

Original Research Article

Management of infected supracondylar femoral nonunion with bone loss by primary knee arthrodesis with hybrid Ilizarov frame: a study of 10 cases

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ABSTRACT

Background: Most of infected nonunion supracondylar femur with bone loss is a challenge to orthopedicians, where amputation is one of the choice. Opinions are divided on the appropriate management of infected nonunion supracondylar femur with bone loss. Evidence supports for both, osteosynthesis with or without salvaging knee joint and above knee amputation.

Methods: 10 consecutive patients at Nizam's Institute of Medical Sciences, from Jan 2013 to December 2016, who underwent limb salvage with knee arthrodesis for infected nonunion supracondylar femur with bone loss were evaluated and followed till union. Treatment option in the form of osteosynthesis with knee arthrodesis was achieved with hybrid Ilizarov fine wire fixator. The hybrid Ilizarov frame comprised of conventional two ring tibial frame and one ring and one Italian arch in the femoral segment with half treaded pins, this construct was chosen because of less weight, less cumbersome without compromising the stability and basic features.

Results: All patients went for solid knee arthrodesis in functional position, with a mean fusion time of 22.4 ± 4.97 weeks. The time interval between primary surgery and definitive treatment was 15.6 ± 6.37 weeks. The mean shortening of lower limb was 3.1 ± 1.19 cms. To achieve arthrodesis quickly, it's necessary to have light weight, compact Ilizarov frame, have good bone to bone contact and allow early full weight bearing.

Conclusions: Osteosynthesis with knee arthrodesis in cases of infected nonunion supracondylar femur with bone loss is a viable option in select cases where the patient is physiologically young, has undergone several procedures around the knee and the knee is stiff. Fusion of the knee enables quick restoration of the patient to his work place.

Keywords: Infected supracondylar femur nonunion, Hybrid Ilizarov frame, Knee arthrodesis, Bone grafting

INTRODUCTION

Knee arthrodesis once performed often for infective gonarthrosis of knee has been sparse.¹ There is a paradigm shift towards knee arthroplasty from knee arthrodesis, once the disease becomes quiescent, because of early diagnosis, availability of powerful medications against tuberculosis and pyogenic infections, better prosthetic knee designs, and development of better

surgical techniques. With innovations in fracture fixations, comminuted fractures are also being salvaged and osteosynthesis is being performed. Despite these advancements and innovations, more and more high energy motor vehicular accidents are striking, leading to a cohort of patients developing infected nonunions with bone loss, where osteosynthesis is not possible without forgoing the knee joint and knee arthrodesis is thought of as a limb salvage attempt. However, the leading

indication of knee arthrodesis today remains the infected non-salvageable prosthetic knee joint, which is not amenable to further reconstructive measures.^{2,3} The advantage of knee fusion in such post traumatic post infected non-unions enables the patient to ambulate quickly, gives painless stable knee with proprioceptive features.

In cases of infected supracondylar femoral nonunions with bone loss, the main goal is to alleviate pain, eradicate the infection, achieve stability, and lead them for bony continuity. As the knee joint is the largest joint in the body, with lot of mobility, so, for fusion to occur it needs stability, vascularity and osteoinductive material. The issues here are infection, bone loss, instability and poor soft tissue envelope, unless these issues are identified and taken care the knee fusion will not occur. To address all these issues, Ilizarov frame appears to be savior. The greatest advantage of Ilizarov frame is it gives rotational stability, axial loading, and static and dynamic compression across the knee which is most essential for the fusion of the knee. The same may not be able achieved by plate or nail or what so ever internal fixation devices especially in the back drop of infection.

METHODS

This is retrospective study with prospective analysis performed at Nizam's Institute of Medical Sciences, Hyderabad, Telangana. 10 consecutive cases infected supracondylar femoral nonunions with bone loss from Jan 2013 to December 2016, where osteosynthesis with knee arthrodesis was performed were included in the study and evaluated. Osteosynthesis with knee arthrodesis is offered to young patients of infected nonunion supracondylar femur with bone loss who have undergone multiple bony and soft tissue procedure where the knee is stiff, beyond salvageable. The decision of arthrodesis of knee was based on the duration of delay in presentation, number of previous surgeries, soft tissue envelope around the knee, preoperative skeletal malalignment, bone deficiency in the condyles of femur and intra operative findings of moderate to severe bone loss, rotated, fixed condyles due to fibrosis and associated severity of osteoporosis, where the definitive fixation will yield poorer results than knee arthrodesis. In every nonunion, osteosynthesis with salvage of knee joint was thought of and judicious decision of arthrodesis was taken based on the above findings, with a well-informed consent from the patient (Figure 2 A-F). As these procedures are very rare and occasionally performed in few, so it was not applied for statistical analysis (Table 1).

Preoperative evaluation and optimization of patient

The patient is thoroughly evaluated for the presence of systemic comorbidities, like anemia, diabetes, vitamin D deficiency, generalized osteoporosis, and peripheral vascular diseases. Smokers strictly should stop smoking

as it has detrimental to bone healing. In loco regional examination, the presence of infection, the draining sinuses, the scars and the skin status is important for proper planning of the definitive procedure (Figure 1). The abnormal mobility should be demonstrated in two planes. The limb alignment like varus deformity, valgus deformity, and rotational malalignment with the exact shortening should be noted. The status of other joints like ankle and contralateral knee should be recorded as these patients are non-ambulatory from a long time. Ipsilateral moderate to severe equinus deformity has a negative impact on the postoperative ambulation as it inhibits normal ambulation and tends to push the knee joint into recurvatum. The neurovascular status as nerve injuries, arterial insufficiency venous insufficiency should be noted and treated accordingly before the definitive procedure. Hematological parameters like CRP and ESR should be taken and recorded as these parameters have prognostic value. Special emphasis should be taken to obtain cultures from the deepest part of the draining sinus, as the organism sensitive antibiotics will help in eradication of the infection. Radiographs of the knee with the entire thigh and proximal leg both in sagittal and coronal translateral plane in preferable 17'×14' cassette to be taken as that gives us the idea of bone alignment, density, sequestra, bone loss and the status of hardware position of the previous surgeries. Before the definitive procedure, the patient is optimized for the systemic comorbidities and organism specific antibiotics are given by oral route for a minimum period of 14 days.



Figure 1: Clinical imaging showing extensive soft tissue injury.

Surgical technique

The surgical procedure was accomplished in three stages.

Debridement

The patient is operated in regional anesthesia, in supine position on a radiolucent table. A sand bag is kept under

the ipsilateral hemipelvis so that the anterior iliac crest is prominent, which aids in harvesting corticocancellous bone from the crest. The entire lower limb including the ipsilateral iliac crest is prepped and draped. Use of a sterile tourniquet is optional, in majority of our cases we haven't used sterile tourniquet. The incision to approach the supracondylar nonunion is dictated by the presence of previous surgery hardware, soft tissue integrity & viability, tenacious soft tissue of poor healing capacity should be avoided in the incisions. If the implants are

there then the implant exit is performed by the previous approach. The same incision is extended distally over the anterior aspect of femoral condyles to expose the condyles. Care is taken to keep the dissection straight up to the bone and not to raise flaps or create fascial planes and remove the entire articular cartilage remnants, sequestra, and the fibrous tissue. The fibrous tissue is excised gently and carefully as it may be adherent to the neurovascular bundle posteriorly.



Figure 2: a=Radiograph showing comminuted supracondylar # femur with crushing of condyles with bone loss; **b=**showing the # stabilized with rush rod; **c=** stabilization with external fixator; **d=**intraop image showing extensive bone loss with deficient condyles; **e=**showing definitive fixation by ilizarov fixator, & clinical image; **f=**showing the definitive knee fusion.



Figure 3: a= radiograph showing pubic rami #, displaced sub trochanteric # comminuted # distal femur & proximal tibia #s; **b=** radiographs showing the #s are fixed with external fixator & rush rods; **c=** radiographs showing infected gap nonunion distal femur and proximal tibia; **d=** radiographs showing the same # with ilizarov fixator; **e=** showing the final knee arthrodesis in sound position; **f=** showing the clinical images with the extensive soft tissue injury.

The important issue is how we handle the patello femoral joint. In cases where the patellofemoral joint is healthy and the wound closure is not a problem and then the articular surface of patella is denuded, retracted laterally, knee flexed, and the denudation of articular cartilage is performed and knee joint fused. In those cases where the patellofemoral joint is infected, or associated with patellar fractures or with compromised soft tissue envelope anteriorly, then the patella is enucleated, keeping the entire soft tissue intact and at the end of the procedure, quadricepsplasty is performed. The advantages of restoring the continuity of extensor apparatus is, it prevents the quadriceps muscle from retraction and gives contour to knee, preserves vascularity to distal femur and soft tissues, gives support to bone grafts anteriorly, prevent wound dehiscence gives anterior dynamic compression to the arthrodesis site, leading to early global fusion across the knee, and does not burn the bridges for future total knee arthroplasty.

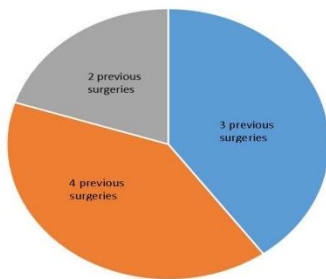


Figure 4: Pie diagram showing the number of previous soft tissue and bony surgeries before the definitive procedure.

The knee joint is now flexed completely and meticulously the articular cartilage of proximal tibia is denuded, keeping the thick subchondral bone intact. This thick subchondral bone helps in holding the tensioned wires and helps in approximation of bones on manual compression of Ilizarov frame. The tibiofemoral surfaces are made flat with minimal bone debridement giving maximum surface area for tibiofemoral apposition. Thorough debridement including the medial lateral gutters and the posterior aspect is performed. Usually, in the posterior aspect pockets of pus, sequestra and abscess are hidden due to long standing non-ambulatory status of patient.

Harvesting of bone graft

The instruments, suction and the electrocautery used for graft harvesting preferably should be separate and the trolley should be away from the contaminated instruments used for the knee work, preferably a double set up principle to be followed.

Ipsilateral iliac crest grafting is preferred, as it causes less morbidity and helps in early postoperative mobilization. Painful iliac crest with contralateral Ilizarov frame hampers ambulation. While harvesting grafts, the most

important factor is to remain subperiosteally and harvest large amount of grafts as the bone defects are quite large after debridement.

Application of hybrid Ilizarov frame

The hybrid Ilizarov frame is a prefixed frame, the construct comprises of four full rings and one Italian arch. Out of four rings 3 rings are in the distal segment, and the proximal fragment is stabilized with one ring and one Italian arch with 3 bicortical multiplanar 6 mm tapered schanz pins. The fine wires are inserted by standard fashion.⁴ Proximal tibia was fixed with a transcondylar K wire of 1.8 mm×400 mm, one medial facial wire and fibulotibial wire. The second ring was fixed with two wires only. The femoral metaphyseal fixation comprised of a full ring with 3 wires in the condylar region, and one ring in the proximal segment proximal to nonunion with one wire. The rationale of using two rings in distal fragment and one ring & an Italian arch in the proximal segment is to ensure stable fixation because of associated bone loss (Figure 2 A-F). At this juncture reamer induced aspirate is obtained manually and stored. The use of olive wires to compress the condyles were not attempted due to the associated osteoporosis. The rationale of using of one full ring proximal to nonunion site enables us to perform accordion maneuver for rapid healing. The Italian arch is anchored to femoral diaphysis with 3 bicortical 6 mm tapered Schanz pins in multiple planes. The optimal position of knee fusion is 5°-8° valgus, 10°-15° of flexion, 5°-10° of external rotation, or rotation equivalent to contralateral leg.⁵ In this position the knee is placed, and the femoral segment and tibial segments are connected with connecting rods with conical couples. The gaps between the denuded femur and tibia as well as the nonunion sites are filled with the harvested bone grafts mixed with the reamer aspirate. Care is taken to place grafts anteriorly adequately and then compress to achieve global contact.

RESULTS

The patients with post traumatic infected supracondylar nonunion femur with bone loss, where arthrodesis of knee was offered as the treatment by a single surgeon were evaluated. The details of the procedure performed, the patient details and associated injuries are given in tabular form. The associated injuries were pure bony in 20% of cases whereas both bony and soft tissue involvement were seen in 80% of patients. All the injuries were due to motor vehicular accidents, on right side. 90% were male patients, with a mean age of 34.4±8.80 years, and the mean time interval between primary and definitive treatment was 15.6±6.37 weeks. The average bony and soft tissue procedures before the definitive treatment was 3.2±0.74 (Figure 4). The bone loss was moderate in 50% of cases and severe in the rest 50% of cases. Regarding the time interval between the primary surgery and the definitive surgery, only one patient (10%) could be operated within 8 weeks from primary surgery, majority, 6 cases (60%) were operated

between 9-16 weeks, 3 cases (30%) presented after 16 weeks for definitive surgery (Figure 5). This delay of presentation was mainly due to poverty. All the patients had successful knee arthrodesis, regarding completion of treatment and frame removal, the criteria for frame removal was radiographic trabecular bridging seen in 3 out of 4 cortices, in a fully dynamised frame, and on removal of connecting rods, attempted movements were painless and no mobility across the fusion site. Once the frame was removed, the pin sites are cleaned and groin to toe weight bearing cast was applied for 6 weeks. The knee was then protected in a bivalved rigid polypropylene cylinder brace for next 3 months (Figure 3 A-F). The mean fusion time from definitive treatment was 22.4±4.97 weeks (Table 2) and the mean shortening of lower limb was 3.1±1.19 cms (Table 3).

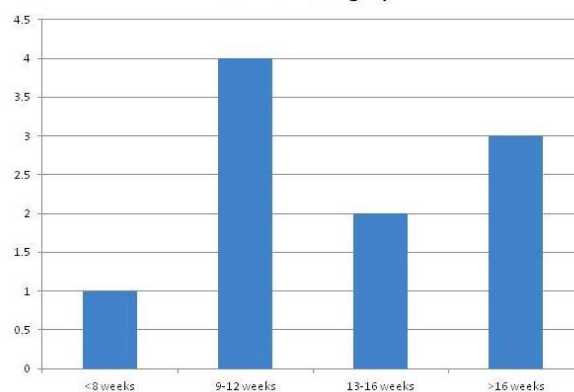


Figure 5: Patients with time interval between primary and definitive surgery.

Table 1: Characteristics of injury, associated injuries and mode of initial stabilization in all patients.

S. No.	Age	Associated soft tissue and bony injuries	Bone loss	Modality of initial stabilization
1	25	Ipsilateral Superior Inferior pubic rami # Right Ipsilateral Sub trochanteric # femur Right, Ipsilateral Crush Injury Rt. Thigh with full thickness degloving injury to upper thigh Ipsilateral Grade III B compound comminuted # both bone leg proximal one third	Severe	Debridement and external fixation with intramedullary rush rod stabilization for femur
2	40	Ipsilateral Grade II Cpd Comminuted upper 1/3 shaft femur Ipsilateral Grade II Cpd Comminuted upper 1/3 both bone leg Ipsilateral Lacerated wounds over medial aspect of distal one third	Severe	Debridement and plating femur for proximal I/3 femur Interlocking nail for tibia Debridement and slab support for supracondylar femur
3	42	Comminuted bicondylar # tibia Large Crushed wound over the knee joint	Moderate	Transarticular external fixator across the knee
4	43	Closed Monteggia # D/L with finger drop Large CLW medial side of distal 1/ thigh and anterior aspect leg upper 1/3	Moderate	Plating for Monteggia # Distal femur plating
5	45	Comminuted crushed distal femur and proximal tibial # with crush injury over the knee	Moderate	Transarticular external fixator across the knee
6	22	Large CLW over the ipsilateral shin and CLW over mid-thigh anterior aspect	Severe	Intramedullary rush nailing from the lateral condyle and transarticular external fixator
7	26	Large Raw area over the anteromedial side of leg secondary to chronic cellulitis. Fixed flexion deformity of knee joint 100°	Severe	Soft tissue release of knee joint, sequestrectomy, transarticular hinged Ilizarov fixator and daily distraction of the frame.
8	28	Crush injury over the knee joint Brachial plexus injury contralateral upper limb	Moderate	Transarticular external fixator
9	31	Grade IIIB comminuted segmental tibia #	Severe	Intramedullary rush nailing of tibia and trans articular external fixator for rt. lower limb
10	42	Ipsilateral shattered patellar #. With crush injury over the proximal tibia Contralateral both bone forearm #	Moderate	Debridement patellectomy with transarticular external fixator.

Foot notes: # fracture, Cpd=Compound, D/L Dislocation, SSG=Split thickness graft.

Table 2: Time duration for knee arthrodesis in all the patients.

Duration in weeks	No. of patients	Percentage (%)
16-20	5	50
21-24	3	30
25-29	1	10
>30	1	10

Table 3: Post-operative limb shortening in patients.

Shortening in cms	No. of patients	Percentage (%)
2	4	40
3	3	30
4	1	10
5	2	20

DISCUSSION

There is paucity of literature on salvage knee arthrodesis in infected supracondylar femoral nonunions. Common indications for knee arthrodesis include failed total knee arthroplasty, periarticular tumor, posttraumatic arthritis, and chronic sepsis.^{1,6} Majority of techniques of knee arthrodesis described in literature are in cases of failed TKR, or bone tumours. We couldn't retrieve any literature on knee arthrodesis in the backdrop of infective nonunion with bone loss. A variety of techniques has been described, including internal fixation by compression plates, intramedullary fixation through the knee with a modular nail, and antegrade nailing through the piriformis fossa and ilizarov external fixation. Ilizarov has several advantages over other techniques of achieving knee fusion. Internal fixation in form of intramedullary nailing or supplemental plate fixation should be attempted in patients with good soft tissue envelope, no infections, and minimal bone loss.⁷ The greatest advantage of Ilizarov fine wire fixator is immediate weight bearing. It's the only modality which can be applied in presence of active and chronic infections. Ilizarov fixator, by the virtue of tensioned wires, it gives maximum stability in all planes, provides freedom for surgeon for intraoperative, post-operative adjustments for alignment and compression.^{7,8} It also can be subjected to induce osteosynthesis by Accordion maneuver and its inexpensive.⁶ This apparatus helps us in achieving length by lengthening in symptomatic patients and does not involve a major procedure for removal.¹ However, it's not the panacea for all the problems. It has several problems, like the fixator is cumbersome, visible externally, frequently associated with pin track infections.⁴ The treatment protocol is long and painful. However, this can be reduced significantly by using light weight frames, and use of bicortical 6 mm tapered Schanz pins in the femoral diaphysis anchored to a single Italian arch instead of wires, which gives similar stability like fine wires sans painful pin track infections and keeps the

fixator light weight and compact. The success rates of arthrodesis of circular fixator are far better than other devices.⁸ The time duration of knee fusion in present series, 22.4±4.97 weeks is comparable to other series which ranges from 28 weeks to 36 weeks.^{6,8}

When compared to above knee amputation, versus limb salvage with osteosynthesis and knee fusion, the patients with osteosynthesis with knee fusion, do better and have better walking potential get better functional independence.⁹ Every effort should be made for limb salvage, with or without salvage of knee joint. As these patients have already in non-ambulatory status from a long time due to the infection, bone loss and painful nonunion, fine wire fixator remains the only hope for osteosynthesis. All attempts should be made to mitigate the frame time. This can be achieved by good bone contact, adequate corticocancellous bone grafting, keeping the frame light weight, less cumbersome, regular meticulous pin site dressings and making the patient full weight bearing with a tripod cane.¹⁰

Regarding debridement of knee, the key factor facilitating debridement is hyper flexion of knee; this can be achieved by retracting the patella laterally gently. At the end of the procedure it's mandatory to reestablish the continuity of extensor apparatus in all possible cases to give dynamic compression at the anterior aspect of knee.¹¹ The knee joint being the largest joint, and remains in 5-10 degrees of flexion, the external compression by Ilizarov fine wire fixator will be more posteriorly and maintaining the extensor apparatus continuity anteriorly will compress evenly leading to fusion quickly. In patients with considerable bone gaps and associated with infected nonunions, when approached with a longitudinal incision and docked, the acute shortening of large bone gap can cause vascular compromise and more so ever difficulty in closure of the wound.⁵ The linear incision on closure of the bone gap will lead to diamond shaped dog ears which will be difficult to close. In such cases the incision to be planned should be Lazy "S" incision over the knee, or to close the wound with the bone gap and gradually dock it once the wound heals.

More secure fixation is required in these cases than the fusion surgery for unsalvageable total knee arthroplasty as the bone quality in total knee arthroplasty is better and the bone loss is geometrical, whereas post traumatic post infective after necrectomy bone loss is geographical and fusion area is less and fusion process is slow.⁷ To achieve maximal bone to bone contact, refashioning the end, addition of corticocancellous bone grafts especially anteriorly is vital. After thorough necrectomy, one should appreciate paprika sign, addition of bone grafts in same sitting or it can be accomplished as a staged procedure. Shortening is an issue after the successful arthrodesis, however most of them adapt with a shoe lift, but when the shortening is significant and symptomatic, as it happens when shortening is more than 3 cms, and then tibial lengthening can be considered in a committed

symptomatic patient with the same fixator.¹⁰ All patients in our series did not opt for lengthening as they are exhausted with previous surgeries.

CONCLUSION

Even in best hands, a small group of patients will land up with traumatic, infected nonunion of distal femur with bone loss with previous multiple surgeries. It needs highest clinical judgement for salvage versus amputation. Forgoing knee joint and salvaging the lower limb appears to be one of the viable alternative for these recalcitrant infected nonunions with bone loss. The key to early solid and sound fusion with hybrid ilizarov is early mobilization and ambulation with full weight bearing as it improves circulation, minimize edema, promotes soft tissue healing and prevent contractures. Weight bearing enhances the osteointegration of the bone grafts and promotes fusion. Use of cane is beneficial than a standard walking frame as it encourages protected full weight bearing. The limitations of this study are, small sample size, and from a single center to offer knee arthrodesis, for infected nonunion of distal femur with bone loss, so sizeable studies are needed to validate our results.

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Ethical approval: The study was approved by the institutional ethics committee

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