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Research Article

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Outcomes of Distal Femur Fractures Treated with Retrograde Indigenous Intramedullary Supracondylar (IMSC) Nailing

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Abstract

Introduction

Fractures of the distal femur are complex injuries that pose a challenge to orthopaedic surgeon. Significant advances have been made in treatment of these fractures. Out of various options for surgical treatment, retrograde intramedullary nailing has several benefits compared to other methods of fixation. Amongst the routinely available IMSC nails which have a specific design, we used an indigenous IMSC nail with unique design.

Materials And Methodology

We conducted a retrospective study among 40 patients with distal femur fractures treated with this indigenous IMSC nail in our institute from May 2019 to October 2021. The patients were followed up in outpatient department till June 2022. Data was retrieved from case record forms and hospital information computer software. The study was conducted after obtaining permission from institutional review board.

Results

All the patients in our study were assessed using knee society score and functional knee score. Average knee society score at final follow up was 88.75/100 and average functional knee score at final follow up was 86.50/100 which showed excellent results. The results were better for extra-articular fractures. Average operative time, blood loss, time for radiological union and rate of complications were considerably less.

Discussion

Retrograde intramedullary nailing has been developed in order to address previous problems associated with distal femur fracture fixation. It has several advantages over plate fixation. Indigenous IMSC nail used in our study has added benefits over the routine IMSC nail due to its structure, number of screw holes in the distal part of nail, alignment of screw holes inside nail and unique thread design of the screws. Thus, it provides multi-planar fixation of fracture rather than in only one plane as achieved by routine IMSC nail giving excellent rotational stability to bone-implant construct.

Keywords: Retrograde nailing, indigenous IMSC nail, knee Society score, functional knee score

Introduction

Fractures of the distal femur are complex injuries that pose a challenge to the orthopaedic surgeon. The estimated frequency is around 0.4% of all the fractures and 3% of femur fractures [1]. The overall incidence of distal femoral fractures is approximately 8.7/100,000 / year [2]. It can result from high energy injuries in

young adults and are associated with concomitant injuries. In contrast, elderly patients with severe osteopenia might sustain solitary distal femoral fractures from trivial trauma.

Significant advances have been made in treatment of these fractures in the last three decades. In 1967, Neer classified the supracondylar fractures of femur and advised conservative management [3]. However operative fixation has been preferred due to its ability to maintain anatomical reduction of the joint surface and early range of motion presenting clear advantages over closed means of treatment.

In 1987, the AO Foundation published Muller AO classification which divided distal femoral fractures into 3 types, according to the localization of the fracture [4]. Muller AO/OTA (Orthopaedic Trauma Association) classification is the most commonly used fracture classification system for distal femur fractures5.

Fixation with a lateral blade plate or its modifications became popular because it allowed fixation of fractures of intra-articular type. Use of plate requires significant soft tissue stripping, which can affect the union and poses a risk of infection. Intramedullary implants offer potential biomechanical advantages over plate and screws. However, the use of antegrade intramedullary nail in the treatment of distal femoral fractures has been associated with angular deformities because of the inability of distal lock of antegrade nail to achieve control of the small distal fracture fragment. Thus, out of the various options for surgical treatment, retrograde intramedullary interlocking nailing has several benefits compared to other methods of fixation which has made it a popular choice of implant.

Amongst the routinely available IMSC nails which have a specific design, we used an IMSC nail with a unique design which gives better fixation and improved stability compared to the routine IMSC nail. This indigenous IMSC nail has been developed to offer better stability to fracture fixation and in order to treat the complex distal femur fractures which are difficult to treat using the routine IMSC nail. Several studies have been done to evaluate the role and efficacy of supracondylar nailing in the recent times showing variable results but the purpose of this study was to determine the clinical and radiological outcome in the management of distal femoral fractures with this indigenous intramedullary interlocking nail.

Materials And Methodology

We conducted a retrospective study among 40 patients with distal femur fractures treated with retrograde nailing with this indigenous intramedullary supracondylar nail in our institute from May 2019 to October 2021. The patients were followed up in outpatient department till June 2022 and data was retrieved from the case record forms and hospital information computer software.

Inclusion criteria for selection of patients were : 1) Patients with distal femur fractures including the supra-condylar and inter-condylar fractures, 2) Patients with closed fracture and open grade-1 fracture, 3) AO type A1 A2 & A3 fractures and AO type C1 C2 fractures, 4) Non-united distal femur fractures, 5) Distal femur fractures extending into shaft of femur, 6) Distal femur fractures associated with ipsilateral shaft femur fracture, 7) No associated vascular injury, 8) No active clinical infection at operative site, 9) Patients greater than 18 years of age.

Exclusion criteria for the patients were: 1) Patients with open grade 2 and 3 fracture, 2) AO type B1 B2 & B3 fractures and AO type C3 fractures 3) Fractures associated with vascular injury that requires amputation, 4) Associated patella fracture, 5) Fractures with epiphyseal plate open, 6) Pathological fractures, 7) Patients lost to follow up, 8) Patients with active infection at the operative site.

In our institute standard preoperative workup included radiographic evaluation using standard antero-posterior and lateral radiographs of femur and knee along with routine blood and related laboratory investigations. All the patients were preoperatively managed with skin traction or skeletal traction until they were taken up for surgery. CT scan of the distal femur was done wherever necessary, to know about the extent of intararticular communition of fracture. Preoperative medical and anesthetic assessment was also done for each patient.

Patient is positioned on simple radiolucent table in supine position with knee in 30-degree flexion. Around 4cm longitudinal skin incision is made just distal to the inferior pole of patella. The patellar tendon is retracted laterally. Proper localization of the entry point is very important. Under IITV guidance on the AP view, the guide wire should be in the centre of inter-condylar notch and on the lateral view it should be located in the extension of Blumensaat's line. The entry point of the nail should be parallel to the axis of femoral medullary canal. After achieving acceptable reduction, guide wire is inserted and the medullary canal is opened using the cannulated drill bit. Appropriate size of nail is inserted. 4 distal screws are inserted through jig into multi-planar screw holes of the nail to achieve compression. Washer and nut mechanism can be used in osteoporotic bones. One or two proximal locks can be done through stab incisions according to the requirement. Proper closure is done after thorough wash. The minimum length of the nail used was two times the fracture length.

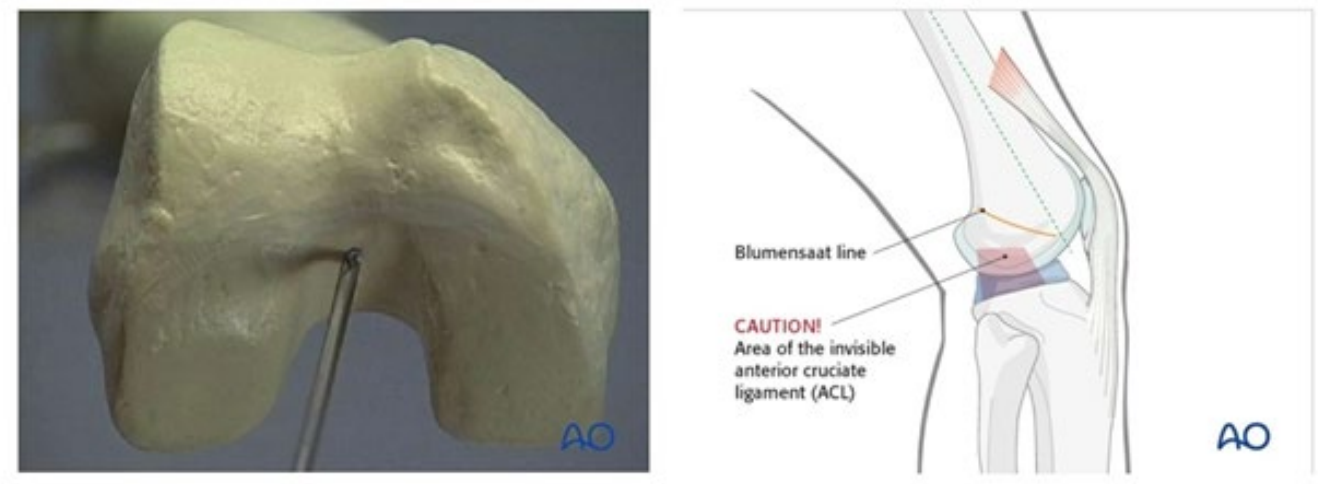

Figure 1[6]: Entry point for retrograde IMSC nailing

Post-operative protocol included intravenous antibiotics given for 48-72 hours followed by oral antibiotics. Post-operatively above knee slab or brace was given along with elevation. On the day after surgery static quadriceps exercises and ankle toe mobilization exercises were started. On every 3rd day suture line dressing was done and sutures were removed after 14 days of surgery. Slab was removed after 5-6 weeks and gradual knee bending was started along with other muscle strengthening exercises. Gradual supported weight bearing was started after around 10 weeks followed by walking without support and climbing stairs. Serial radiographs were done at regular intervals to evaluate osseous union. Patient was followed up every week for 1 month and after that every 15 days for next 2 months. After 2 months patient was assessed in each follow up every month till 14 months post operatively.

The results were determined after evaluation of patients based on following clinico-radiological parameters; 1) Fracture pattern according to the Muller AO/OTA classification, 2) Soft tissue condition at the time of admission, 3) Operative time (starting from skin incision to skin closure) and blood loss, 4) Complications, 5) Radiological union in weeks using serial Xrays, 6) Knee society score and functional rating score at each follow up.

Knee Society score includes parameters like pain (0-50 points), total range of flexion (1-25 points), stability (0-25 points), flexion contracture (if present -5 to -25 points), extensor lag (if present -5 to -15 points) and alignment (varus/valgus - 0 to -15 points). It has a maximum of 100 points. Functional knee score includes range of walking, walking with or without support and ability to climb stairs. It has a maximum of 100 points.

Knee Society Score

KNEE SOCIETY RATING	Points	Patient Score
Pain (50 Points)		
None	50	= 50
Mild or occasional	45	
Stairs only	40	
Walking and stairs	30	
Moderate occasional	20	
Moderate continual	10	
Severe		
Range of Motion 5 degrees = 1 Point	25	= 25
	0	
Anteroposterior Stability (maximum movement in any position)		=10
<5 mm	10	
5-10 mm	5	
10 mm	0	
Medial lateral Stability		= 15
<5 degrees	15	
6-9 degrees	10	
10-14 degrees	5	
15 degrees	0	
Deductions		= 0
Flexion contracture		
5-10 degrees	2	
10-15 degrees	5	
16-20 degrees	10	
>20 degrees	15	
Extension lag		
<10 degrees	5	
10-20 degrees	10	
>20 degrees	15	
Alignment		
5-10 degrees	0	
0-4 degrees	3 points each	
11-15 degrees	3 points each	
Other		

Knee society score grading

< 60 Poor
60-69 Fair
70-79 Good
80-100 Excellent

Figure 2[7]: Knee society score

Knee Society Score

Function Rating	Points	Patient Score
Walking		= 50
Unlimited	50	
>10 blocks	40	
5-10 blocks	30	
<5 blocks	20	
Housebound	10	
Unable	0	
Stairs		= 50
Normal up and down	50	
Normal up, down with rail	40	
Up and down with rail	30	
Up with rail, unable down	15	
Unable	0	
Deductions		= 0
Cane	5	
Two canes	10	
Crutches or walker	20	
Score		
Knee Rating=100		
Function=100		
(Adapted from: Insall JN, CORR 1989;248:12)		

Functional knee score grading
< 60 Poor
60-69 Fair
70-79 Good
80-100 Excellent

Figure 3[7]: Functional knee score

Results

Epidemiology

Out of 40 patients in our study, 28 patients (70%) were male and 12 (30%) were female. Age distribution varied from 19 years to 65 years with most common age group being 35-45 years. 22 (55%) out of 40 patients had right sided fracture and 18 (45%) had left sided fracture.

Mode of injury

The mode of injury in majority cases (26) was Road Traffic Accident (65%). 12 patients (30%) had associated injuries other than distal femur fracture. 2 patients had peri-prosthetic fracture.

Fracture pattern according to Muller AO/OTA Classification

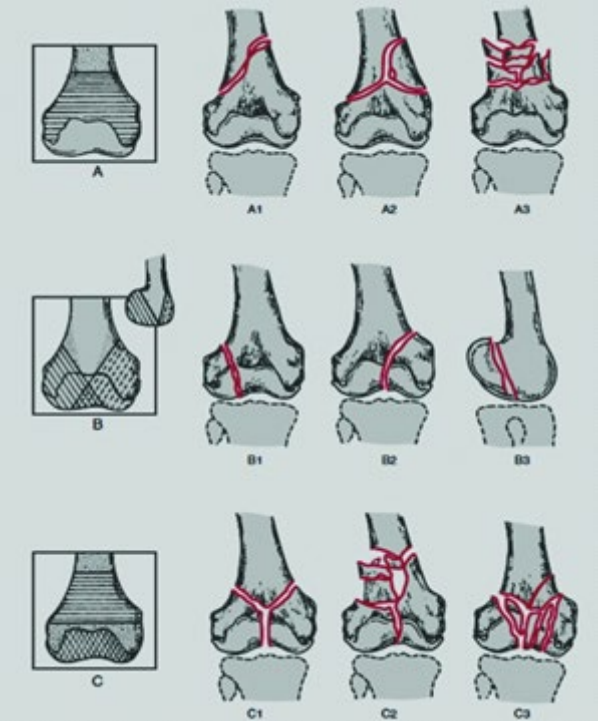

Figure 4[8] : Muller AO Classification

The patients were classified according to Muller AO/OTA Classification. Out of 40 patients in our study, 16 patients (40%) had 33-A1 type of fracture pattern, 8 patients (20%) had 33-A2 type, 6 patients (15%) had 33-A3 type, 8 patients (20%) had 33-C1 type and 2 patients (5%) had 33-C2 type of fracture pattern. Overall 30 patients (75%) had extra-articular fracture and 10 patients (25%) had intra-articular fracture. Results according to knee society score and functional knee score were excellent for patients with extra-articular fractures (30 patients) and for intra-articular fractures the results varied. Out of 10 patients with intra-articular fractures, 2 patients had excellent result, 7 patients had good results and 1 patient had poor result.

Operative time

Average operative time was around 90 minutes which was less compared to usual operative time in distal femur plating.

Complications

Out of 40 patients, 3 patients (7.5%) had knee pain while walking at the final follow up which was relieved by analgesics. Knee stiffness was found in 3 patients (7.5%). Average knee flexion was around 90 - 120 degrees, which is better than degree of flexion achieved by plate fixation. 1 patient (2.5%) had superficial infection which was managed with regular dressings and antibiotics. None of the patients had deep infection and none of them needed implant removal. 1 patient (2.5%) had delayed union which was treated with dynamization through proximal screw removal and PEMF (Pulsed electromagnetic therapy). Limb shortening was not seen in any of the patients.

Table 1: Complication rate

COMPLICATION	NUMBER OF PATIENTS
Knee pain	3 (7.5%)
Knee stiffness	3 (7.5%)
Superficial infection	1 (2.5%)
Deep infection	0
Delayed union	1 (2.5%)
Limb shortening	0

Radiological union in weeks

Average time for radiological union was 10-12 weeks.

Knee society score and Functional knee score

Average knee society score of 40 patients at final follow up was 88.75 out of 100 which showed excellent results. Average functional knee score at final follow up was 86.50 out of 100 which showed excellent results.

Table 2: Results based on knee society score

RESULTS BASED ON KNEE SOCIETY SCORE	NUMBER OF PATIENTS
Excellent (80-100)	32
Good (70-79)	7
Fair (60-69)	0
Poor (<60)	1

Table 3: Results based on functional knee score

RESULTS BASED ON FUNCTIONAL KNEE SCORE	NUMBER OF PATIENTS
Excellent (80-100)	31
Good (70-79)	8
Fair (60-69)	0
Poor (<60)	1

Discussion

The distal femur is defined as the region from the metaphyseal-diaphyseal junction to the articular surface of the knee, involving approximately the distal 15 cm of the femur [9]. The deforming unbalanced forces in a distal femur fracture cause the fracture fragment to go into varus. This varus displacement can be effectively corrected and stabilized by anatomical retrograde supracondylar nailing.

Previously stabilization was usually achieved with an angled blade plate, fickle devices, rush rods, Ender nails, dynamic condylar screw and locking compression plate. Regardless of the method of fixation, the principles of internal fixation must be met in all cases. These include anatomical reduction of the articular surface of distal femur, stable internal fixation with restoration of axial and rotational alignment, minimal soft tissue stripping and early active mobilization.

Retrograde intramedullary nailing has been developed in order to address some of the previous problems associated with distal femur fracture fixation. The supracondylar intramedullary nail was developed by Henry SL, Green. S, Seligson and manufactured by Smith & Nephew Richards, Memphis, TN in 1988. It is a load sharing device which helps in directing compressive forces to fracture site which imposes less stress on the implant and imparts stability to bone-implant construct.

Henry et al. in 1991 reported that due to its intramedullary position, nail has a bio mechanical advantage over laterally placed conventional devices [10]. The intramedullary position decreases the lever arm, reducing varus or valgus angulations. He found plate & screws were stiffer in lateral bending and in tension than a supracondylar nail and concluded that supracondylar nail had comparable biomechanical rigidity to condylar screw & plate with varus loading.

Retrograde IMSC nailing has several advantages over plate fixation; 1) It reduces soft tissue dissection and periosteal stripping as it can be inserted via a closed technique thus preserving the fracture hematoma, which is a major factor affecting rates of union and infection, 2) It can be inserted using smaller incision which leads to minimal scarring post operatively along with lesser surgical site morbidity 3) Operating time is reduced, 4) It reduces overall blood loss, 5) Advantages of its intramedullary position offering biomechanical advantages like load sharing, 6) IMSC nail is introduced in anatomical axis which gives better alignment to the fracture fragments, 7) It imparts better torsional stability than plate fixation, 8) Medial parapatellar approach used, permits direct visualization of the articular surface facilitating an anatomical reduction of fracture fragments and allowing subsequent reconstructive procedure, 9) Range of motion achieved via IMSC nail is better than plate because of post-operative adherent scar due to longer incision which affects extensor mechanism 10) Simultaneous treatment of other ipsilateral shaft femur fracture, 11) Less technically demanding procedure.

Indigenous IMSC nail used in our study has added advantages over the routine IMSC nail due to its structure, number of screw holes present in distal part of the nail, alignment of screw holes inside nail and unique thread design of the screws. This nail is longer than the routinely available IMSC nails and it has an anatomical curvature similar to that of femur so it fits perfectly into the femoral canal and no incidence of thigh pain due to nail impingement over cortex was seen. Due to longer nail size, the nail crossed the isthmus of femur and thus it fitted snugly inside the bone giving the required stability. There are 4 screw holes in the distal lock region compared to the 2 screws holes in routine IMSC nail. Moreover, the screw holes are aligned in different planes, 2 screw holes in medio-lateral plane and 2 screw holes in the oblique plane. This type of alignment of screw holes provides multi-pla-

nar fixation of fracture rather than in only one plane as achieved by routine IMSC nail. This multi-planar fixation provides excellent rotational stability to the bone-implant construct which was assessed by limb alignment in post operative period and during follow up visits. The thread design of the screws is such that the pitch is different at both ends of the screw, thus during screw insertion this thread design gives better compression to the fracture fragments than the routine IMSC nail screws. The washer and nut mechanism of screw is particularly used for achieving compression in osteoporotic bones. Overall stability and results achieved with this indigenous IMSC nail were found to be superior to those achieved with routine IMSC nail.

Figure 5: Peri-prosthetic fracture (pre-operative Xray)

There are also some demerits of IMSC nail like need for a repeat arthrotomy in patients requiring nail removal and anterior knee pain in some patients, but the benefits of retrograde IMSC nailing outweigh the demerits significantly. Synovial metallosis resulting from nail fretting or breakage has been rarely reported.

Acharya et Rao reported a prospective series in 28 patients treated with retrograde nailing with union in 93%, malunion in 10% and excellent or good functional results in 85% of cases [12]. For Thompson et al., statistical results for the rate of surgical revision and the rate of malunion are better for retrograde intramedullary nailing [13]. Hierholzer et al. confirmed these results in a retrospective series of 115 fractures comparing retrograde nailing (n = 59) and mini-invasive locking plate (n = 56) [14].

One of the extended indications of retrograde nailing is peri-prosthetic fracture fixation. The incidence of distal femur fractures following total knee arthroplasty is increasing [11]. The integrity of the prosthesis determines treatment of these complex injuries. If the prosthesis is stable, treatment options are open reduction and internal fixation or retrograde nailing. If the prosthesis is loose, revision arthroplasty with stemmed prosthesis is the most suitable option. In our study 2 patients had distal femur fracture on the same side where total knee arthroplasty was done and they were successfully treated with retrograde IMSC nailing.

Figure 6: Fracture fixation using retrograde IMSC nail (post-operative Xray)

Table 4: Comparison of results and complication rate of standard studies with our study

STUDY	RESULTS (%)	COMPLICATION RATE (%)
Acharya et Rao[12]	93%	10.71%
Gellman et al[15]	91.66%	8.33%
Handolin et.al[16]	89.13%	8.69%
Iannacone .et.al[17]	92.10%	12.19%
Our study	97.50%	7.5%

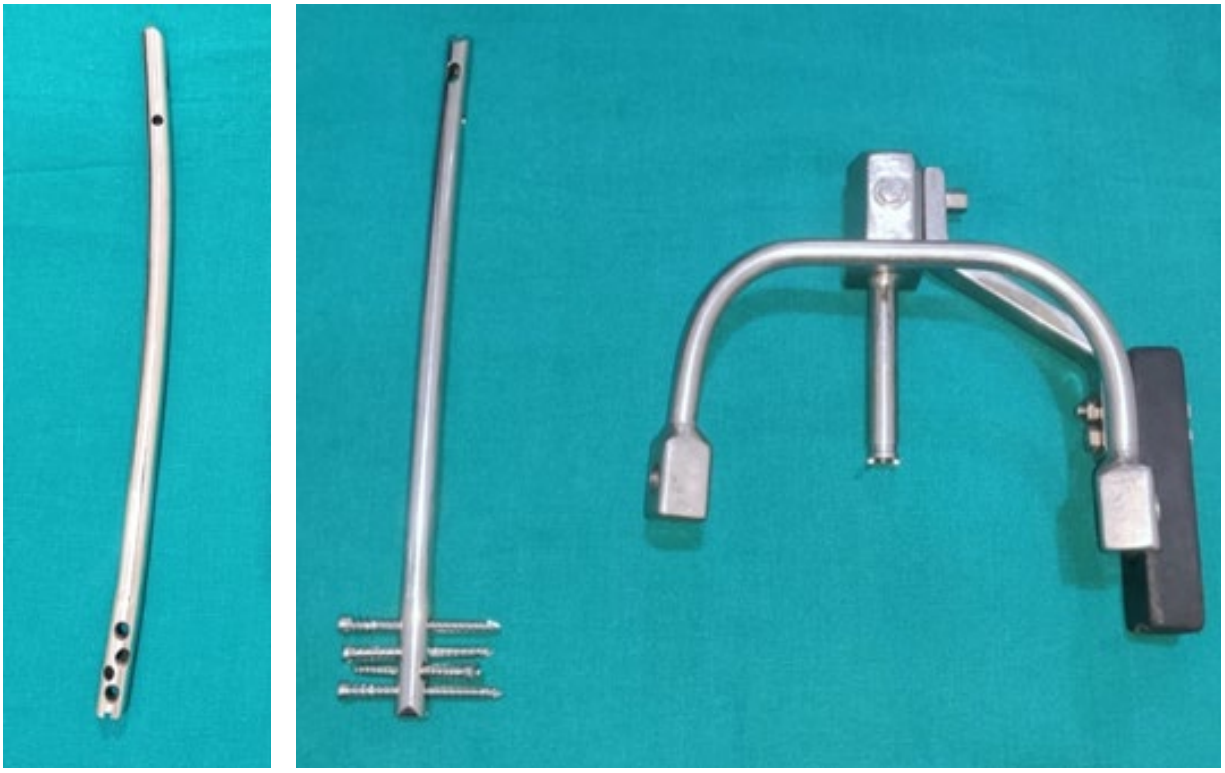

Figure 7: Indigenous IMSC nail used in our study with jig and screws

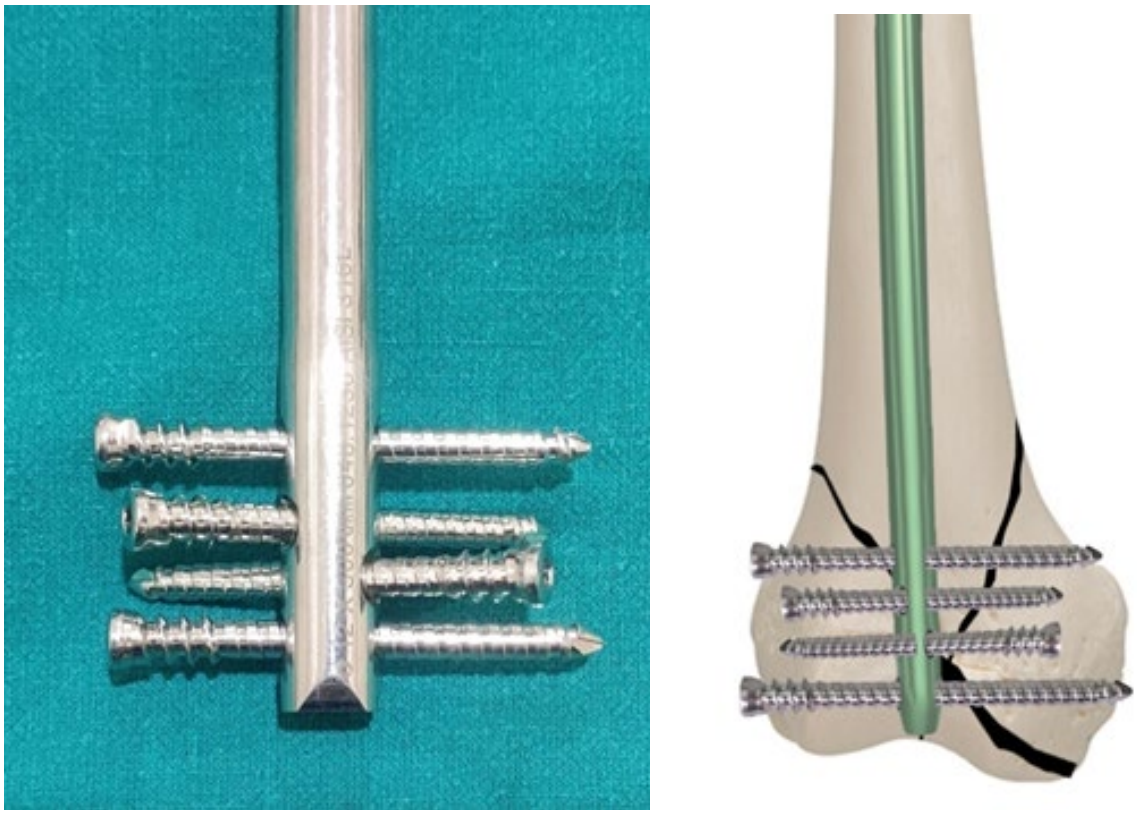

Figure 7: Multi-Planar Arrangement of Distal Locking Screws

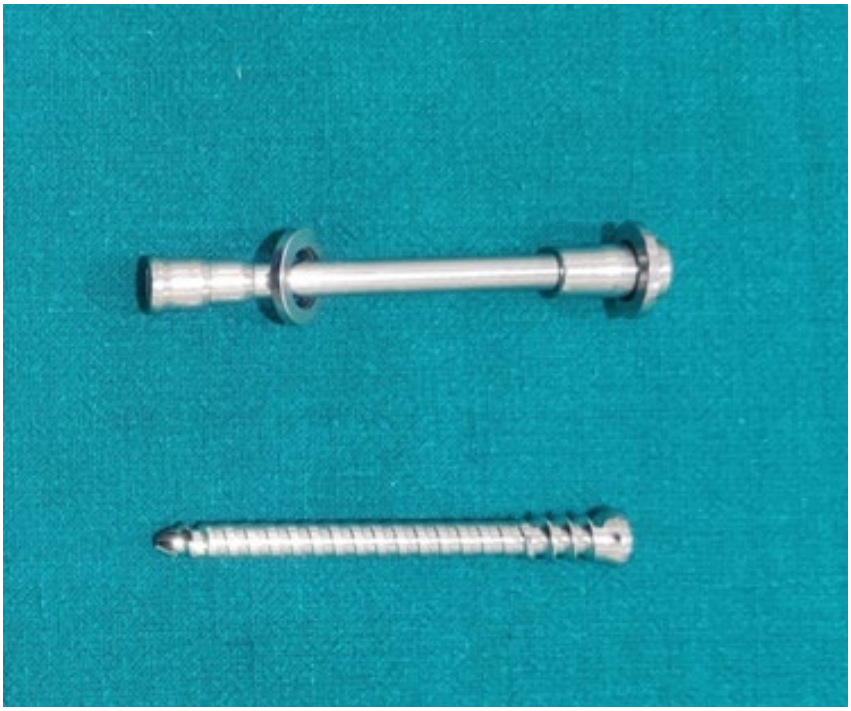

Figure 9: Unique screw design having different pitch in proximal and distal part of screw and screw with washer and nut mechanism

Case

A 67-year-old male patient sustained distal femur fracture (Muller AO/OTA 33-A3) on left side (Figure 7). He was operated with indigenous IMSC nail as shown in immediate post-operative Xray (Figure 8). Xray image in figure 9 shows 9 months follow up Xray with normal alignment and anatomy of distal femur.

Figure 10: Pre-Operative XRAY

Figure 11: Immediate Post-Operative XRAY

Figure 12: 9 Months Follow Up XRAY

Clinical Pictures

Conclusion

From this study we conclude that in distal femur fractures AO/OTA type 33-A1, A2, A3, C1 and C2, use of this indigenous retrograde Intramedullary Supracondylar (IMSC) nail gives better results in terms of functional outcome and radiological union with less complications and added advantages.

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