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Proximal Femur Salvage in Revision Knee Arthroplasty Due to Oncologic Indications: Long-term Results of Onlay and Overlapping Allograft in Revision Surgeries

Sanghyun Cho, MD*, Dae-Geun Jeon, MD*, Wan Hyeong Cho, MD*, Won Seok Song, MD*, Yongsung Kim, MD*,†

*Department of Orthopedic Surgery, Korea Cancer Center Hospital, Seoul,
†Department of Orthopedic Surgery, Seoul National University Bundang Hospital, Seongnam, Korea

Background: Mechanical failures of tumor endoprosthesis in the distal femur usually require revision surgery. We investigated if the proximal femur host bone can be salvaged by onlay and overlapping allograft in revision surgeries due to aseptic loosening and stem fractures.

Methods: We retrospectively reviewed 18 patients (7 men and 11 women) with osteosarcoma around the knee. The entire cohort was classified into three subgroups (no bone graft: 6, onlay allograft: 7, and overlapping allograft: 5) according to our treatment strategy.

Results: The median interval from the initial surgery to the revision was 94.5 months (range, 21–219 months), and the median follow-up period from the revision surgery was 88.0 months (range, 24–179 months). At the last follow-up, 9 of the 18 patients maintained their endoprostheses, and the 5-year prosthesis survival rate was 57.9%. Limb survival was 100%. Five-year prosthesis survival rate was 66.7% in the no bone graft group, 85.7% in the onlay allograft group while 30.0% in the overlapping allograft group. In the no bone graft group and onlay allograft group, 66.7% (4/6) and 57.1% (4/7) maintained their revision prostheses while no prostheses survived in the overlapping allograft group. Recurrent stem loosening was observed in 14.2% (1/7) and 60.0% (3/5) of the onlay allograft and overlapping allograft groups, respectively, despite allograft bone union. The complication rate was 66.7% (12/18) in the entire cohort. The most common type of complication was infection (n = 6), followed by aseptic loosening (n = 4) and mechanical failure (n = 2).

Conclusions: This study indicates that onlay allograft can be used as a supportive method in revising failed endoprosthesis if the extent of host bone destruction is extensive. However, applying overlapping allograft to secure bone stock showed a high rate of mechanical failures and infection in the long term. Future studies with a larger cohort are necessary to assess the prognostic factors for the higher complication rate in overlapping allograft and the need for overlapping allograft. Surveillance with consideration of the risk of anteromedial osteolysis in allograft and efforts for prevention of periprosthetic infection are essential.

Keywords: *Prosthesis failure, Complication, Loosening, Revision, Femur*

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Correspondence to: Yongsung Kim, MD
Department of Orthopedic Surgery, Seoul National University Bundang Hospital, 82 Gumi-ro 173beon-gil, Bundang-gu, Seongnam 13620, Korea
Tel: +82-31-787-7214, Fax: +82-31-787-4056, E-mail: yong.kim@snu.ac.kr

Prosthetic reconstruction is one of the most common strategies performed after the surgical excision of a bone tumor.[1-3] This modular type reconstruction has many advantages such as initial stability and rapid restoration of function.[4-6] However, the complications of prosthesis use and failure of reconstruction have increased as the life expectancy of young patients has increased with successful adjuvant treatment.[7]

The most common complication of endoprostheses around the knee in the late period is aseptic loosening.[7] Mechanical failure remains as a major problem in long-term survival of prosthesis and usually requires revision surgery.[8,9] According to a comprehensive analysis of 534 cases by Henderson et al.,[10] infection was the most common mode of failure and aseptic loosening was the second when the location was confined to knee joints (13.9%–24.9%). Stem fracture is known to occur in 1.6 % to 6.3% of uncemented tumor prostheses.[11,12] This type of mechanical failure also requires revision surgery with removal of the broken stem.[13] Except for trauma cases, most of stem fractures occur as a mid- to long-term complication. Yoshida et al.[14] reported 6 cases of stem fracture, which happened during a mean period of 68.3 months after primary surgery. Aseptic loosening and stem fractures have in common that revision procedures cause host bone destruction. Cortical windows for broken stem removal and removing endosteal bone cement with a curette, drill, or burr can cause weakening of the host femur. The incidence of cortical perforation in revision surgery is known to be 13%.[15] In addition, being the late-period complication, the quality and length of the remnant bone is often compromised due to osteoporosis from disuse, cortical atrophy, or previous revision procedures.[7,16,17] Minimizing the host bone destruction while removing the stem or bone cement is important for restoring proper fixation of the stem.

Firm fixation of the stem is another challenging issue, which affects the prosthesis survival. To improve fixation of the stem in revision surgery, we have used allograft in an onlay or overlapping fashion according to the extent of the host bone destruction.[18-20] We hypothesized that bone grafting in an onlay or overlapping fashion in the case of host bone loss can function as a biological plate with additional bone stock. To our knowledge, there are few reports on the revision outcome of endoprosthetic reconstruction around the knee regarding specific complications such as stem fractures and aseptic loosening, which cause inevitable host bone destruction.[21-26] We therefore sought to find whether we could salvage proximal femur bone stock with these procedures by analyzing clinical outcomes of revision surgeries in patients with osteosarcoma of the distal femur. Specifically, we aimed to document the followings: (1) What is the overall survival of the prostheses according to the strategies? (2) What types of failure were observed in each subgroup? (3) Are the results of onlay allograft and overlapping allograft acceptable for the restoration of proximal femur bone stock in revision surgeries compared to those reported in previous literatures?

METHODS

This study was approved by Institutional Research Review Board of Korean Cancer Center Hospital (No. 2020-04-012). Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

Study Design and Setting

A retrospective review was initiated following Institutional Review Board approval. We reviewed medical records in our institute from 1999 to 2018. In total, 381 patients had osteosarcoma of the distal femur or proximal tibia. Among them, 73 patients with insufficient medical records were excluded and 308 patients were left for analysis (distal femur, 211; proximal tibia, 97). The inclusion criteria were as follows: patients with (1) osteosarcoma around the knee, (2) revision surgery in the distal femur, and (3) a minimum follow-up of 2 years. Among 60 patients who underwent revision surgery in the distal femur, we extracted patients who underwent revision surgery due to aseptic loosening or a stem fracture. After excluding 23 patients with periprosthetic fractures, 12 patients with periprosthetic infection, and 7 patients with tumor progression, 18 patients (12 patients with aseptic loosening and 6 patients with stem fracture) were left for analysis.

Demographic Data

Clinicopathological and demographic information included sex, age, pathologic diagnosis, primary location, location of mechanical failure, reconstruction method at initial surgery/revision surgery, resection rate, use of bone cement, the number of previous surgeries, interval from previous surgery, and final status of the patients (Table 1). In the entire cohort, there were 7 male patients and 11 female patients with a median age of 25.0 years (range, 12–43 years). All patients were diagnosed with osteosarcoma in the postoperative pathologic diagnosis and

Table 1. Demographic Data of the Patients

No.	Age (yr)	Sex	Location of tumor	Initial reconstruction	Resection rate (%)	Cement	Number of previous surgeries	Prosthesis at the time of revision	Type of failure	Interval from initial surgery (mo)	Local recurrence	Metastasis at diagnosis	Last status
1	23	F	DF	Arthrodesis	37.5	Cemented	1	Endo knee	Loosening	120	No	No	CDF
2	31	M	DF	Endo knee	44.4	Cemented	1	Endo knee	Loosening	187	No	No	CDF
3	32	F	DF	Kotz	59.1	Cemented	3	Kotz	Loosening	35	No	No	CDF
4	21	F	DF	Endo knee	31.5	Cemented	1	Endo knee	Loosening	89	No	No	CDF
5	18	M	DF	Endo knee	28.5	Cemented	Primary	Endo knee	Loosening	169	No	No	NED
6	30	M	DF	Endo knee	53.9	Cemented	Primary	Endo knee	Loosening	123	No	No	CDF
7	24	F	PT	Arthrodesis	-	Cemented	8	APC	Loosening	52	No	No	CDF
8	27	F	DF	APC	40.6	Cemented	1	MUTARS	Loosening	55	No	No	NED
9	21	F	DF	MUTARS	36.9	Cemented	Primary	MUTARS	Loosening	100	No	No	CDF
10	26	M	DF	APC	28.9	Cemented	1	APC	Loosening	32	No	No	NED
11	40	M	DF	Endo knee	38.1	Cemented	4	MUTARS	Loosening	129	No	No	CDF
12	28	F	DF	MUTARS	62.2	Cemented	Primary	MUTARS	Loosening	50	No	No	NED
13	20	F	DF	Kotz	67.9	Cementless	Primary	Kotz	Stem fracture	57	No	No	CDF
14	16	F	DF	Endo knee	38.3	Cemented	Primary	Endo knee	Stem fracture	36	No	No	NED
15	15	M	DF	Kotz	47.7	Cementless	Primary	Kotz	Stem fracture	21	No	No	CDF
16	12	F	DF	arthrodesis	59.3	Cementless	1	Kotz	Stem fracture	195	No	No	CDF
17	43	F	DF	Endo knee	38.9	Cemented	Primary	Endo knee	Stem fracture	219	No	No	CDF
18	33	M	DF	Endo knee	46.6	Cemented	1	Endo knee	Stem fracture	122	No	No	NED

DF: distal femur, CDF: continuously disease-free, NED: no evidence of disease, PT: proximal tibia, APC: allograft-prosthesis composite.

the primary location was the distal femur in 17 patients (94.5%) and the proximal tibia in 1 patient (5.5%). Wide excision was performed in all cases. In 15 patients (83.4%), reconstruction with a mobile joint prosthesis was done while arthrodesis with flexible intramedullary nails and bone cement augmentation was performed in 3 patients (16.6%; patients 1, 7, and 16). These 3 patients underwent revision surgery and changed their joints to prostheses. The location of mechanical failure was all in the distal femur and no failures were observed in the tibia. Of the 18 patients (loosening, 12; stem fracture, 6), 8 patients were in the primary surgery status at the time of failure and 10 were in the revision surgery status. The causes of revision surgery before the failure included correction of leg length discrepancy (n = 5), periprosthetic infection (n = 2), and change from arthrodesis to endoprosthesis (n = 3). At the time of the index surgery, which is the revision surgery due to mechanical failure including aseptic loosening or stem fracture, the 3 patients with initial arthrodesis had revision surgeries of the mobile joints. Regarding the type of prosthesis at the time of revision, 4 patients received the Kotz Modular Femur Tibia Reconstruction system (KMFTR; Stryker Inc., Mahwah, NJ, USA), 8 patients received Endo-Model® Knee (Link) prostheses, 4 patients received MUTARS, and 2 patients underwent pasteurized autograft-prosthesis composite reconstruction with Endo-knee Model Knee (LINK, Germany). The median resection rate, which was defined as the percentage of resected bone length divided by the whole bone length, was 40.6% (range, 28.5%–67.9%). In case 7, the primary location of the tumor was the proximal tibia and we did not include the resection rate (31.5%) of this site since the failure occurred in the distal femur. There were 3 cementless fixations in patients with stem fractures while all the patients with aseptic loosening were operated with cemented fixation. All patients had clinical symptoms, including pain and subjective instability with an average duration of 3.5 months (range, 0.5–12.0 months). In the stem fracture group, there were no patients with history of trauma. Average body mass index at the time of revision surgery was 22.2 kg/m^2 (range, 19.4–25.1 kg/m^2). At the time of failure, leg length discrepancy more than 2 cm was identified in 5 patients while only 2 patients (patients 9 and 16) mentioned discomfort. None of the patients in the entire cohort had a soft-tissue defect. The median interval from the initial surgery to the revision was 94.5 months (range, 21–219 months).

Surgical Technique

The entire cohort was classified into three subgroups (no bone graft, 6; onlay allograft, 7; and overlapping allograft, 5) We treated all cases according to the strategy as follows (Fig. 1): (1) When the extent of cortical bone destruction was minimal and less than one third in longitudinal circumference and the quality of the host bone stock was intact, stem fixation was performed with bone cement and no bone graft. (2) If the extent of host bone destruction was more than one third in circumference or more than a half-stem length in longitudinal, we performed cement fixation of the stem, applied strut allograft in the onlay fashion, and fixed with wiring. In detail, fresh-frozen strut allograft was cut into 3 to 4 bars with the length of stem 2–3 cm. These allografts were placed around the distal host bone-stem junction fixed with at least two cerclage wires (Fig. 2A-C).[18] (3) If the bone defect during revision procedure was extensive with poor host bone quality, we resected certain amount of the distal host bone until we reached the bone with satisfactory quality. When the remaining femur was not long enough for a longer stem (150–200 mm), we applied fresh-frozen femur allograft in the overlapping fashion and cemented stem fixation with a longer stem (Fig. 2D and E). The mean length of the additionally resected host bone in our study was 6.8 cm (range, 2.9–10.1 cm). This procedure was done according to our previous study.[20] Regarding the extent of the endoprosthesis change, stem revision was performed in 8 cases; 10 cases required whole prosthesis revision (Table 2).

Aseptic Loosening

In cases of aseptic loosening, the loosened stem might be easily removed. However, the remnant bone cement attached to the endosteal canal must be removed thoroughly via curettage or burr. All patients in our cohort with aseptic loosening had cemented stems. Among 12 patients

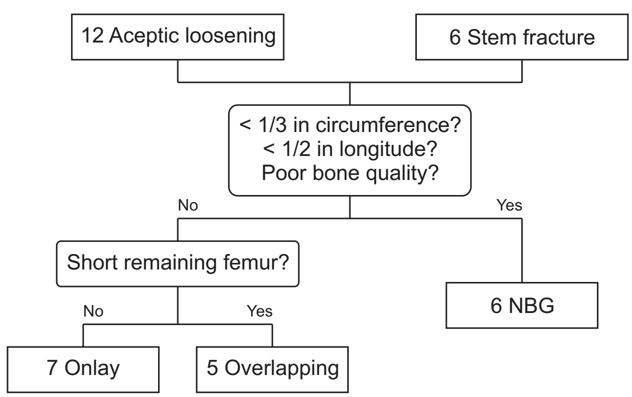

Fig. 1. Authors' treatment strategy according to the extent of host bone destruction. NBG: no bone graft.

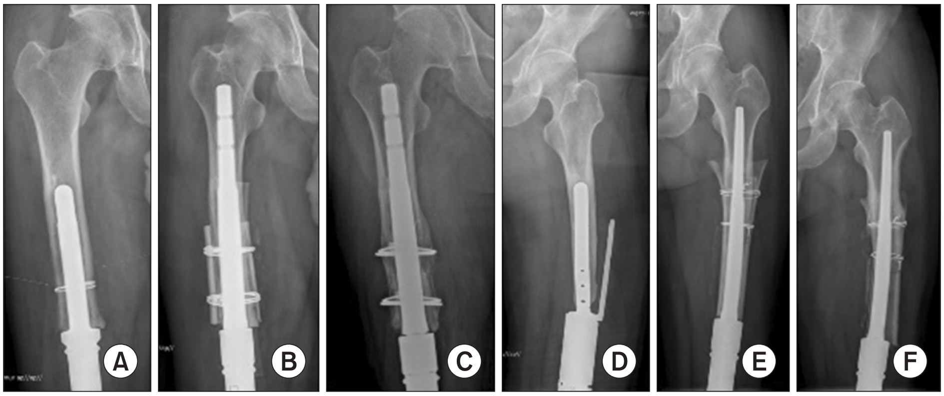

Fig. 2. (A) Plain radiograph of a 27-year-old female patient (case 8) with aseptic loosening in the distal femur. (B) Stem revision with onlay allograft was performed 4.6 years after the previous surgery. (C) The final follow-up radiograph shows a well-fixed stem and bone union. (D) Plain radiograph of a stem fracture in the femur in a 15-year-old male patient (case 15). (E) Stem revision with overlapping allograft was performed 1.8 years after the previous surgery. (F) The X-ray taken 2 years and 10 months postoperatively shows recurrent loosening of the stem in the medial aspect.

with aseptic loosening, 5 patients did not require allograft, 4 patients had onlay allografts, and 3 patients underwent overlapping allograft.

Stem Fracture

In most cases of stem fracture, the broken stem was left inside the host bone and approached by making a cortical window with a saw or chisel. We usually made a bar-shaped cortical window in size of less than one third in circumference and less than half in length. After removal of a broken stem, additional bone cement removal was necessary in cases the stem was fixed with bone cement. In our cohort, all 6 patients underwent cortical window osteotomy for exposure of the broken stem. Among stem fracture patients, 3 patients (50.0%) had cemented stems and 3 patients (50.0%) had cementless stems. After removal of the broken stem, the cortical window was restored to the original site and fixed with wiring. Refixation of the stem was performed with the same strategy as aseptic loosening. Among 6 patients with stem fractures, 1 patient did not require allograft, while 3 patients and 2 patients received onlay allograft and overlapping allograft, respectively.

Rehabilitation

Joint range of motion exercise was started 10 days to 2 weeks postoperatively. After 4 to 5 weeks of partial weight-bearing, we allowed full weight-bearing when joint stability was confirmed via radiography. We performed simple radiography every month for the first 3 months postoperatively and then every 3 months thereafter to confirm bone union of the host bone-allograft junction or cortical window.

Survival Analysis

Statistical analysis of the data focused on survival of the implant and endpoint of the investigation was revision resulting from any cause. Prosthesis failure was defined as surgical removal of the original endoprosthesis. Prosthesis survival according to treatment strategy was analyzed with the Kaplan-Meier survival methods and log-rank test. Complications were classified according to the Henderson et al.[10] On mechanical failure, we reviewed presences of cortical atrophy, trauma, infection, and soft-tissue defect at the time of failure. If the allograft was applied at the time of revision surgery, bone union was confirmed with simple x-ray and computed tomography. Descriptive summary included means and frequencies of cases. We used IBM SPSS ver. 24.0 (IBM Corp., Armonk, NY, USA) for statistical analysis.

RESULTS

Post-revision Survival of the Prosthesis

The median follow-up period from the revision surgery was 74.0 months (range, 24–217 months). At the last follow-up, 8 of the 18 patients maintained their endoprostheses, and the 5-year and 10-year prosthesis survival rate was 57.9% and 44.4%, respectively. Limb survival was 100%. In subgroups, the 5-year prosthesis survival rate was 66.7% in the no bone graft group, 85.7% in the onlay allograft group, and 30.0% in the overlapping allograft group ($p = 0.518$). Regarding the bone union, the union rate of the entire cohort was 83.3% (10/12) and the rates of onlay allograft group and overlapping allograft group were 85.7% (6/7) and 80.0% (4/5), respectively (Table 2). The period of bone union did not show statistically significant difference ($p = 0.639$).

Table 2. Summary of Revision Procedures and Final Status of the Cohort

No.	Cortical window	Extent of revision	Bone graft	Bone union (mo)	Complication	Interval from revision to re-revision (mo)	FU period from revision (mo)	Final status
1	No	Implant change to MUTARS	No	NBG	No	47	-	Stationary
2	Yes	Stem	No	NBG	Infection	11	32	Implant change
3	No	Implant change to MUTARS	No	NBG	Infection	4	27	Implant change
4	No	Implant change to MUTARS	No	NBG	No	159	-	Stationary
5	No	Implant change to MUTARS	No	NBG	No	39	-	Stationary
6	Yes	Implant change to MUTARS	Onlay allo	11	No	88	-	Stationary
7	No	Stem	Onlay allo	12	No	37	-	Stationary
8	No	Stem	Onlay allo	15	No	101	-	Stationary
9	No	Stem	Overlapping allo	13	PEEK fracture	26	56	Insert change
10	No	Implant change to MUTARS	Overlapping allo	11	Loosening	21	53	Implant revision
11	No	Stem	Onlay allo	13	Stem fracture, infection	72	104	Arthrodesis due to infection
12	No	Stem	Overlapping allo	11	Loosening, infection	56	108	Implant change to total femur
13	Yes	Stem	Onlay allo	18	Loosening	180	217	Conservative treatment
14	Yes	Stem	No	NBG	No	179	-	Stationary
15	Yes	Implant change to MUTARS	Overlapping allo	14	Loosening	98	98	Conservative treatment
16	Yes	Implant change to MUTARS	Onlay allo	11	No	88	-	Stationary
17	Yes	Implant change to MUTARS	Overlapping all	Nonunion	Infection	3	24	Arthrodesis due to infection
18	Yes	Implant change to MUTARS	Onlay allo	Nonunion	Infection	3	60	Implant change

FU: follow-up, NBG: no bone graft, PEEK: polyethylene insert.

Subgroup Analysis of Complications after Revision Surgeries

Although prosthesis survival did not show statistically significant difference among three subgroups, the complication rate was higher in groups with allografts than without allografts. Complication incidence was 63.1% (12/19) in the entire cohort. The most common type of complication was periprosthetic infection (n = 6), followed by aseptic loosening (n = 4), and structural failure (n = 2). Recurrent aseptic loosening was observed in 14.2% (1/7) and 60.0% (3/5) of onlay allograft and overlapping allograft groups, respectively.

In patients without allograft, there were no mechanical failures (Fig. 3A) Two patients (28.6%) had complications of deep infection at 11 months and 47 months after revision surgery. Both patients underwent two-staged surgery of incision and debridement with antibiotic bone cement spacer insertion for staged prosthesis re-insertion. Three out of seven patients (57.1%) with onlay allograft had complications in median period of 88 months (range, 3–180 months) (Fig. 3B). There were 2 cases of mechanical failures in this group. Stem fracture occurred in patient 11 after 72 months of revision surgery. Additional loosening was observed 15 years after revision surgery in patient 13. The patient refused surgery and was under close observation. Periprosthetic infection occurred in 2 patients (patients 11 and 18) after 4 and 3 months postoperatively.

All the patients with overlapping allograft had com-

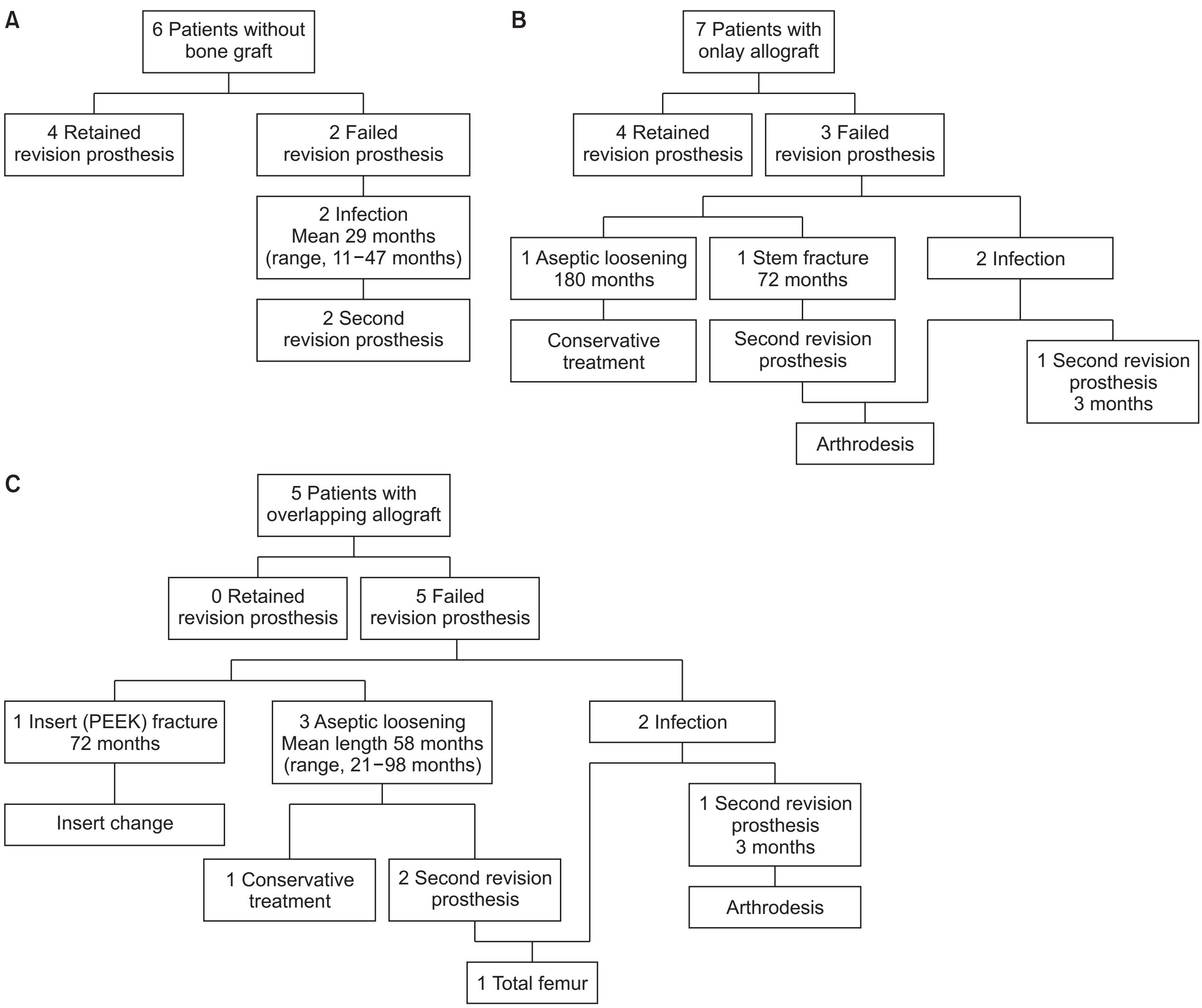

Fig. 3. The clinical course of patients without bone graft (A), with onlay allograft (B), and with overlapping allograft (C) are summarized in the flow diagram, with the mean time to complications listed for mechanical and other failures. PEEK: polyethylene insert.

plications in median period of 26 months (range, 3–98 months) (Fig. 3C). There were 3 cases of major mechanical failures with a minor failure. Aseptic loosening occurred in 3 patients. There were 2 cases of periprosthetic infection and 1 case of insert fracture. In patients 10 and 12, loosening occurred at 21 and 56 months after revision surgery and they underwent prosthesis revision with allograft change. Patient 12 showed recurrent loosening with osteolysis of medial aspect allograft. After allograft change and refixation, periprosthetic infection occurred. This patient ended up having total femur replacement after 3 times of revision due to recurrent infection and insufficient bone stock in the proximal femur at 47 months after revision surgery. In patient 15, signs of medial osteolysis of overlapping allograft was observed in simple X-ray at 62 months after revision without any symptoms. The stem showed superior migration with additional loosening (Fig. 2F). The patient refused further treatment due to lack of symptoms and was under regular surveillance. Patient 9 had a polyethylene insert (PEEK) fracture at 26 months after revision and underwent minor insert change surgery. Besides patient 12, patient 11 had deep infections at 3 months after revision surgery. Recurrent infection occurred after prosthesis removal, incision, and debridement with antibiotic bone cement spacer insertion for staged prosthesis reinsertion. This patient finally ended up having arthrodesis due to recurrent infection.

DISCUSSION

There is no standard treatment in revision surgery of failed tumor prostheses around the knee. In general, options are press-fit fixation, cemented fixation, allograft-prosthesis composite, and total femur replacement. Their long-term prosthesis survival is reported as poor.[21,22,24,25)]

Especially in cases with inevitable host bone destruction during revision procedures, proper fixation method is challenging. We hypothesized that bone grafting in the onlay and overlapping fashion could compensate for severe bone loss in specific cases such as mechanical loosening and stem fracture. We sought to find whether this procedure could help in salvaging proximal femur bone stock. We found that the 5-year prosthesis survival of our cohort was 57.9% with 100% of final limb survival. In subgroup analysis, the onlay allograft group showed a comparable survival rate to the no bone graft group. However, patients with overlapping allograft had the highest complication rate with 30% of prosthesis survival rate. In this group, 3 out of 5 patients showed recurrent aseptic loosening. Immediate postoperative infection was higher in groups with bone graft. Thus, salvage procedure of proximal femur with overlapping allograft did not achieve satisfactory results.

Our study has several limitations. First, the small cohort size precluded meaningful statistical analysis of our results. However, the cohort was homogeneous in terms of anatomical location and the study focused on specific types of mechanical failures as opposed to other literatures in which revision patients with different anatomic locations and all types of failures were comprehensively analyzed.[21,22,24-27)] Second, we had difficulty in classifying the extent of host bone destruction. Poor bone quality due to revision procedures or osteoporosis was also difficult to assess. Instead, we weighed on the quantitative extent of destruction and applied a different treatment strategy. Lastly, this is a retrospective analysis of osteosarcoma patients who underwent revision of tumor prostheses due to mechanical failures. Therefore, there is the possibility of selection bias regarding the treatment and follow-up of patients in the cohort.

The Kaplan-Meier prosthetic survivorship of the entire cohort showed 57.9% and 44.4% at 5 years and 10 years, respectively. This result is comparable to previous literature (Table 3). Unwin et al.[21)] reported a 5-year survival rate of 19% in their study with revision distal femur prostheses. In a follow-up report published in 1995, the 5-year survival rate of the prostheses of mixed anatomic locations was 45%.[22)] Four years later, Shin et al.[26)] and Wirganowicz et al.[23)] reported their analyses of revision surgeries in various anatomic sites. Shin reported 65% of 10-year prosthesis survival in 35 prosthesis revisions and Wirganowicz et al.[23)] reported 34% of failure rate at 5 years. However, recent studies of Pala et al.[25)] and Zimel et al.[27)] showed higher survival rates and lower complications than our data. Interestingly, Pala et al.[25)] reported better survivorship of their revision prostheses than that of primary reconstructions (80% vs. 65%).[25)] Zimel et al.[27)] also reported excellent results of 11% mechanical failure with modern prostheses. Although a comparison is difficult due to our heterogenous prostheses, our focus on host bone loss during revision surgery and inclusion criteria for patients with aseptic loosening and stem fracture cases do not violate assessing the prosthesis survival and the results are compatible with other literatures.

The onlay allograft group showed comparable results with no bone graft group while overlapping allograft for compensation of host bone loss had higher incidence of mechanical failure than other groups. We carefully investigated to identify any possible contributing factors to higher complications. Onlay allograft is a well-known

Table 3. Previous Literatures and Current Study on Clinical Outcomes of Revision Surgeries of Tumor Prostheses around Knee

Study	Year	Number of patients	Site	Prosthesis	Prosthesis survival rate (%)
Unwin et al.[21]	1991	47	DF	Stanmore custom (Elstree)	18.8 (5 yr)
Shin et al.[26]	1999	35	DF, PT	Custom	65 (10 yr)
Morgan et al.[24]	2006	32	DF, PT	HMRS (Stryker)	44 (10 yr)
Pala et al.[25]	2015	72	DF, PT	GMRS (Stryker)	72 (8 yr)
Zimel et al.[27]	2016	27	DF	The Compress Compliant Pre-Stress implant (Biomet)	71 (10 yr)
This study	2020	18	DF, PT	KMFTR (Stryker), Endo-Model knee (LINK), MUTARS (Implant cast)	57 (5 yr)

DF: distal femur, PT: proximal tibia, HMRS: Howmedica Modular Replacement System, GMRS: Global Modular Replacement System, KMFTR: Kotz Modular Femur Tibia Reconstruction system.

method for increasing bone stock and achieving high rates of fracture union in periprosthetic fractures. Haddad et al.[18] reported 98% (39/40) fracture union rate using strut allograft as a biologic plate within a mean period of 28 months. In our cohort, bone union of allograft was achieved within 2 years (range, 11–18 months) except for 1 case in which allograft was removed due to periprosthetic infection. Recurrent aseptic loosening in the onlay allograft group (n = 1, patient 13) developed after 180 months, which is far longer than the period mentioned in references. According to Emerson et al.,[28] the allograft is the weakest at 4 to 6 months due to its remodeling process and vulnerable to mechanical failure. Morgan et al.[24] reported that the incidence of failures was highest within 3 years and aseptic loosening was the most common cause. The stem fracture in patient 11 occurred 72 months after the revision surgery. The host bone and onlay allograft were properly remodeled at second revision, which required substantial host bone loss to remove the broken stem. Considering the long interval and acceptable maturation of allograft from simple X-ray, onlay allograft is not likely the major contributor of recurrent mechanical failure.

Although the overlapping allograft method is also a useful technique for reconstructing major segments of diaphysis when remnant host bone is insufficient, our results showed the highest incidence of failures among three groups.[19,20] We observed gradual osteolysis in the anteromedial aspect of the allograft in 3 patients with recurrent loosening. This phenomenon causes varus stress and aggravated loosening results in proximal migration of the stem. Apparent loosening was observed at a mean of 58 months postoperatively. Bone union was achieved in 4 of 5 cases in a mean period of 12.2 months (range, 11–14 months). There was no gross and radiological mal-alignment and all 5 patients were in the primary surgery status. Emerson et al.[28] reported in his series of revision total hip replacement arthroplasties that osteolysis was the most common cause of bone loss and medial bone deficit was twice as common as lateral and suggested that allograft by itself cannot provide full support for femoral component. This means highest stress is applied on the medial aspect of the bone-implant junction. Not only the extensive host bone destruction, but also the poor quality of host bone might have contributed to this phenomenon. In addition, limited availability of allografts with optimal size at the time of surgery may have influenced appropriate stem fixation. Thus, our results show that overlapping allograft solely may not be a sufficient strategy for bone stock restoration. Recently, Zimel et al.[27] reported the long-term clinical outcome of their novel Compress Compliant Pre-stress implant system for failed distal femoral megaprostheses with cortical bone loss.[27] The cumulative incidence of mechanical failure and other failure at both 5 and 10 years were 11% and 18%, respectively. This system can be a viable option if only the system is available.

Periprosthetic infection was the most common and immediate complication among all failure types. The infection rate of megaprostheses is known to increase from 2%–20% to 43% after revision surgery due to extensive resection of the bone and soft tissues and longer operation time. The incidence of periprosthetic infection in our cohort was 33.3%, compatible with the literatures.[29-31] However, recurrent infection was the main reason of multiple revisions, which ended up as arthrodesis and total femur replacement in 3 patients. In addition, all 6 periprosthetic infections in our cohort were immediate within 1 year. Therefore, maintenance of a strict and thorough aseptic condition during operation and appropriate use of intravenous antibiotics postoperatively should be emphasized in revision surgeries.

This study indicates that onlay allograft can be used as a supportive method in revising failed endoprosthesis if the extent of host bone destruction is extensive. However, applying overlapping allograft to secure bone stock showed a high rate of mechanical failure and infection in the long term. Future studies with larger cohorts are necessary to assess the prognostic factors for higher complications in overlapping allograft and the need for overlapping allograft. Surveillance with consideration of the risk of anteromedial osteolysis in allograft and efforts to prevent periprosthetic infection are essential.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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ORCID

Sanghyun Cho https://orcid.org/0000-0002-6986-3299
Dae-Geun Jeon https://orcid.org/0000-0001-5722-1080
Wan Hyeong Cho https://orcid.org/0000-0002-4768-2075
Won Seok Song https://orcid.org/0000-0003-2852-5581
Yongsung Kim https://orcid.org/0000-0003-4203-9280

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