	27/M	Shaft	Femur nail	Femur nail	-	5.5	4/4	-
Case 9	34/F	Shaft	Femur nail	Custom made nail	Canal narrow	5	5/5	-
Case 10	26/M	Shaft	Femur nail	Humerus nail	Canal narrow	5.5	4/4	-
Case 11	28/M	Shaft	Femur nail	Broad LCP	Canal narrow	11	4/5	Non-union
Case 12	39/M	Shaft	Femur nail	Femur nail	-	3.5	5/5	-
Case 13	58/F	Condylar	DFLCP	Proximal Humerus LCP	Small condyles	3.5	3/4	Knee stiffness
Case 14	46/M	Condylar	DFLCP	Proximal tibial LCP	Small condyles	3.5	4/4	-
Case 15	50/M	Condylar	DFLCP	DFLCP	-	4	4/4	-
Case 16	49/F	Condylar	DFLCP	Proximal Humerus LCP	Small condyles	4.5	2/2	-
Case 17	58/M	Condylar	DFLCP	Proximal tibial LCP	Small condyles	3.5	3/3	-
Case 18	44/M	Condylar	DFLCP	DFLCP	-	3.5	3/3	-
Case 19	39/F	Condylar	DFLCP	Proximal Humerus LCP	Small condyles	3.5	9/9	-
Case 20	27/M	Condylar	DFLCP	DFLCP	-	4	5/5	-

Abbreviations- M= Male, F= Female; NOF= Neck of femur, Troch= Trochanteric region; CCC= Cannulated cancellous screw, DHS= Dynamic Hip Screw, PFN= Proximal Femur Nail, DFLCP= Distal Femur LCP, PFN-A2= Proximal Femur Nail Antirotation

Outcome was measured according to Vignos scale for lower extremities [4] (Table 3). All cases achieved their pre-operative level of function except one patient (non-union) who deteriorated from a score of 5 to 4 and another patient (knee stiffness) from 4 to 3. Range of knee flexion was from 90° to 130° (Mean 104°).

Table 3: Vignos Scale for lower extremities [4]

1. Walks and climbs stairs without assistance.
2. Walks and climbs stair with aid of railing.
3. Walks and climbs stairs slowly with aid of railing (over 25 s for 8 standard steps).
4. Walks unassisted and rises from chair but cannot climb stairs.
5. Walks unassisted but cannot rise from chair or climb stairs.
6. Walks only with assistance or walks independently with long leg braces.
7. Walks in long leg braces but requires assistance for balance.
8. Stands in long leg braces but unable to walk even with assistance.
9. In a wheelchair.
10. Confined to bed.

Complications encountered included one case of non-union for which autologous iliac crest bone grafting was done. One case had post operative knee stiffness. There were no cases with infection, implant failure or other complications. Out of 20 cases - 16 cases had solid union, 1 case had non-union (for which bone grafting was done) and 2 cases were lost to follow up.

4. Discussion

On literature search, only two case series analysing the management of femoral fractures in polio affected limbs were found. One by Khalil [4] and the other by Wang et al [5]. Few other articles about polio fractures are only case reports of one or two cases. There is one study by Nam et al [6] where they have detailed the incidence of falls in polio survivors where the incidence of a fall in one year was 68.5% and of these, 23.3% reported fractures. As per Bickerstaffe et al [7], the incidence of falls in polio survivors is 73.8% in one year and 7.1% of these, sustain a fracture.

Due to the paucity of literature, the references quoted in this article are few.

In the study by Khalil [4] in 2010, 13 cases were operated, of which broad plates could be used in 7 cases (of these, 2 were distal femoral LCPs). In the remaining 6 cases, as the bones were small and atrophic, narrow LCPs were used. So from this study, it is obvious that nearly in one out of two cases of polio, the femur cannot accomodate the regular locking plates. One case in his study developed non-union, which was later bone grafted and in that case the pre-injury function (according to Vignos scale) could not be achieved.

The study by Wang et al [5] was a retrospective study with 16 femoral fractures treated using locking compression plates which gave good results in their patients, except for a case of delayed union. They recommended the use of locking plates in osteopenic, small and deformed bones in polio affected limbs. The principles to be followed while applying LCP in these polio affected femurs have been analysed and elucidated in this study.

In fractures of neck of femur in a post-polio limb, difficulty in fixation is anticipated, due to high neck shaft angle, excess anteversion, narrow neck diameter and in certain cases, a dislocated and dysplastic hip. Also, paralysis, asymmetric involvement and hypoplasia of the limb may lead to osteoporosis and can predispose to fracture neck of femur even with trivial trauma [8].

Out of the 9 cases which had altered dimensions, one was a case of subcapital fracture neck of femur (Fig. 3a, b, c, d) which had a very narrow neck diameter, a very narrow medullary canal 7 mm, an increased neck shaft angle and the patient was 50 years of age. As three cancellous screws cannot be inserted in this narrow neck considering subcapital fracture type and a compromised vascularity due to PPRP status, the chances of AVN and non-union are very high. Hence, a primary replacement was planned. DDH stem of Corail which is the smallest stem available in Depuy system (6mm), with modular bipolar head itself was snug fitting in the narrow canal (Fig. 3g). Anteversion was nearly 25°. This patient had sustained a supracondylar fracture of femur 10 years ago for which retrograde nailing was done(Fig. 3e, f). Here, the bone geometry was such that it could accomodate an IM nail. At 2 years follow up, the patient is doing well (Fig. 3h, i, j,k).

Fig 3a. Pre-operative X-ray

Fig. 3b: Pre-operative CT

Fig. 3c. Pre-operative CT

Fig. 3d: Pre-operative 3D reconstruction

Fig 3e: Pre-operative X-ray-Old trauma trauma

Fig 3f: Pre-operative X-ray- Old

Fig 3g: Post-operative X-ray

Fig 3h: 2 years follow up X-ray

Fig 3i: Functional outcome

In 2 cases of trochanteric fractures (one of them shown in Fig. 4a, b, c) (out of the four in our study), the dimensions (Table 1) were smaller than normal but they could still accomodate the standard DHS. In these two cases, the neck diameter was 24mm and 22.5mm. The guide wire had to be passed in centre of the neck to prevent any cortical breach while using standard DHS screw with thread diameter of 12.5mm (Fig. 4d). We managed to pass the guide wire in the centre of the neck and head using 135° angle-guide (retrospectivey confirming the neck shaft angle to be around 135°). At 3 years follow up (Fig. 4e, f), this patient is having a good outcome and there is no implant failure. In all 20 cases of polio limbs in our study, the neck shaft angle was high, with a mean of 135.85°.

Fig 4a: Pre-operative X-ray

Fig 4b: Pre-op 3D reconstruction

Fig 4c: Pre-Op templating

Fig 4d: Post-operative Xray

Fig 4e: 3 years follow up X-ray

Two out of the five cases having fractures of shaft of femur in our study, had shaft diameters of 9mm or above, with length more than 360mm. In these cases, standard interlocking intramedullary femoral nails could be used as the minimum available standard femoral nails are 9mm and above in diameter, and 340mm or above in length. In one case, the diameter of the femoral shaft was 8mm and femoral length was 380mm (Fig. 5a, b) . For this case, regular nails could not be used. So, custom made nails of 340mm x 8mm and 360mm x 8mm were made available. The custom-made 360mm x 8mm nail was used intra-operatively (Fig. 5c, d). At 5 years follow up (Fig. 5e), the patient is doing well. In one case the shaft diameter was only 7mm and the femur length was 320 mm. We could not measure the anterior bowing in this case so we had custom implant of 7mm x 300/320mm. We also made available humerus nail of sizes 6mm and 7mm diameter. After closed reduction, we noticed that there was no anterior bowing of the femur. So we could insert only the humerus nail which is straight without any anterior curvature. In one case as the canal was very narrow (diameter 7mm) and the piriform fossa was not clearly palpable intraoperatively. Due to a risk of intra-operative neck fracture (while making the entry point for nailing), an open reduction with broad LCP was chosen and performed. For this case also, custom made nails and humerus nails were made available but only plating was possible due to reasons mentioned above.

Fig 5a: Pre-operative Xray

Fig 5b: Post-op Xray

Fig 5c: Post-op X-ray

Fig. 5d: 5 years follow up

Three out of eight cases in our study with condylar fractures of the femur could be managed with standard distal femoral LCP. Of the remaining five cases (Fig. 6a, b), the anteroposterior diameters were 28mm, 31mm and 32mm, 30mm, 31mm

respectively, a standard distal femoral LCP (AP diameter 32mm) would overhang and there is also a risk of screw penetration into the joint. Hence, in three cases, we used locking proximal humerus plate (LPHP) (Fig. 6c, d, e) which has a width of 20mm and in two cases, a proximal tibial LCP (with AP width of 24mm) was used. Minimal contouring of the humerus and tibial plates were done to match the femur of the polio limb.

Fig 6a: Pre-op Xray

Fig 6b: Pre-op Xray

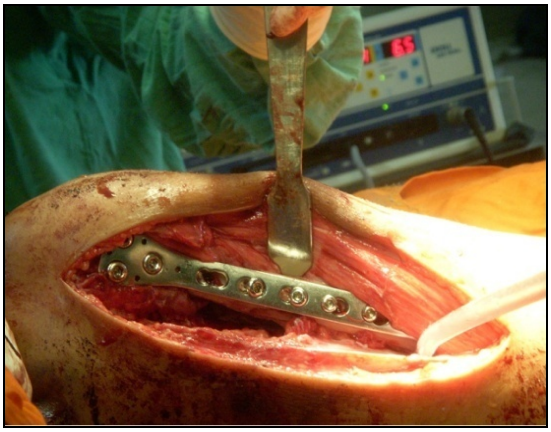

Fig 6c: Intra-operative photograph

Fig 6d: Post-operative X-ray

Fig 6e: 4 years follow up X-ray

One case in our study had a segmental fracture of femur, with one fracture at the supracondylar level and the other fracture at the level of proximal shaft. For this case, since the supracondylar fracture was more distal and medullary canal diameter was 7mm, and cannot accomodate antegrade intramedullary nail, a 'divide and rule' policy was used, wherein a narrow LCP was applied for the proximal shaft fracture and a locking proximal humerus plate was used for the condylar fracture. A similar case was reported by Rajan et al [9] wherein a long 95° angled blade plate was used. The canal diameter was so narrow that an intramedullary nailing was not possible.

According to Nam *et al.* [6], factors such as female sex, elderly age group, low bone mineral density, weak muscle strength of knee extensor and poor balance confidence were not significantly associated with falls. Only leg-length discrepancy was a significant factor associated with falls in Korean polio survivors. Malalignment between the affected and unaffected limb length is the key factor contributing to falls in polio survivors.

Poliomyelitis is usually associated with muscle contractures.

In our study, any attempt to correct these soft tissue contractures has not been done. Only minimal release of soft tissues, as required for fracture reduction was done wherever necessary.

Out of 20 patients, 2 patients had a deterioration of Vignos score. 90% of patients reverted to their pre-operative functional level after surgery. Mean per-operative Vignos score was 4.15 and mean post-operative Vignos score was 4.25. Mean time for bony union was 4.63 months.

Good functional outcome and radiological union was achieved using suitable implants matching the altered geometry.

5. Conclusion

No implant is unique for surgical management of femur fractures in post-polio residual paralysis patients. Proper pre-operative evaluation and planning should be individualised for each case according to the measured femoral geometry. The best implant should be chosen and a wide array of implants should be made available during surgery to achieve good results.

6. References

1. 7th Meeting of the South-East Asia Regional Certification Commission for Polio Eradication (SEA-RCCPE) - New Delhi, India, 26-27 March 2014; World Health Organization. Polio-free certification: WHO South-East Asia, 2014.
2. Narayan A, Ganesan S, Shenoy UV, Narayanan E. Provocative poliomyelitis causing postpolio residual paralysis among select communities of two remote villages of North Karnataka in India: A community survey. Indian journal of public health. 2011; 55(4):309.
3. Chang KH, Lai CH, Chen SC, Tang IN, Hsiao WT, Liou TH, *et al*. Femoral neck bone mineral density in ambulatory men with poliomyelitis. *Osteoporosis international*. 2011; 22(1):195-200.
4. Khalil AES. Locked plating for femoral fractures in polio patients. Archives of orthopaedic and trauma surgery. 2010; 130(10):1299-1304.
5. Wang WJ, Shi HF, Chen DY, Chen YX, Wang JF, Wang SF, Xiong J. Distal Femoral Fractures in Post-poliomyelitis Patients Treated with Locking Compression Plates. Orthopaedic surgery. 2013; 5(2):118-123.
6. Nam KY, Lee S, Yang EJ, Kim K, Jung SH, Jang SN, Lim JY. Falls in Korean polio survivors: incidence, consequences, and risk factors. Journal of Korean medical science. 2016; 31(2):301-309.
7. Bickerstaffe A, Beelen A, Nollet F. Circumstances and consequences of falls in polio survivors. Journal of rehabilitation medicine. 2010; 42(10):908-915.
8. Suresh Babu S, Suresh Babu TV, Kopuri Ravi Kiran G, Sudhakar MUSK, Sridevi. Difficulty in Fixation of Fracture Neck of Femur in a Paralytic Hip: A Case Report. Journal of Evolution of Medical and Dental Sciences. 2014; 3(30):8484-8489.
9. Rajan Sarad, Rajan Sharma, Raj Kumar Aggarwal. Segmental Fracture of Proximal Shaft Femur of Polio Affected Paralytic Limb Treated with 95 Degree Angled Plate Fixation by MIPO Technique. Journal of Evolution of Medical and Dental Sciences. 2014; 3(61):13628-13631.