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Resection arthrodesis with Ilizarov fixator in advanced cases of GCT around the knee - Outcome with problems, obstacles and complications

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Abstract
Background: GCT's are aggressive benign but potentially malignant lesions of bone.50% of these tumors involve knee joint. Wide resection and gap reconstruction by various methods are used for aggressive GCT's around knee joint. In this study we tried to evaluate the outcome of resection arthrodesis of knee by primary Ilizarov procedure.
Materials and Methods: 20 patients with mean age of 30.5 years with campanacci grade III GCT around knee joint treated by resection arthrodesis and primary Ilizarov techniques between 2010-2015 were evaluated in this retrospective study. There were 8 males and 12 females. Mean follow up was 36 months (30- 42 months range). Functional evaluation was done with musculoskeletal tumor society scale.
Results: At the final follow up the functional score ranged from 26.4 out of 35. The average duration in fixator was 16 months and the mean regenerate achieved was 10.8 cm at final follow up Average duration to union was 6 months. All patients were ambulatory. There were no requirements for bone grafting in all 20 cases. 3 cases had nonunion at docking site one because of local recurrence and one case because of infection.
Conclusion: Resection Arthrodesis with Ilizarov is a viable alternative and provides a long-lasting and cost-effective reconstruction for average patients in developing countries.

Keywords: Aggressive GCT, resection arthrodesis, Ilizarov, complications

Introduction
Giant cell tumor, a benign, aggressive potentially malignant lesion includes 3-8% of all bone tumors but in the eastern world including India and china the prevalence is about 20 % [1]. Young female between 20-40 years of age are affected 1.5 times more than their male counterparts [2–4]. The evolution of GCT based on its histological features is unpredictable. Its treatment and prognosis still remain an unsolvable puzzle. The distal femur and proximal tibia are frequently affected sites. In 80% of patients it runs a benign course whereas in 20-50% of patients it results in local recurrence. The malignant transformation rate is 10% and pulmonary metastasis occurs in 1-4% of patients [5].
Repeated surgeries lead to disability and to poor quality of life as a result of a loss of bone stock, scarring of the soft tissues, and secondary arthritis of the joints. All these factors make treatment decisions difficult and the surgeon has to weigh the relative pros and cons while suggesting either conservative or surgically aggressive approach. There is a high rate of recurrence, especially after intralesional curettage in most cases within the first 12 to 36 months [6] and rarely after five to six years. Stage-3 GCTs, which have already destroyed the cortex tend to recur more often and when the defect is large and the joint surface destroyed, resection is indicated.
The skeletal defect created is reconstructed using autologous grafts or an endoprosthesis because it is difficult to use allogenic bone. If the defect is fairly long, however, autogenous strut fibula grafting is not likely to be successful. There are also several problems related to the endoprosthesis for the reconstruction of bony defects, such as infection, prosthetic loosening, and breakage [7].

Bone transport techniques using the Ilizarov apparatus have become one of the most popular methods for skeletal reconstruction after resection of infected bone or traumatic bone loss [8]. The great advantage of the bone transport method is that the skeletal gap is filled with the de novo autogenous bone. The difficulties are the prolonged treatment period in an external fixator even if it was a definitive procedure and the many complications that are associated with limb lengthening procedures. This method is not recommended for patients with bone sarcoma who may have a poor prognosis, as it has an unacceptably high complication rate [9]. To shorten the duration of external fixation, bone transport combined with an intramedullary nail might be better, as suggested by some workers [10]. In this study we evaluated the outcome of resection arthrodesis of the knee using the Ilizarov principles and fixator in late cases of GCT around the knee in our patient population with a focus on the functional result and study the difficulties and complications associated with the same.

Materials and Methods

In this retrospective case series study, the outcome after resection arthrodesis using the Ilizarov fixator and principles are presented, along with the problems encountered during the treatment of 20 cases. The Hospital and follow-up records of the patients were reviewed and analyzed. All the cases were operated by the senior-most surgeon. All cases presenting to the Orthopaedics OPD during the period 2010 to 2015 who fell under the Grade 3 were given the option of resection arthrodesis of the knee. Low-grade GCT with Campannaci grade I and II, Recurrent GCT, Those with Pulmonary metastasis, Patients unwilling for resection arthrodesis, Patients with less than 3 years follow-up were excluded from the study. Out of the total 28 cases operated 8 were excluded. Among the rest 20 patients included in the study, 8 were male and 12 were female patients.14 lesions were in the distal femur (Figure 1,2,3,4) and 6 lesions in the proximal tibia (Figure 20,21). 12 lesions on the right side and 8 lesions on the left side. 8 patients clinically presented with pathological fracture. The consenting patients were informed of the nature of the entire procedure and worked up. Besides the routine-preoperative investigations including Chest X-rays and CT thorax, MRI to delineate the extent of the tumor and soft tissue involvement were done. An Incision biopsy was carried out for histological confirmation. For resection of tumor anterior midline, the medial parapatellar approaches were used. Wide Marginal Resection was done through normal bone and also included a layer of surrounding soft tissues that were removed with cautery (Figure 5, 6, 7, 22). After removal of the tumor (Figure 25), the posterior vital structures were protected with a surgical mop and the rest of the space was irrigated with the hydrogen peroxide solution and normal saline. The posterior infiltrations were repeatedly cleared by carefully identifying the neurovascular bundles and using peanut gauze dissection around them, followed up with copious irrigation and suction. The intraoperative resection gap was measured (Figure 23). The wound was closed with a drain which was clamped in the post-op period if the drainage was found to be excessive. In 13 cases a preconstructed Ilizarov ring fixator (Figure 24) was applied at the same sitting after some amount of docking at the gap (about 4 cm), while in the remaining 7 cases, the limb was put in a rigid knee brace. These cases were allowed to rest to partially close the gap spontaneously and put on the fixator at a later date. In this interval, 5 cases were given injection Zoledronic acid. Corticotomy was always done at the second sitting and followed by distraction histogenesis after waiting period 7 to 10 days at the rate of 1mm per day in an equal rhythm of 0.25mm/6hrly (Figure 27). All the patients were encouraged to start partial weight-bearing ambulation with appropriate shoe raise and walker support in the post-operative period. All cases received a 3 months course of Calcium and Cissus Quadrangularis. Analgesic used was Tramadol tablets as necessary. The resection gap that remained was docked subacutely (Figure 26) every week, which was done as per the comfort of the individual case. This amounted to approximately 2 cm per week. With docking completed in most cases by 4-6 weeks. At this time, the docking site was opened minimally and the tibial plateau in the region of the spine was removed with an osteotome and local grafts were applied after the ends were docked. Pin tracts were incised distally to relieve any tension to the soft tissues. This docked site (Figure 10, 11) was compressed later at a rate of 0.25mm every alternate day till union (Figure 10, 18, 28, 29). Functional evaluation was done with musculoskeletal tumor society scale [11].

The fixator was removed in all cases after the radiological calcification of the regenerate was observed (Figure 13, 14). Before removal, a 2 weeks dynamization was done to assess regenerate and docking site consolidation clinically (Figure 12, 19, 30).

Results and Observation

20 patients of Grade 3 GCT around the knee were treated with resection arthrodesis using the Ilizarov technique from 2010 to 2015. The mean age was 30.5 years. The average duration of symptoms preceding surgery was 4 months. (Table 1)

The mean gap resulting after resection was 14 cm (12-16). However due to a variety of reasons the mean regenerate created was 10.8 cms. Average duration to union was 6 months (Figure 10, 11, 29). The average duration in the fixator was 16 months. Mean Hospital Stay was 4 months. 4 patients were left eventually with residual limb length discrepancy of greater than 4 cms. The Problems, Obstacles, and Complications encountered are discussed below (Table 2).

No serious infections in any of the transosseous wires were noted, but almost every half pins (Figure 15) were involved to some extent over the entire treatment period. Injections of Gentamicin were infiltrated after dressings of such pin tract infection and resulted in healing in most cases. Any skin tensions were also released to prevent necrosis and aid in the drainage. None of the half pins needed to be removed during the distraction, however 4 distal pins in 3 patients were found to be loose at the time of removal and 1 case had lysis around the distal pin tract in the femur that was curetted. There were Collections and abscesses at the docking site during gradual docking, 4 cases had collections at the gap that spontaneously pointed out through the surgical wound. These were evacuated and left to heal secondarily and did not recur.

The Axial deviation of the transported segment (Figure 8, 17) was the most persistent issue that was universally found in all the femur cases. The transported segmented deviated medially resulting in a varying amount of varus (Figure 16) in the proximal femur. The problem was initially thought to be multifactorial, from weak half pins, deformation of the clamps and half rings, inadequate medialization of the connecting rods, cantilever bending of the half pins due to soft tissue tension on the lateral side, pull off the contracted Adductor magnus. A variety of remedial measures were tried, ranging

from the use of stouter half pins, improving medial side distraction, angulating half pins distally in the initial construct, frequent release under LA for the half pin tracts to release tension, but with partial success (Figure 9). It is now presumed that this deformity is mainly from the contracted adductor magnus because it has been found to be less in the cases where acute docking was done less aggressively and only transport performed.

Hardware failures ranging from mild bending of half pins and Half rings to breakage of clamps, and proximal femoral arches were encountered but could be managed by appropriately reinforcing the frames from time to time as distraction progressed. 3 cases had nonunion at the docking site (Figure 16). One turned out to be local recurrence while the other had severe infection and fibrosis around the docking site from aggressive docking initially. This case was also not tolerating the ring fixator after 1 yr on the fixator, so it was removed and after a gap of 6 weeks, a rail fixator was applied to compress the docking site which was also grafted.

The equinus deformity in the ankle (Figure 30), present in a variable degree in 6 cases, but one case needed surgical lengthening of the TA. Local recurrence: one case which was biopsied after there was nonunion at the docking site and also showed lysis in both the bones turned out to be a recurrence. After being on the fixator for over a year. The patient was amputated eventually. 4 patients were left eventually with residual limb length discrepancy of greater than 4 cms. The residual limb length discrepancy of less than 4 cm was considered clinically insignificant.

Fig 1: Clinical image of GCT

Fig 2: X-ray Distal Femur GCT

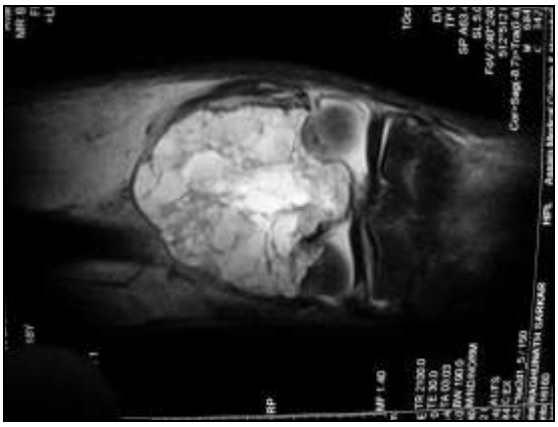

Fig 3: CT Coronal cut

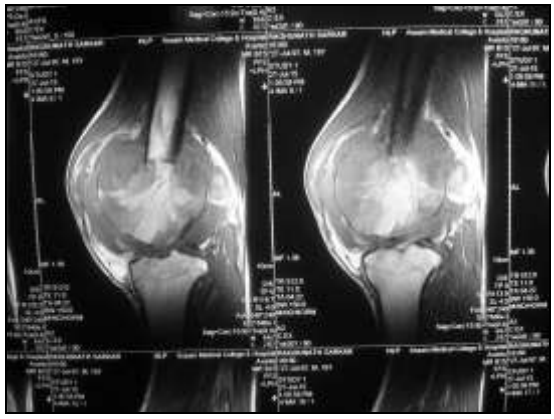

Fig 4: CT Sagittal cut

Fig 5: Intra-op Picture

Fig 6: Resected Tumor specimen

Fig 7: Immediate Post-op after excision

Fig 8: Complication - Varus at Osteotomy Site

Fig 9: Correction of Varus by extra Pin Insertion at Prox Frag and Distraction Osteogenesis

Fig 10: Union at docking site at final follow-up

Fig 11: Lateral view of docking site

Fig 12: Clinical picture at final follow up

Fig 13: Final follow-up after ring removal

Fig 14: Patient Ambulation with Shoe Raise

Fig 15: Complications infections at larger pins

Fig 16: Complication Varus of Femur and Nonunion at Docking Site

Fig 17: Complication - Failure of Regeneration at Oste0tomy Site

Fig 18: Final follow up of another case showing union at docking site

Fig 19: A case of GCT with Ring insitu

Fig 20: A case of GCT prox tibia

Fig 21: CT image of same patient

Fig 22: Intra-op image showing excision of tumor

Fig 23: Resction gap

Fig 24: Ring application immediate post-op

Fig 25: Immediate post-op X-ray

Fig 26: X-ray after docking

Fig 27: Showing regenerate

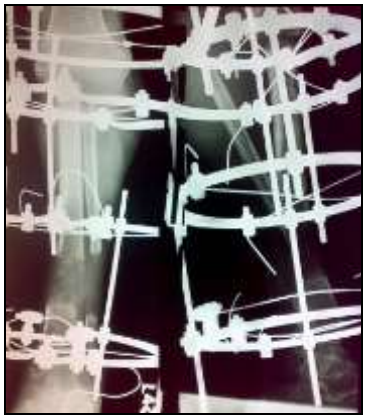

Fig 28: Final follow up

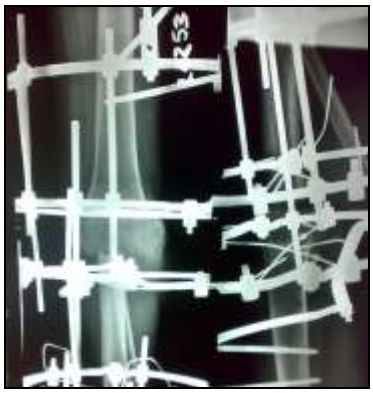

Fig 29: Docking site union

Fig 30: Clinical picture showing shortening and ankle equinius

Table 1: Patient characterstics

No	Sex/Age (years)	Campanacci grade	Pathological fracture	Tumour site	Side	Length of bone defect(Cm)	Time to heal (months)	MSTSFS (score)	Regenerate achieved (cm)
1	F/26	III	NO	Distal femur	R	12.5	7	26	9
2	M/29	III	NO	Proximal Tibia	L	13	5.5	27	11
3	F/37	III	YES	Distal femur	R	13	6.5	25	10
4	F/28	III	NO	Distal femur	L	15	6	28	12
5	F/32	III	YES	Distal femur	R	13.5	5.5	26	10
6	F/30	III	NO	Distal femur	R	14.5	6	25	10.5
7	M/29	III	YES	Proximal Tibia	R	15.5	6	24	11.5
8	F/33	III	YES	Distal femur	L	13.5	6	27	10
9	M/19	III	NO	Distal femur	L	12.5	6	28	9
10	F/34	III	YES	Proximal Tibia	L	16	7	26	12
11	M/26	III	NO	Proximal Tibia	L	13.5	5	26	11
12	M/28	III	NO	Distal femur	R	14.5	5	24	11
13	F/28	III	NO	Distal femur	R	13.5	5	28	11.5
14	M/34	III	YES	Distal femur	L	14.5	5	27	11.5
15	M/29	III	NO	Distal femur	R	13	6	27	11
16	F/33	III	NO	Distal femur	R	16	6	26	12
17	M/38	III	YES	Distal femur	R	14.5	6	25	11.5
18	F/38	III	YES	Proximal Tibia	L	15	6.5	28	12
19	F/28	III	NO	Proximal Tibia	R	13	6.5	28	10.5
20	F/31	III	NO	Distal femur	R	13.5	6.5	27	10.5

Table 2: Complications

Complications	No of cases	Percentage
Pin site infection and loosening	4	20%
Abscess at the docking site	4	20%
Equinus deformity at ankle	6	30%
Local recurrence	1	5%
Non union at docking site	3	15%
Residual Limb length discrepancy Patient No(6,7,10,16)	4	20%

Discussion

The aggressive grade-3 GCT lesions according to Enneking [12] and Campanacci *et al*. [13] classification break through the cortical bone and have a soft tissue component covered by a pseudo capsule and periosteum. On rare occasions, the tumor extends its barrier, the articular cartilage, and enters the joint

Although Campanacci nominates this group of GCT as malignant, the term 'aggressive' is more justified because in most cases this tumor has benign histology and can be cured by conservative surgery, namely curettage. This final stage has, however, a greater risk of local recurrence. There are also other aspects that factor in the clinical decision-making process.

The primary form (1% to 3% of all GCTs) is malignant from the onset where frankly sarcomatous stroma is juxtaposed to areas of typical GCT [5]. Secondary malignant GCT (5% to 10% of all GCTs) may develop during recurrence of a benign GCT, or undergo a malignant transformation after radiotherapy. On very rare occasions, the development of a bone sarcoma has been seen after a very long period (18 to 25 years) after the treatment of a primary GCT [14].

This high rate of recurrence after surgery (30% to 50%) historically [13], has lead to different adjuvants being introduced. The thermal effects of liquid nitrogen, methyl methacrylate, or chemical (phenol, hydrogen peroxide, alcohol) presumably remove the tumor cells which remain after curettage [15, 16, 17, 18, 19]. Adjuvants combined with careful curettage may decrease the rates of local recurrence, which were reported in the historical series of Goldenberg *et al*. [17] and Campanacci *et al*. [12] as being from 30% to 43% and 8% to 17%.

However, these can be suitably applied only with an intact peripheral shell of bone, left after the curettage due to adverse effects on the soft tissues and vital structures. Additionally, some authors found no recurrence either with [20] or without [21, 22] the use of additional adjuvants, but the number of the patients reported was small.

GCT is relatively rare, and there are only a few multicentre studies that have described a large number of cases, the indications, treatment philosophy, and statistical methods used vary and, there is a lack of prospective, randomized studies. The evaluation of prognostic factors is difficult for various reasons. The most significant factor is the surgical procedure employed for the removal of the tumor i.e., curettage with adjuvant therapy (34% recurrence) versus resection (7% recurrence). This observation has been confirmed by many others authors [21, 23].

Limb reconstruction following resection depends on the extent of the tumor and soft tissue involvement. Arthrodesis, endoprosthesis, and osteoarticular allografting are the most commonly used options. The choice of treatment depends on the lifestyle of the corresponding patients, the surgeon's preference, and affordability (particularly in developing countries). An endoprosthesis provides immediate stability and mobility to the knee joint but is costly and of limited longevity [24]. Aseptic loosening is a major threat to endoprosthetic replacement [24, 25, 26]. Its incidence ranges from 8 to 56% over 5 to 10 years of follow up. Most series report infections (5–12%) as the commonest cause of failure. The use of autogenous vascularised fibula may achieve high union rates and hypertrophy, although complication rates are relatively high [27].

The 5-year survival is reported to be 73 to 83%, whereas the 10-year survival is 59 to 67%. [24]Postoperative infection occurs in 2%–25% of patients treated with curettage and cement placement. The prevalence of infection is probably increased with more extensive surgery involving en bloc resection and placement of an endoprosthesis; however, the data on this point are currently limited [28, 29].

There are a few reports of the use of the Ilizarov method in the treatment of GCT around the knee joint. We have found these references like review papers where authors have described a variety of treatment modalities in a variety of situations and shared their experiences. (Table 3) In some studies, the Ilizarov fixator has also been used as an adjunct

method for supporting grafts, and as a means for subsequently managing limb length in earlier treated cases, with other methods. However, there are none that have dealt with a specific technique in a homogenous group.

Studies show that the success rate of arthrodesis in GCT around the knee to be around 92 % [30–32]. A study conducted by Kapoor *et al.* In the year 2007 comparing 3 modes of resection arthrodesis for GCT around the knee with IM nail with fibular autograft, Plating with autogenous fibular grafting and long IM nail and ring fixator showed that plating was technically easier but complications like poor soft tissue coverage and skin impingement and fracture of the graft because of stress shielding. Also patients treated with Long IM nail with fibular autograft had a high incidence of nonunion at graft site even though the procedure was technically easier. Overall the result was better with Ilizarov fixator with Long IM nail combined together in terms of the better union of the graft, early weight bearing, and a lower rate of fracture and better restoration of limb length. However, they encountered complications like recurrent pin tract infections and equino-varus deformities of the ankle and foot [30].

In our study we used only Ilizarov fixator for arthrodesis without any additional internal fixation devices like IM nail and bone graft since the construct was stable enough to provide adequate stability and the corticotomy acts like a graft by distraction -histogenesis. We avoided additional nail to ensure the endosteal blood supply is left intact to enable early union even though we faced some axial deviation of regenerate. Some modifications in the construct like the addition of extra pins and ring translation were used to overcome axial deviation.

Table 3: Discussion

Study	No. of patients	Aseptic loosening (%)	Prosthetic survival (%) 5 years	Prosthetic survival (%) 10 years	Infection (%)	Stem/graft fracture (%)	Musculoskeletal Tumour Society functional score (mean)
Knee arthrodesis by plate fixation and bone grafting Saikia *et al.* [33]	32	0	0		3.2	3.2	26
Knee arthroplasty							
Myers *et al.* [34]	192	35	83	67	47.8	3.7	-
Maruthainar *et al.* [35]	25	33	100	100	-	0	-
Sharma *et al.* [36]	77	-	84	79	7.8	3.9	30
Ahlmann *et al.* [29]	108	2.4	76.9	56.3	5.2	0.5	22.25
Morgan *et al.* [37]	105	17.1	73	59	-	-	30
Gitelis *et al.* [19]	80	15	75	-	2.5	-	-
Nakamura *et al.* [38]	8	-	100	-	-	-	-
Flint *et al.* [39]	44	0	72.7	-	15.9	4.5	25
Natarajan *et al.* [40]	143	4.2	92.3	-	6.9	8.3	-
Knee arthrodesis Present study	20	NA	-	-	40% (20 %-pinsite) (20 % docking site)	-	26.4

Conclusion

Among the limb salvage techniques, in the context of increased risk of recurrences, infections, revision surgeries, expenses and limitations of autograft methods, treatment with the Ilizarov principle produce predictable long term results and enable a strong, durable and stable limb and a satisfactory lifestyle, with limited disability due to loss of knee motion. With this method, long-term fixation with an apparatus was required, so the quality of life of the patients was considerably reduced. During transport, psychological care became important. This form of surgery may be indicated as a salvage procedure following failed prosthetic replacement or osteoarticular allografting also. Appropriate counseling for emotional issues associated with the prolonged period in fixator and loss of knee function is vital. Resection Arthrodesis is a viable alternative and provides a long-lasting and cost-effective reconstruction for average patients in developing countries.

Conflict of interest

None of the authors involved in the study do have any financial interest, any other relationship with a commercial company, or a conflict of interest related directly or indirectly to this research.

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