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Applications of external fixation for management of complications associated with musculoskeletal tumors and related surgery

Kas-iskelet sistemi tümörlerinin ve cerrahi tedavi komplikasyonlarının tedavisinde eksternal fiksatör uygulamaları

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Amaç: Kemik tümörüne bağlı veya tümör cerrahisi sonrası gelişen komplikasyonların tedavisinde eksternal fiksatör (EF) yönteminin sonuçları ve tedavi süreci değerlendirildi.

Çalışma planı: Çalışmada EF ile tedavi edilen 18 hasta (9 erkek, 9 kadın; ort. yaş 19; dağılım 6-35) üç grupta incelendi. Histolojik tanılar osteosarkom (n=3), Ewing sarkomu (n=3), kalıtımsal multipl egzostoz (n=3), kondrosarkom (n=2), sinovyal sarkom (n=2) ve birer olguda Ollier hastalığı, dev hücreli kemik tümörü, desmoid fibrom, kondromiksoid fibrom ve enkondrom idi. Kemik tümörüne bağlı (n=4) veya ekstremite koruyucu cerrahi sonrasında (n=14) gelişen komplikasyonların tedavisinde dokuz hastada Ilizarov tipi sirküler EF, altı hastada tek taraflı EF, üç hastada isi her iki tip EF kullanıldı.

Sonuçlar: Birinci grupta, tümör cerrahisi sonrası gelişen deformite veya enfekte kaynamama nedeniyle EF ile tedavi edilen sekiz hasta vardı. Bu hastalarda ortalama kısalık 10.6 cm, ortalama uzatma 9.7 cm, tedavi fiksatör indeksi 48.8 gün/cm idi. Bir hastada fiksatörün çıkarılmasından sonra damarlı fibula greftinde kırık gelişti, iki hastada ise amputasyon gerekti. İkinci grupta, tümör cerrahisi sonrası ortaya çıkan kısalığın tedavi edildiği altı hasta vardı. Ortalama kısalık 7.5 cm, ortalama uzatma 6.5 cm, tedavi fiksatör indeksi 28 gün/cm idi. Bu grupta önemli komplikasyonlar implant sorunları ve diz hareket kısıtlılığı idi. Üçüncü grupta, tümörün kendisinden (3 multipl egzostoz, 1 Ollier hastalığı) kaynaklanan deformite ve kısalığı olan dört hasta vardı. Bu grupta ortalama kısalık 7.5 cm, ortalama uzatma 6.5 cm, tedavi fiksatör indeksi 57.2 gün/cm idi. Bir hastada büyüme atağı sonrası 2 cm ulnar kısalık gelişti.

Çıkarımlar: Özellikle genç hastalarda kemik tümörüne veya kemik tümörü cerrahisine bağlı komplikasyonların tedavisinde EF tedavisi ile başarılı sonuçlar elde edilmiştir.

Anahtar sözcükler: Kemik neoplazileri/cerrahi/komplikasyon; eksternal fiksatör; osteogenezis, distraksiyon/yöntem; rekonstrüktif cerrahi işlem; kurtarma tedavisi/yöntem.

Objectives: We evaluated the results of, and the course of treatment with, external fixation (EF) in treating complications associated with bone tumors and related surgery.

Methods: Eighteen patients (9 males, 9 females; mean age 19 years; range 6 to 35 years) who were treated with EF were evaluated in three groups. Histologic diagnoses were osteosarcoma (n=3), Ewing's sarcoma (n=3), hereditary multiple exostosis (n=3), chondrosarcoma (n=2), synovial sarcoma (n=2), Ollier's disease, giant cell tumor of bone, desmoid fibroma, chondromyxoid fibroma, and enchondroma. Complications secondary to bone tumors (n=4) and occurring following limb salvage surgery (n=14) were treated with Ilizarov circular EF in nine patients, unilateral EF in six patients, and both in three patients.

Results: The first group included eight patients who were treated with EF for infection and nonunion or deformity following surgery. The mean shortening was 10.6 cm, the mean lengthening was 9.7 cm, and the mean external fixator index was 48.8 days/cm. One patient developed fracture of the free vascularized fibula graft after EF removal, and amputation was required in two patients. The second group consisted of six patients who had shortening secondary to tumor surgery. The mean shortening was 7.5 cm, the mean lengthening was 6.5 cm, and the mean external fixator index was 28 days/cm. In this group, the major complications were implant failure and knee stiffness. The third group included four patients with deformity and shortening secondary to multiple exostosis (n=3) and Ollier's disease. The mean shortening was 7.5 cm, the mean lengthening was 6.5 cm, and the mean external fixator index was 57.2 days/cm. One patient developed ulnar shortening of 2 cm after growth.

Conclusion: The use of EF in the management of complications associated with bone tumors and related surgery yields successful results especially in young patients.

Key words: Bone neoplasms/surgery/complications; external fixators; osteogenesis, distraction/methods; osteotomy; reconstructive surgical procedures/methods; salvage therapy/methods.

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Limb salvage surgery is performed with proper planning and phasing before operation at many patients with bone tumour diagnosis. Since both malign tumours and benign tumours of bone may lead to limb shortenings and deformities, importance of reconstructive surgery at oncologic surgery has increased. Loosening of prosthesis, periprosthetic fracture, infection, union delay and nonunion of allografts are among the complications seen after reconstructive surgery. These complications are seen more frequently because of failures in patient's immune system, large resections while operation and large dead spaces. [1] Distraction osteogenesis concept, which was defined by Ilizarov, is often used in the treatment of bone loss, nonunion and bone infection.[2] Treatment with external fixator overtops the conventional treatment methods due to its biomechanical stability, providing soft tissue regeneration, opportunity of extending the bone with distraction osteogenesis, possibility to be used on areas with local mark problem. The place of external fixator treatment in the treatment of complications arisen from limb salvage tumour surgery or tumour itself and its consequences were evaluated.

Material and method

18 patients (9 female, 9 male; mean age 19;(from 6 to 35)who were followed due to bone tumour and who developed complication and treated with external fixator were taken into the study. Complications were developed after limb salvage surgery in 14 of the patients; and due to bone tumour in 4 of the patients who were included in the study. As histological diagnosis, 3 osteosarcomas, 3 congenital hereditary multiple exostosis, 3 ewing sarcomas, 2 chondrosarcomas and 2 synovial sarcomas were existed in our patients. There were one patient each with diagnosis of Olier's disease, giant cell bone tumour, desmoids fibroma, chondromyxoid fibroma. Patients taken into the study were examined in 3 groups because of treatment reason. i)infection and infected non-union ii) shortening with deformity due to previous surgery iii) shortening with deformity due to tumours itself.

Results

Infection and infected non-union

There were eight patients in total. Mean age 20 (from 6 to 30) Two patients were evaluated with the diagnosis of Ewing sarcomas (tibia and proximal femur), two patients with the diagnosis of osteosarcoma (distal femur and proximal tibia), two patients with synovial sarcoma (knee and cruris posterior), one patient with giant cell bone tumour (proximal tibia) and one patient with chondrosarcoma (distal femur). Prior to the treatment of the complications with external fixator, the patients were operated 2.4 times in average (from 2 to 5). The average time between the last operation and the treatment of complication due to that operation with external fixator was 15 (from 7 to 24) months. (table 1)

Ilizarov type circular external fixator was used in five patients while in 3 patients circular and external fixators were used together. Indications of treatment with external fixator were nonunion of allograft in 3 patients, tumour prosthesis infection in 3 patients, infected pathological fracture and arthrodesis failure in one patient each. All patients except for two patients were treated with three stage surgery. In the first stage following the removal of all infected and avascular tissues, temporary external fixator utilization was done for stability. In this stage, antibiotic chains or rod with antibiotics were used in order to provide high antibiotic concentration in the infected area. Teicoplanin and bone cement were used for the production of antibiotic chain or rod. Retrogress of local inflammation findings or flix was clinically used for the monitoring of the patients and leukocyte count, sedimentation and C reactive protein (CRP) were used as laboratory parameters. Sedimentation value being less than 20 mm/h, CRP being value less than 5 mg/dl and leukocyte count being less than 10000 were assessed as normal. With the retrogress of clinical and laboratory findings it was passed to the second stage in 6-8th week. In this stage, after the removal of antibiotic cement structures from nonunion area, compression was started to be applied. In the third stage definitive treatments were applied. In the figure 1, the three stage treatment process and results of the patient, who was monitored due to synovial sarcoma, are seen.(figure 1)

In a patient who was applied vascularized fibula graft for defect in tibia, external fixator was used for union process and lengthening was done in this patient. In one patient, before utilisation of distraction osteogenesis, lengthening was done with femoral epiphyseal distraction for two times and periodical lengthenings in our adolescent patient is being continued. Distraction and compression were applied to our two patients after the clearing of necrotic tissues. Tibia lengthening was done in our four patients; in

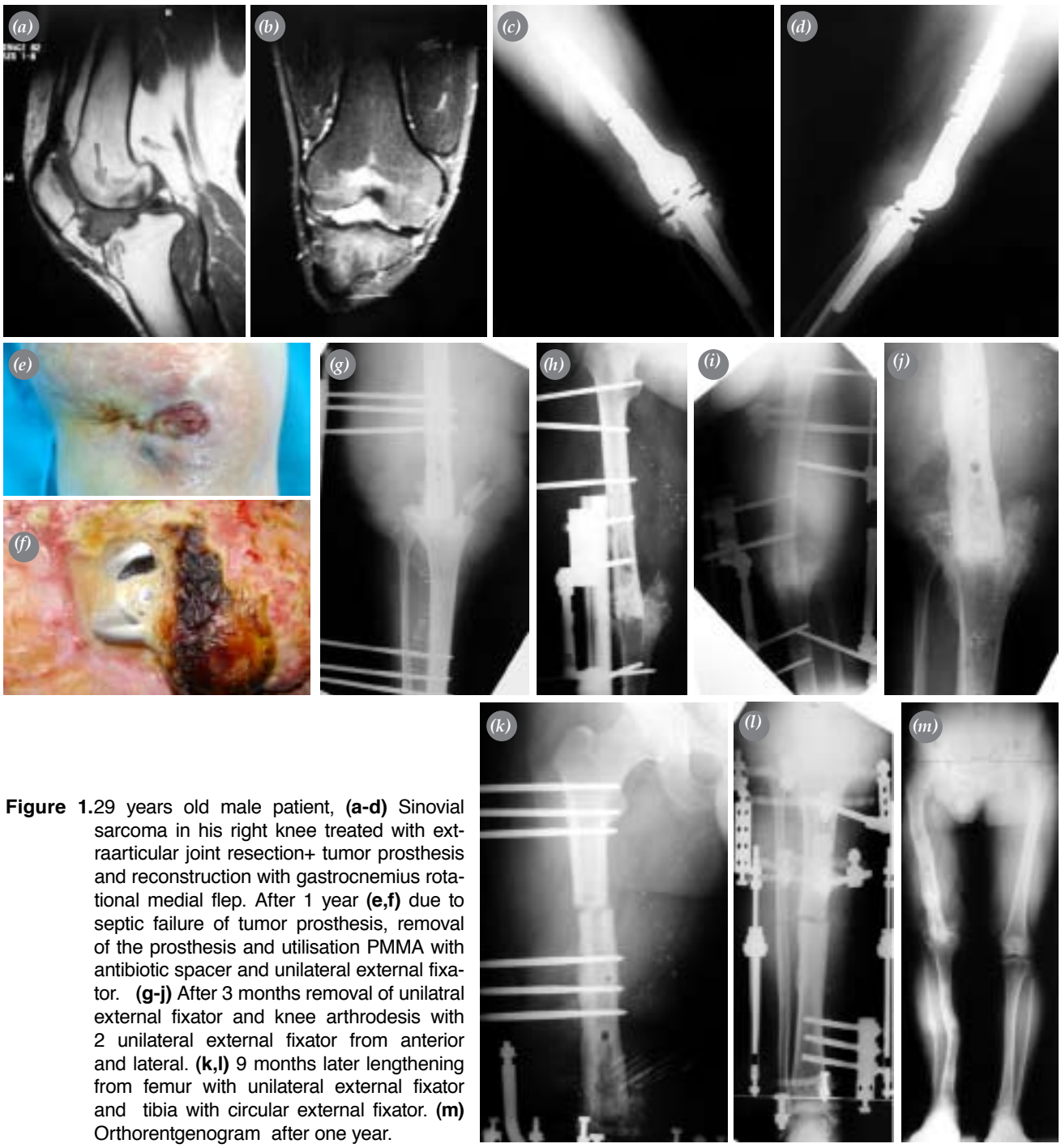

Figure 1.29 years old male patient, **(a-d)** Sinovial sarcoma in his right knee treated with extraarticular joint resection+ tumor prosthesis and reconstruction with gastrocnemius rotational medial flep. After 1 year **(e,f)** due to septic failure of tumor prosthesis, removal of the prosthesis and utilisation PMMA with antibiotic spacer and unilateral external fixator. **(g-j)** After 3 months removal of unilatral external fixator and knee arthrodesis with 2 unilateral external fixator from anterior and lateral. **(k,l)** 9 months later lengthening from femur with unilateral external fixator and tibia with circular external fixator. **(m)** Orthorentgenogram after one year.

one of our other patients femur and tibia lengthening and in another patient only femur lengthening was done. In two of our six patients lengthening was done over nails. In one patient femur was extended over nail with the help of unilateral external fixator, in on patients' tibia was extended over nail with ilizarov type circular external fixator together with pantalar arthrodesis.

Knee arthrodesis in three patients, whom infection of was treated, and tibia lengthening together with ankle arthrodesis in one of our patients was provided successfully.

While the average shortness in this group was 10.6 cm (from 4 to 22), average lengthening was 9.7 cm (from 3.5 to 19). Average external fixator duration was

Table 1. Infection and infected nonunion

Patient	age	Diagnosis	(a) Firs treatment (b) Complication	After first treatment, (a) Treatment, (b) Time, (c) Complication	(a) Shortnees (b) Lenghtening	Results
F	19	R distal femur chondrosarcoma	(a) Resection and knee arthrodesis (b) Infected nonunion and shortness	7 months (a) Ilizarov type circular EF (b) 10.3 months, (c) Bone infection	(a) 5.5 cm (b) none	Amputation
M	18	R ewing sarcoma tibia proximaly	(a) Resection, nailing and grafting (b) Nonunion and infection	15 months (a) Debridement, antibiotic chain and UEF, (b) 12 months (c) Bone infection	(a) ?? (b) none	Desarticulation
M	30	L tibia giant cell bone tumour	(a) Excision and tumour prosthesis (b) Infected prosthesis loosening	12 months (a) Prosthesis rem.oval, antibiotic chain, femur lengthening over nail, tibia, ilizarov type circular external faxator (b) 6 months, (c) none	(a) 7.5 cm (b) 7.5 cm	Knee arthrodesis
M	18	R tibia proximal osteosarcoma	(a) Excision and allograft (b) Infection + recurrence	18 months (a) DBM + antibiotics chain + +ilizarov type circular external, fixator. FVFG 2. (b) 11+9 months, (c) Graft breakage	(a) none (b) none	Complete union
F	27	R leg posterior synovial sarcoma	(a) Large soft tissue resection (b) Distal tibia pathological fracture, infection	12 months (a) Plantalar arthrodesis with combined technique, (b) 5.5 months (c) Nonunion and infection	(a) 4 cm (b) 3.5 cm	Ankle arthrodesis
M	29	R knee synovial sarcoma	(a) Resection and tumour prosthesis (b) Infected prosthesis loosening	8 months (a) Femur UEF, tibia lengthening with ilizarov type circular external fixator (b) 7+16 months (c) Nonunion and infection	(a) 15 cm (b) 12 cm	Knee arthrodesis
F	25	L distal femur osteosarcoma	(a) Large tumour resection Tm, prosthesis, arthrodesis due to prosthesis Loosening. (b) Infection, nonunion and shortness in arthrodesis	24 months (a) Bifocal comp with Ilizarov type circular external fixator arthrodesis and lengthening with dist., grafting (b) 13 months, (c) Residual shortness, pin track infection	(a) 10 cm (b) 7 cm	Knee arthrodesis
M	6	R femur proximal, ewing sarcoma	(a) Large resection Allograft with grafonage and intremeduller nailing (b) Infection and shortness	24 mnths (a) Gradual lengthening wit ilizarov type circular external fixator (epiphyseal distraction) (b) 7+7+6 months (c) Pin track infection	(a) 22 cm (b) 19 cm	Re-lengthening is planned

Characteristics of all patients, DBM: Demineralised bone matrix, FVFG: Free vascularised free fibula, UEF:Unilateralexternalfixator Tm: tumour Comp: compression Dist: distraction EF: external fiksatör

14.8 (from 6 to 23) months. The time passed for lengthening amount in treatment, external fixator index was determined as 48.84 day/cm. Although the final lengthening in one patient will be done in maturity, since now he is in adolescence the periodical lengthenings are being continued. There were complications (n:10) consisting of osteomyelitis (n:2), broken vascularized fibula graft after the removal of fixator (n:1), nonunion of knee arthrodesis (n:2), breakage of intramedullary nail (n:1), grade 2 pin track infection (n:2) and residual shortness (n:2). Chemotherapy was started in two of our patients, who were being treated due to osteomyelitis, after lung metastases were detected during routine controls. Above knee ampu-

Table 2. Shortening with deformity due to previous surgery

Patient	age	Diagnosis	(a) Firs treatment (b) Complication	After first treatment, (a) Treatment, (b) Time, (c) Complication	(a) Shortnees (b) Lenghtening	Results
M	22	L acetabuler chondromyxoid fibroma	(a) Large resection (b) Shortness	72 months (a) Femur lengthening with ilizarov type circular external fixator,(b) 9 months (c) Pin track infection and residual shortness	(a) 6 cm (b) 4.5 cm	Residual shortness
M	26	R humerus Ewing sarcoma	(a) Large resection and vascularized fibula (b) Graft breakage, nonunion and shortness	12 months (a) Ilizarov type circular external fixator, nailing and grafting, (b) 4 months (c) None	(a) none (b) none	Complete union
F	35	L distal femur chondrosarcoma	(a) Large resection allograft and rec with nail (b) Nonunion, nail breakage and shortness	30 months (a) Intramedullary nail removal, + removal of pseudoarthrosis area + lengthening over nail with unilateral external fixator (b) 4 months (c) Implant problem and delayed union	(a) 8 cm (b) 7.5 cm	Complete union
M	21	Desmoids fibroma in tibia and gluteal area	(a) Resection (b) Shortness, sciatic nerve palsy	39 months (a) Pantalar arthrodesis with ilizarov type circular external fixator and tibia lengthening over nail (b) 3 months , (c) Residual shortness and pin track infection	(a) 3.5+2 cm (b) 3.5 cm	Residual shortness
F	7	L distal femur osteosarcoma	(a) Large resection and vascularized fibula (b) Shortness	144 months (a) Femur lengthening with UEF (b) 7.5 months, (c) Early union and residual shortness	(a) 9 cm (b) 8.5 cm	0.5 cm shortness
F	13	R distal femur enchondroma	(a) Excision (b) Deformity and shortness	13 months (a) Deformity Correction and with ilizarov type circular fixator (b) 7 months, (c) Knee ROM restriction and residual shortness	(a) 9 cm (b) 8.5 cm	Deformite was corrected

Characteristics of all patients, rec: Reconstructive, UEF:Unilateralexternalfixator, ROM:range of motion

tation in one of them and knee disarticulation in the other were done. Union was achieved with external fixator utilisation in the patient who developed vascularized fibula fracture after two weeks following the removal of external fixator. Target area grefonage and replacement of nail was applied to the patient that there was breakage in the intramedullary nail during knee arthrodesis.

B. Shortening with deformity due to previous surgery

There were six patients in this group (2 male, 4 female,average age 21;from 7 to 35). As histological diagnosis, categorised as ewing sarcoma (humerus), osteosarcoma (distal femur), chondromyxoid fibroma (acetabulum), desmoid fibroma (cruris) and osteochondroma (distal femur).

In this group, external fixator was applied due to shortness in three patients and vascularized fibula graft fracture, shortness with deformity and nonunion together with shortness in other three patients. Average operation number prior to the utilisation of external fixator was 1.3 (from1 to 4). The time passed from the last operation to the utilisation of external fixator was 51.6 (from 12 to 72) months. In two patients unilateral external fixator was used while in 4 patients ilizarov type circular external fixator was used. In figure 2, treatment processes and results of the complications developed after surgery of one patient who was monitored because of femur distal osteosarcoma.

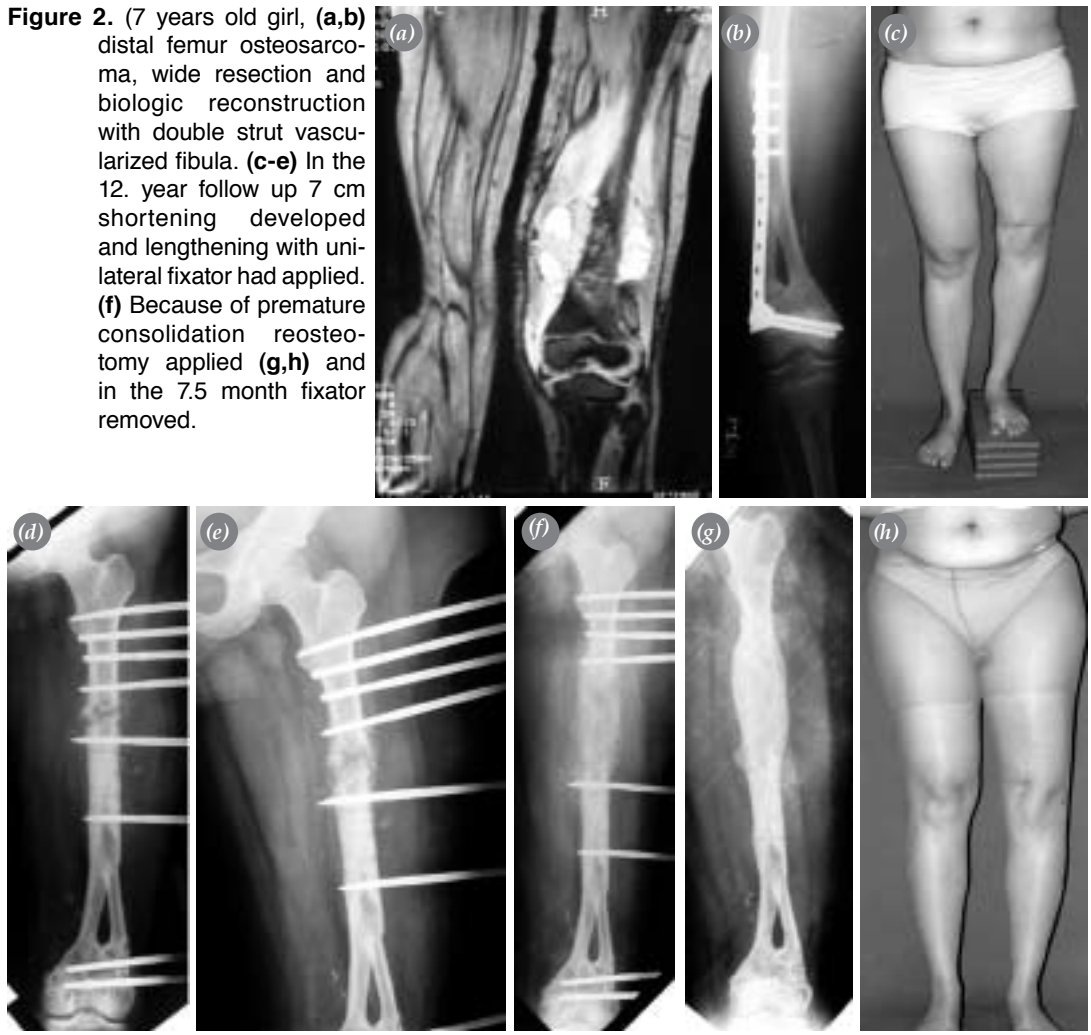

Figure 2. (7 years old girl, **(a,b)** distal femur osteosarcoma, wide resection and biologic reconstruction with double strut vascularized fibula. **(c-e)** In the 12. year follow up 7 cm shortening developed and lengthening with unilateral fixator had applied. **(f)** Because of premature consolidation reosteotomy applied **(g,h)** and in the 7.5 month fixator removed.

External fixator was utilised in one patient due to nonunion of fibula graft in humerus and in others due to deformity and shortness. Lengthening was done in five patients (2 tibia, 3 femur), osteosynthesis was provided with intramedullary rush pin and external fixator due to vascularized fibula fracture in one patient. In two patients unilateral external fixator was used for lengthening purpose while ilizarov type circular external fixator was used in 3 patients. The lengthening was done over nails in two of our patients, one femur and one tibia lengthening. For lengthening over nail, unilateral external fixator was used in femur while ilizarov type circular external fixator was used in tibia. In order to accelerate union, grafting was done with bone graft taken from iliac wing. Grafting was done at the time of utilisation of external fixator after fracture of fibula graft in one patient and 5 months after the utilisation of external fixator due to delay of union in one patient. To the patient who developed sciatic nerve apoplexy after previous surgical attempts, lengthening with tibia circular external fixator was done together with pantalar arthrodesis.

Success was provided in all of our patients with the treatment. Average fixator utilisation time was 5.8 (from 3 to9) months. Average shortness was 7.5 cm (from 5.5 to 9 cm) and average lengthening was 6.5 cm (from 3.5 to 8.5) cm. Average residual shortness was 1 cm and external fixator index was 28 day/cm.

Complications were seemed at all patients. The 2 cm shortness at most consisting of residual shortness after treatment in four patients. Grade 2 pin track infections that respond to local dressing and oral antibiotics treatment in two patients. Knee movement restriction in one patient. Nail breakage was treated with nail replacement and grafting in one patient.

Table 3. Shortening with deformity due to tumor itself

Patient	age	Diagnosis	(a) Firs treatment (b) Complication	After first treatment, (a) Treatment, (b) Time, (c) Complication	(a) Shortnees (b) Lenghtening	Results
Erkek	14	Congenital multiple exostosis	(a) Excision (b) L ulnar club hand	8 months (a) Exostosis exsicion radius osteotomy, ulnar lengthening with UEF, (b) 9 months, (c) Recurrence of radial deformity	(a) 2 cm (b) 2.5 cm	Deformity was corrected
Erkek	14	Congenital multiple exostosis	(a) Excision (b) R ulnar club hand	7 months (a) Exostosis excision, radius osteotomy and ulnar lengthening with UEF , (b) 4 months (c) 2.5 cm shortness	(a) 2 cm (b) 2.5 cm	Deformity was corrected
Kadın	10	Congenital multiple exostosis	(a) (–) (b) Bilateral Ulnar club hand	6 months (a) Bilateral ulnar lengthening over K wire with UEF (at different times) (b) 7+6 months, (c) Pin track infection	(a) 3 cm (b) R 3 cm L 3.5 cm	Deformity was corrected
Kadın	8	Ollier's disease	(a) (–) (b) Shortness and deformity	7+6 months (a) Tibia bifocal compression distraction With ilizarov type circular external fixator and femur def. corr. and lengthening with UEF, (b) 7+6 ay (c) Residual shortness 0.5 cm	(a) 9.5 cm (b) 9 cm (tibia 7 cm, femur 2 cm)	Deformity was, corrected and residual shortness

Def: deformity Corr: correction UEF: unilateral eksternal fiksatör

Shortening with deformity due to tumours itself

There were four patients in this group (two male , two female ; average age 12; from 8-14). Four limbs of three patients with congenital multiple exostosis, one patient with Olier's disease (distal femur genu varum, tibia proximal genu valgum and shortness) were examined in this group. Average time passed from the first surgery to the utilisation of external fixator was 6.5 (from 6 to 8) months.

Lengthening over K wire on both two ulnas of one of our patients and acute correction to radius after exostosis excision in ulnar distal and ulnar lengthening was done in our other patients. Lengthenings were done gradually. Unilateral external fixator was used in our patients. In figure 3, treatment processes and results of gradual ulnar lengthening and acute radial correction of one patient who was monitored due to multiple exostosis. Gradual oblique plan deformity correction and lengthening was done to tibia by using ilizarov type circular external fixator and gradual lengthening was done to femur by using unilateral external fixator in Olier's disease patient.

Average shortness was 3.3 (from 2.3 to 9.5) cm (2.3 cm in congenital exostosis patient and 9.5 cm Olier's disease patient) and average external fixator time was 6.5 (from 4 to 9) months. Average lengthening amount 3.4 (2.9 - 9) cm (from 2.8 to 9) (2.8 cm in congenital exostosis patient and 9 cm Olier's disease patient). External fixator index was 57.18 day/cm. Deformity correction and lengthening was performed successfully in all patients. When compared to the other side, in order to prevent the shortness that may be developed after growth attack, 0.5 cm more ulnar lengthening was applied to the patients who has congenital multiple exostosis. (Figure 3)

Discussion

Especially in the patients with life expectancy more than 5 years, limb salvage surgery after bone tumour has become the standard approach compared

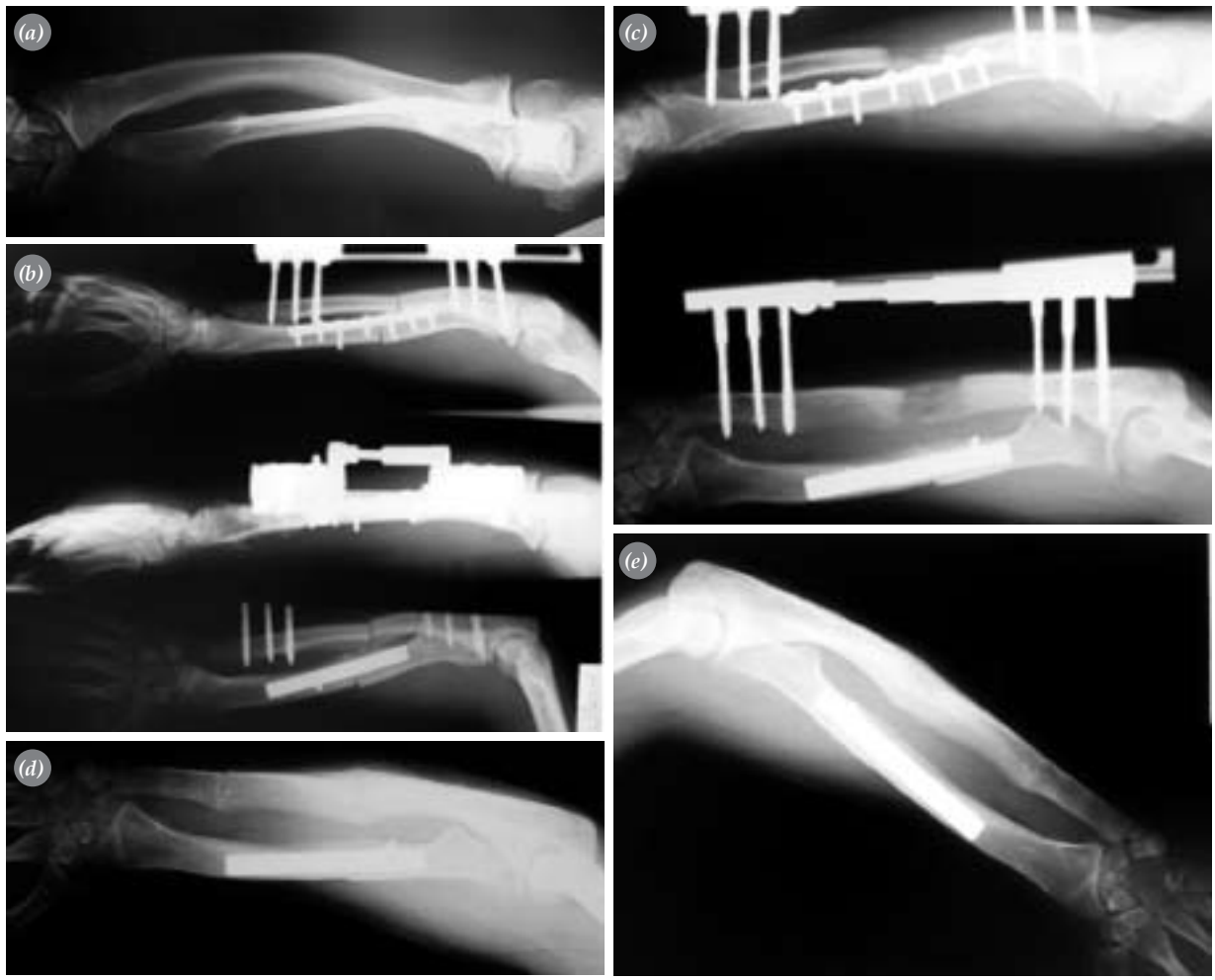

Figure 3. 14 years old boy, kongenital multipl encondromatosis.**(a-c)** R ulnar club hand, radius acute deformity correction with plate-screw fixation and ulna deformity correction and lengthening with external fixator , removal of fixator in the 4.month **(d,e)**: The x rays in the 6. month.

to amputation because of its functional outcomes. [3]. With the increase of utilisation of limb salvage surgery, complications of limb salvage surgery also indicate and increase. Among these complications, loss of graft and loosening of prosthesis, allograft and prosthesis infection which may even lead to loss of limb can be counted.[4,5] The risk of early complication shows increase, especially local decrease of soft tissue bulk with utilisation of chemotherapy or combination of chemotherapy with radiotherapy.[4] Loosening and breakage of prosthesis, nonunion in allograft are the complications that are seen in long period. Amputation, prosthesis revision, rotationplasty and arthrodesis are the options that may be used for treatment of these complications. Because of rigid social and psychological approaches, reconstructive surgery application is a more valid option to amputation. [6] Single or double stage prosthesis revision may be applied but infection rate in revision prosthesis are seen unacceptably high. Resection arthroplasty and brace usage can be recommended to the patients for the patients that do not accept reconstructive surgery utilisation.

In an ideal reconstruction, bone should have a firm and infection resistant mechanical stability which is called biological reconstruction by using external fixator.[1] Failure risk of limb salvage surgery varies depending on the status of soft tissue, closeness to knee joint and utilisation of chemotherapy and/or radiotherapy.[7] In the presence of these risk factors the option of treatment with external fixator comes to the front as limb salvage surgery option. Distraction osteogenesis is commonly used for deformity correction, nonunion, loss of bone and bone infection.[2,10] However its usage for reconstruction of defects re-

mained after bone resection done due to benign or malignant bone tumours is also defined.[1,11] Ozaki et. al. have notified high complication rates in distraction osteogenesis done with ilizarov after sarcoma resection.[12] In this study, average bone loss was notified as 17 cm and external fixator index was notified as 95 day/cm. They have linked their poor results to excessive soft tissue resection and to adjuvant chemotherapy following tumour resection. Chemotherapy delays the bone recovery and causes prolongation of external fixator time.

In this study, average bone loss in two group were respectively 10.6 cm and 6.5 cm, average external fixator utilisation time were respectively 14.8 months and 5.8 months. Fixator index in treatment in first group was found 48.84 day/cm and in second group was found 28 day/cm. We think that less tissue resection and making lengthening over nails in 5 of our 11 patients were among the reasons of having better results in this study. In the study of Kocao_lu et al. about reconstruction of bone defects in chronic bone infection, it is emphasised that lengthening over nail is together with increased patient comfort and decreased external fixator time.[13]

Moreover, because of the time between external fixator utilisation and last surgical attempt, no negative impact of chemotherapy on bone recovery was seen in our study. Bone recovery with external fixator provides a good biomechanical stability and has an important place at avoiding complications that may be developed due to utilisation of prosthesis and allograft particularly in young patients.[1] External fixator time can be decreased by lengthening over nail.

In first group, amputation was done in two patients that lung metastasis was occurred during uncontrolled bone infection and bone infection treatment. In both patients, tumour was around knee and had malign soft tissue. In the patients with high risk, ablative surgery in early stage is recommended.[7]

In third group, deformities developed secondarily to tumour were taken into the study. Around forearm, there was shortness in ulna due to congenital multiple exostosis and varus deformity in wrist. Although various treatment options were proper, the one that was agreed is ulna lengthening and deformity correction operation with osteotomy to radius.[14] . Gradual lengthening prevents nerve and vascular complications. In order to prevent deformity recurrence, additional lengthening is required for our adolescent patients. In our study, approximately 0.5 cm additional lengthening in ulna to our adolescent patients was made compared to the other side. In Olier's disease patient, deformity correction in knee and ankle surrounding was done together with tibia and femur lengthening. In Olier's disease, discrepancy between deformity and lengthening is commonly seen.[15] The disease, due to its wide distribution nature, cannot be removed with curettage and because of the same reason utilisation of internal detection methods for the correction of deformities are not proper.[15] External fixator is a proper treatment method that is used for deformity correction and provides doing lengthening at the same time. However, although we couldn't reach a conclusion basing on this, successful results with external fixator have been notified in the literature.[15]

In the patients with bone tumour, since limb salvage is aimed in especially young patients in the treatment of tumour itself and the treatment of complications developed after tumour surgery, long term and permanent solutions are needed. Complications developed due to tumour's own course or after its surgery are large bone defect, nonunion, infection or deformity. Distraction osteogenesis done with external fixator was used for both regaining lost bone tissue and providing union. External fixator is a successful method for the permanent treatment of developed complications. However long time problem in the lengthenings with external fixators can be overcome with external fixator method utilised together with nail method.

References

1. Tsuchiya H, Tomita K, Minematsu K, Mori Y, Asada N, Kitano S. Limb salvage using distraction osteogenesis. A classification of the technique. J Bone Joint Surg [Br] 1997; 79:403-11.
2. Ilizarov GA. Clinical application of the tension-stress effect for limb lengthening. Clin Orthop Relat Res 1990;(250):8-26.
3. Frink SJ, Rutledge J, Lewis VO, Lin PP, Yasko AW. Favorable long-term results of prosthetic arthroplasty of the knee for distal femur neoplasms. Clin Orthop Relat Res 2005;(438):65-70.
4. Matejovsky Z Jr, Matejovsky Z, Kofranek I. Massive allografts in tumour surgery. Int Orthop 2006;30:478-83.
5. Manoso MW, Boland PJ, Healey JH, Cordeiro PG. Limb salvage of infected knee reconstructions for cancer with staged revision and free tissue transfer. Ann Plast Surg 2006;

56:532-5.
6. Postma A, Kingma A, De Ruiter JH, Schraffordt Koops H, Veth RP, Goëken LN, et al. Quality of life in bone tumor patients comparing limb salvage and amputation of the lower extremity. J Surg Oncol 1992;51:47-51.
7. Hardes J, Gebert C, Schwappach A, Ahrens H, Streitburger A, Winkelmann W, et al. Characteristics and outcome of infections associated with tumor endoprostheses. Arch Orthop Trauma Surg 2006;126:289-96.
8. Capanna R, Morris HG, Campanacci D, Del Ben M, Campanacci M. Modular uncemented prosthetic reconstruction after resection of tumours of the distal femur. J Bone Joint Surg [Br] 1994;76:178-86.
9. Ogose A, Hotta T, Kawashima H, Kawaji Y, Endo N. Ischial weight-bearing brace after the infection of megaprosthesis a salvage method for resection arthroplasty. J Arthroplasty 2005;20:954-6.
10. De Bastiani G, Aldegheri R, Renzi-Brivio L, Trivella G. Limb lengthening by callus distraction (callotasis). J Pediatr Orthop 1987;7:129-34.
11. Tsuchiya H, Tomita K, Shinokawa Y, Minematsu K, Katsuo S, Taki J. The Ilizarov method in the management of giant-cell tumours of the proximal tibia. J Bone Joint Surg [Br] 1996;78:264-9.
12. Ozaki T, Nakatsuka Y, Kunisada T, Kawai A, Dan'ura T, Naito N, et al. High complication rate of reconstruction using Ilizarov bone transport method in patients with bone sarcomas. Arch Orthop Trauma Surg 1998;118:136-9.
13. Kocaoğlu M, Eralp L, Rashid HU, Şen C, Bilsel K. Reconstruction of segmental bone defects due to chronic osteomyelitis with use of an external fixator and an intramedullary nail. J Bone Joint Surg [Am] 2006;88:2137-45.
14. Matsubara H, Tsuchiya H, Sakurakichi K, Yamashiro T, Watanabe K, TomitaK. Correction and lengthening for deformities of the forearm in multiple cartilaginous exostoses. J Orthop Sci 2006;11:459-66.
15. Watanabe K, Tsuchiya H, Sakurakichi K, Yamashiro T, Matsubara H, Tomita K. Treatment of lower limb deformities and limb-length discrepancies with the external fixator in Ollier's disease. J Orthop Sci 2007;12:471-5.