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Research Article

Midterm Results of 2 Stage Revision for Periprosthetic Knee Infection. Comparison of Metal/Polyethylene and Metal/Cement Types of Spacers

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Abstract

Background: Two stage revision for periprosthetic joint infection after total knee arthroplasty is the golden standard of treatment, but it has a large number of reinfections and outcomes of re-implantations are far from optimal. Many patients after spacer implantation are not being reimplanted during the first 6 months due to multiple reasons.

Method: In this prospective study 160 patients (160 joints) who underwent two stage revision for septic knee arthroplasty were included. In all cases articulating spacers with primary metal femoral component and armed intramedullary spacers (dowels) were implanted. 4 patients were lost to follow-up within a year after the spacer implantation with confirmed infection sedation at the first follow up in 3 months after spacer implantation and were excluded from the study. Out of the rest 156 cases in 81 case liner of bone cement was used. In 75 cases we used polyethylene liner. Medical comorbidities, type of knee replacement (primary vs. revision), culture results, serum hemoglobin level, erythrocyte sedimentation rate, Knee Society Score, knee range of motion, were all recorded before the first spacer implantation, in 3 months and at the last follow-up in average 56.35±18.77 months after reimplantation or spacer with poly liner implantation.

Results: After the first stage infection relapsed in 33% (N = 27) of the cases in cement liner group and in 8% (N = 6: 4 during the first 6 months after the 1st spacer implantation and 2 later) of cases in poly liner group. At the last follow-up control over infection with functioning articulating knee was achieved in 85% and 94.7% of cases, respectively. Clinical and functional results in poly liner group were significantly better than in cement liner group at all periods of follow-up ($p \leq 0,05$).

Conclusion: superior results of poly liner spacers over cement liner spacers made us completely abandon cement liner spacer technique and broaden the indications for so called temporary-permanent spacers with polyethylene liner in cases of infection in the knee with possibility to achieve knee stability with non-constrained spacer. Success of temporary-permanent spacers implantation may lead us towards wider use of one stage revisions in "high risk" deep infection after knee arthroplasty.

Keywords: Knee; Complications; Infection; Spacer; Flap

Introduction

Periprosthetic joint infection (PJI) is the one of the leading causes of reoperations after total knee arthroplasty and serious medical and social problem, as it is associated with a large number of complications and high mortality [1]. The cost of treatment of patients with this devastating complication is much higher than in primary or revision for aseptic instability cases [2,3]. Rise of highly resistant germs, such as methicillin-resistant staphylococcus epidermidis (MRSE), bacteria with an extended spectrum of beta-lactamases, ampicillin-resistant Enterococcus, Acinetobacter spp. and vancomycin-resistant Enterococcus [4], polymicrobial associations (PMA) and gram-negative germs [5] only exacerbates the problem.

In many countries current practice of PJI management is approximately the same. In cases of early infection surgeons try to save the implant and perform the Debridement, antibiotic, irrigation and retention of the implant (DIAR) procedure, usually with liner exchange [6-8], for the late "uncomplicated" PJI – one stage revision (1SR) and for "complicated cases" of late PJI – two stage revision (2SR) [9-13]. The rate of reinfection after the first spacer implantation during 2SR can reach up to 33% or more and depends on a number of factors: the initial range of motion (ROM), severity of anemia and bone loss, comorbidity, body mass index (BMI), quality of soft tissues covering, etc. [12,14]. Approximately 20% of patients after spacer implantation (SI) for knee PJI never go for revision arthroplasty (RTKA) [15]. Moreover, after RTKA following successful first stage, only 75% of patients achieve good and excellent clinical and functional midterm results [12]. It was shown that the frequency of complications related to the surgical wound after early revisions due to mechanical reasons after primary total hip arthroplasty (THA), can reach up to 12% or more and progressively decreases as the interval between primary implantation and revision increases [16]. In a 2SR with the implantation of a cement/cement spacer, on the contrary, probability of infection relapse increases along with the length of antibiotic holiday before reimplantation [17]. Perhaps this is partly related to the fact that almost all modern spacers are unsuitable for long-term function under daily living conditions.

The high frequency of 2SR failure in knee PJI, makes it necessary to search for more effective methods of surgical treatment of late PJI, especially for high-risk patients, develop more universal antibacterial spacer adapted for long-term functioning in order to improve functional outcomes and decrease financial pressure on the health care system.

Materials

In this prospective study participated 156 cases of 2SR for PJI after TKA performed since 01.01.2012 till 31.12.2018 were included (Table 1). In all cases at the first stage of surgical treatment articulating spacers (AS) composed of primary femoral component, armed intramedullary spacers (dowels) made of antibiotic loaded bone cement (ALBC) and liner were implanted. In 81 case liner was formed in operating room out of ALBC (CL group, N = 81). In 75 cases standard primary polyethylene liner was used (PL group, N = 75). For PJI confirmation since 2013 IDSA criteria were used [18].

Initial characteristics (T_0)	CL N = 81	PL N = 75	P
Age (years)	60,0 ± 9,8 (23-80)	61,8 ± 3,6 (27-84)	≥ 0.05
TKA - T_0 (months)	14,66 ± 14,2	20,1 ± 21,7	0.05
TKA - onset of PJI symptoms (months)	7,3 ± 8,4	13,5 ± 18,1	≤ 0.05
Sex, M/F (male %)	19/62 (23%)	23/52 (32%)	≥ 0.05
BMI (kg/m2)	31,4 ± 5,3	29,7 ± 3,3	≤ 0.05
TKA for posttraumatic OA (PTOA)	15 (19%)	11(15%)	≥ 0.05
Charlson comorbidity index (CCI)	3,23 ± 0,98	3,58 ± 1,19	≤ 0.05
Surgical treatment for current PJI in an external hospital	30 (37%)	20 (28%)	≥ 0.05
Fistulas (%)	56 (69%)	43 (58%)	≥ 0.05

Table 1: Initial patients' characteristics in CL (#1) and PL (# 2) groups (T_0).

There was no statistically significant difference in level of hemoglobin (Hb) and erythrocyte sedimentation rate (ESR) between patients of both groups. Comparisons of groups on a quantitative scale were made based on the nonparametric Mann-Whitney test. The statistical significance of various values for binary and nominal indicators was determined using the Chi-square test. To describe quantitative indicators, the average value and standard deviation

in the format "M ± S" were used. The correlation analysis was based on nonparametric Spearman rank correlation. The level of statistical significance was fixed at an error probability of ≥ 0.05. Statistical data processing was performed using Microsoft Excel 2019.

Surgical technique

Common steps

After proper surgical debridement and components removal, remaining bone cement and necrotic bone were carefully removed. The intramedullary (IM) canals were cleaned, reamed and washed. Using trial components from the revision knee set, trial reduction was performed to make sure that condition of soft tissues allows to cover and stabilize the joint. We determined the size of the necessary femoral component, liner, diameter and length of IM dowels and augmentation needed. In cases of critical capsular/skin and subcutaneous fat defects or patella ligament lesion, we mobilized gastrocnemius flap (most often medial one) and after that evaluated if flap is big enough to cover the joint and provide joint stability throughout the ROM. If it was not the case the implantation of articulating spacer (AS) was abandoned in favor of static spacer (SS).

After trial reduction the IM canals were packed with squeezed wet 0,1%H_2O_2 0,5% povidon-iodine towels to stop the bleeding and continue antiseptics exposition.

On the separate table, reinforcing rods with the diameter of 6.5 -10.0 mm and a length of 10-15 cm or Kirshner wires were covered with a layer of ALBC (usually 1-2g of vancomycin and 2g of ceftazidime per 40 g dose of cement) (Fig. 1A). The rods/wires were used to provide greater structural strength to the construct and facilitate IM spacer removal. On the surface of the table, we poured 1g of antibiotic, selected according to the sensitivity of the germs (most often vancomycin).

While using trial stems as templates, we "rolled out" 2 dowels, leaving on one side of the tibial one 1 cm of the threaded part of the arming rod free of ALBC (in PL group only) (Figure 1B). scattered over the preparation table was intended to increase load of the superficial layer of the BC. This method allowed us to produce dowels of the required diameter without rough deformation of dowels during cement hardening. In the PL group the remaining mixed BC was used to build up augments on the final femoral component if needed. These augments enabled to restore anatomical joint line

Figure 1: "Rolling out" of intramedullary dowels with trial stems.

level, maintain optimal position of femoral component during implantation and ensure cement interdigitation into the bone. As soon as ALBC of dowels and augments set, the femoral canal was washed and dried again and loaded with dowel. After that point, corresponding to the center of the tibial IM canal, was located using the Dr. Belokobylov's tibial template. The template was applied to the surface of the tibial plateau with trial stem inserted into the IM canal (Figure 2). The hole corresponding to the center of the stem was marked on it and used later for insert drilling or making a void in bone cement liner.

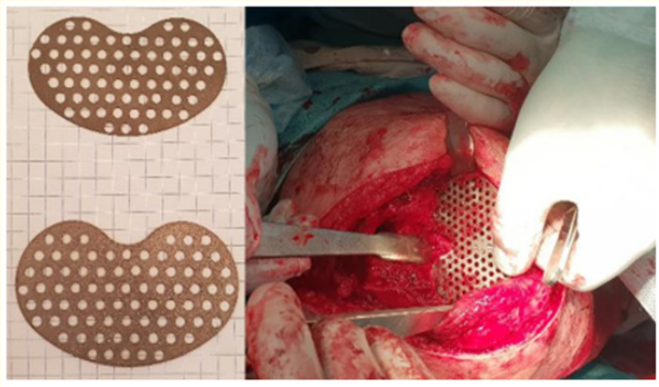

Figure 2: Location of the intramedullary canal center on the tibial plateau using a Belokobylov' template.

- **Cement liner (CL) group:** tibial liner of corresponding size and thickness was made of ABLC in a silicon mold with a hole in the middle for protruding part of tibial dowel. After that tibial IMS was inserted into the bone canal, BC liner was placed on the top of it without cementing and metal femoral component was cemented on half-set ALBC.

- **Polyethylene liner (PL) group:** with Dr. Belokobylov's template of the tibial plateau [19], on the back side of the definite PL of appropriate height and size, we drilled a hole up to 1,5 cm deep for the threaded part of the tibial dowel and several holes of a smaller depth for ALBC interdigitation and screwed tibial dowel into the liner.

In parallel with the IM dowels preparation, the joint was thoroughly washed with at least 5 liters of warm antiseptic solution (Figure 3) and after that packed with antiseptic soaked towels for 15 min.

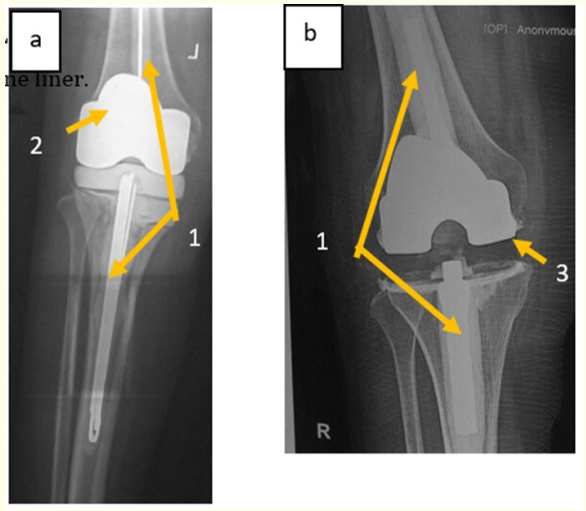

Figure 3: X-rays of knee joints with cement liner (a) and poly liner (b) spacers.

- IM dowels, armed with K-wires (CL group) and threaded rods (PL group).

- Liner of ALBC.

- Polyethylene liner.

Results

Some results of treatment presented in table 2, 3 and 4, figure 4 and 6.

Characteristics/groups	CL (N = 81)	PL (N = 75)	P
Gastro flap used with 1st spacer	7 (9%)	10 (13%)	P ≥ 0.05
Failures after 1st spacer implantation* %	27 (33%)	6 (8%)	p ≤ 0.001
Gastro flap over the 2nd spacer	1% (1)	4% (3)	P ≥ 0.05
Reimplantation (RTKA)	71 (88%)	18 (24%)	p ≤ 0.001
Median period between the last spacer and RTKA	7,13 ± 4,70	6,39±4,06	P ≥ 0.05
Follow-up period after RTKA**	71,9 ± 15,2	47,1 ± 10,7	p ≤ 0.001
Reinfection/infection relapse ***	6 (8%)	4 (5.33%)	P ≥ 0.05
No infection at the LFU****	67 (83%)	72 (96%)	p ≤ 0.01
Malalignment of tibial component of the 1st spacer (deg.)	3,28 ± 3,44	1.35 ± 1.33.	P ≤ 0.01

Table 2: Results of the treatment.

* Signs of infection within 6 months after spacer implantation

** Period after reimplantation or PL type spacer implantation, if not explanted till the last follow-up (T_{lfu}).

*** After reimplantation or in the "late" period (> 6 months) after PL spacer implantation.

**** Functioning knee and no clinical and laboratory signs of infection at the T_{lfu}.

The use of PL spacers correlated with greater probability of infection control ($p < 0.01$), a greater range of motion (ROM), Knee society clinical score (KSCS), knee society function score (KSFS) and Oxford knee score (OKS) both at T_3 and T_{LFU} ($p < 0.01$) and inversely correlated with an error in positioning the tibial component of the spacer in the frontal plane ($p < 0.01$), the need for additional reoperations ($p < 0.01$), relapses of infection ($p < 0.05$). Clinical results evaluated by ROM, KSCS, KSFS and OKS in the PL group significantly exceeded those for the CL group ($p < 0.05$) not only between revision stages but also at the last follow-up.

Germs	CL spacer			PL spacer		
	No infection (N = 54)	Infection at T_3 (N = 27)	Infection/at T_{LFU*} (N = 12)	No infection at T_3 (N = 69)	Infection at T_3 (N = 6)	Infection at T_{LFU*} (N = 3)
Gr -		2	1	7		
Gr -/Gr -	2	2	1	1	1	1
CoNs	25	5	3	18	2	
CoNs/Gr -	2			1		
CoNs/other Gr +	1					
MRSE	3	4	1	5	0	
other Gr +	1	2		2	1	
MRSA		6	2	8	2	1
MRSA/Gr -	1		1			
S aureus	12	2	1	15		
S aureus/Gr -	2			1		1
S aureus/Gr -/Fungi	1					
S aureus/CoNs		3	1	3		
S aureus/Gr -		1	1			
Not found	4			9		

Table 3: Results of 1st SI depending of germs found in periprosthetic tissues.

T_3 - Control point in 3 months after the first spacer implantation.

T_{lfu} - time of the last follow-up.

"CoNS" - Coagulase-negative staphylococci, "Gr – "- gram-negative germs, "other Gr +" - gram-positive germs excluding S. aureus and CoNS.

* Infection, arthrodesis, amputation or death of a person with no confirmation of PJI sedation.

In CL group share of "Gr -" germs in failed subgroup was 4 times higher than in success subgroup. Such a big difference we've not seen in PL group. Maybe it was related to the lack of proper pre-operative microbe diagnostics and use of ALBC in CL group mainly targeting Gr+ germs.

At the last follow-up (T_{LFU}) 85% of patients from CL group had functioning RTKA/PL spacer.

Clinical case 1 (CL group)

Patient Zh. 22 y.o. Primary TKA for posttraumatic arthritis. In 7 months started to feel pain in the knee, and a fistula opened. S. aureus was found in joint aspirate (Figure 5a). CL spacer was implanted (Figure 5b). The postop period was uneventful. In 5 months after the 1stt spacer implantation reimplantation was performed (Figure 5c). At the last follow-up 35 months after reimplantation - skin and joint capsule defect up to 5 by 10 cm (Figure 5d).

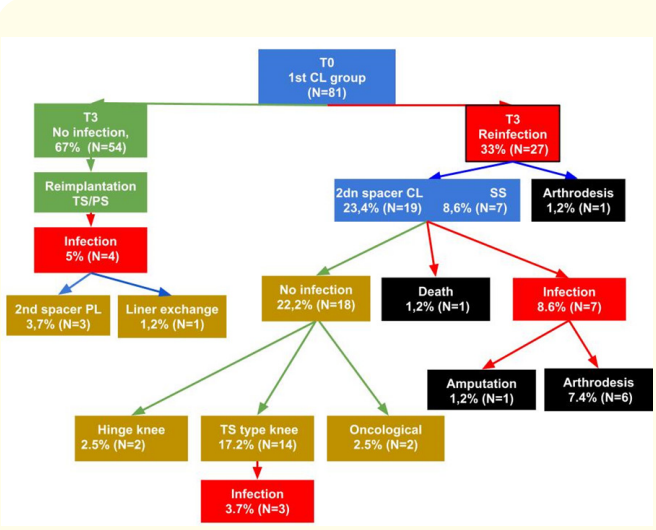

Figure 4: Results at the last follow-up in CL group.

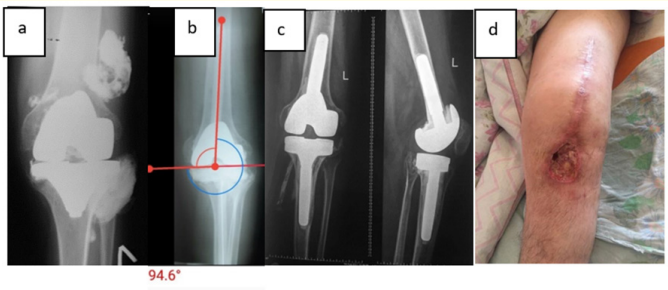

Figure 5: X-rays at T_0, T_3 and T_{LFU}, photo of the knee at TLFU for clinical case 1.

Polymicrobial association was cultured out of knee probes: S. epid, Pseudomonas aeruginosa.

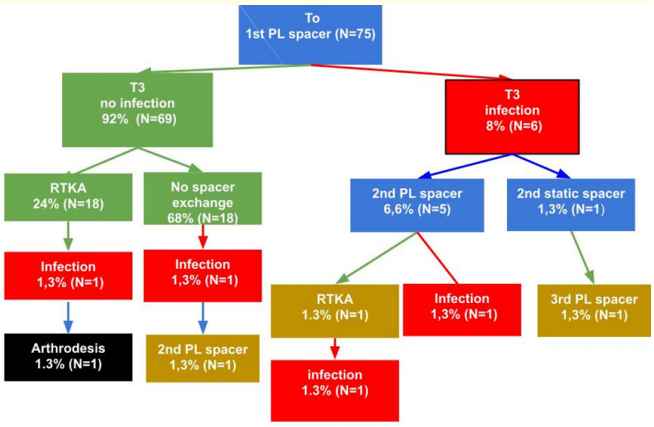

Figure 6: The results of PL spacer implantations.

Clinical case 2 (PL group)

Patient D. 72 y.o. BMI 37 kg/m^2, methicillin resistant staphylococcus aureus (MRSA) with low sensitivity to vancomycin. 12.2017 primary TKA for OA, in 2 weeks, necrosis of the skin and capsule on the anterior surface of the knee joint (Figure 7).

The bottom of the wound is formed by the patella, the patella ligament and the tibial insert. Rupture of patella ligament. ROM-20 deg., KSCS score -20 points, KSSF -5 points, OKS-50 points.

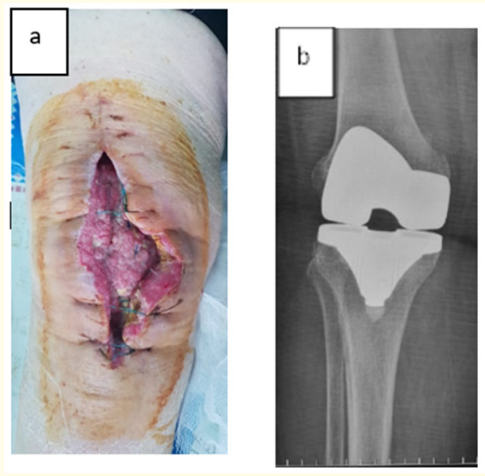

Figure 7: Photo of a wound and X-ray at T_0, clinical case 2.

01.2018-the first PL spacer was implanted (Figure 7 a, b) with daptomycin. Capsular defect was covered by the medial gastrocnemius flap.

The muscle flap completely closed the capsule defect. Muscle simultaneously was covered with a split skin graft (8b).

The x-ray taken 40 months after the spacer implantation. Full active extension and flexion up to 90 degree, KSCS -70 points, KSSF - 65 points, OKS- 28 points (Figure 8 b, c).

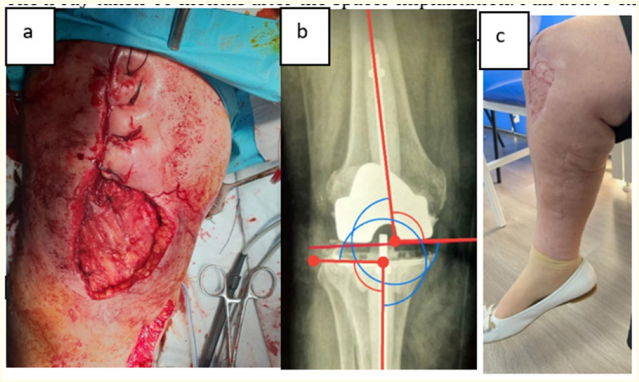

Figure 8: Intraoperative photo of the knee, X-ray and photo of the knee at the last follow-up.

Clinical case 3 (continuation of clinical case 1)

Patient Zh. 27 y.o. 35 months after reimplantation revision knee was removed. During the procedure proper debridement and joint lavage were performed and PL spacer was implanted. Intraoperatively: purulent meltdown of the patellar ligament, tibial and femoral bone defects AORI IIB-III (Figure 9a). Vancomycin and Ceftazidim were added into the BC (Figure 9b).

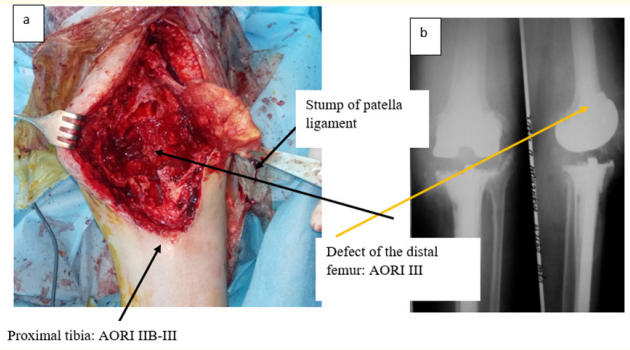

Figure 9: Intraoperative photo of the wound after surgical debridement T_0 and X-ray of the implanted PL spacer T_3.

In 48 months after PL spacer implantation: ROM - 90 deg., KSCS-76 points, KSSF-75 points, OKS-24 points (Figure 10a, b).

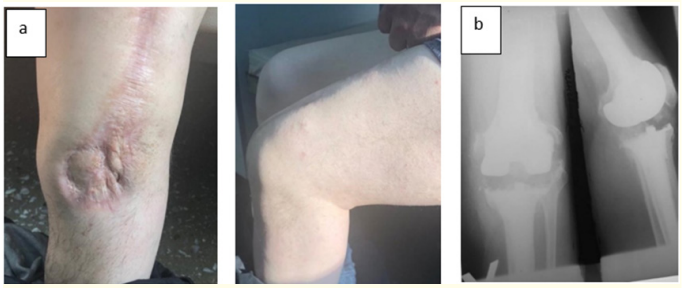

Figure 10: Pictures of the leg and X-ray clinical case 1/3 TLFU (48 months) after PL spacer implantation.

In patients with fistulas (N = 99), we found a statistically significant correlation between the number of relapses of infection after the 1st SI and posttraumatic arthritis, the initial level of ESR, joint capsule defects ($p < 0.01$), non-staphylococcal infection ($p < 0.01$), and an inverse correlation with the use of the muscle flap ($p < 0.01$).

Complications

In this study, intraoperative complications during spacer implantation and RTKA were observed in 15 cases (9,6%) out of them 3 tibia and 2 femur fractures, but all these complications did not have serious short-and medium-term negative consequences. In 7 cases, a partial or complete rupture/avulsion of the patellar ligament was managed by transosseous sutures (in cases of severe osteoporosis sutures were passed through the tibial IM spacer to increase strength). Difficulties with dowels removal reinforced with Kirschner wires and mentioned in literature cases of potentially dangerous migration of wires made us abandon them and use reinforcing rods. As a result, in PL spacer group we did not encounter any difficulties with intramedullary spacers removal.

Discussion

One of the most problematic indications for RTKA is PJI, which accounts for 16% to 27% of all post-TKA revisions [20-23]. PJI is the main reason for early revisions (< 2 years) [24]. Despite the fact that various methods are used to treat such patients, 2SR with the use of articulating or static spacers based on ALBC remains the golden standard worldwide. Wide variety of articulating spacers is proposed. Mainly surgeons use spacers made of ALBC hoping that surface of the ALBC will not be covered by bacterial biofilm, although this is constantly questioned. Cement/cement articulating spacers has a number of disadvantages. A warehouse of spacer components is required, patients are forced to limit weightbearing, RTKA should be performed soon after the end of antibiotic therapy [17]. It was published that early reoperation after THA due to mechanical reasons predisposes to infection and wound complications. Frequency of infectious complications and problems with the operating decrease from 11.8% to 7.8% 2.2% and 1.5% for reoperations done first 2 weeks, 14-90 days, 90 bays and more and 180 days or more after the initial THA, respectively [16]. It is logical to assume that this pattern may extends to reimplantations after SI. Early reimplantation itself may be a cause of septic complications.

In the CL group, we did not cement intra-articular components of the spacer (femoral component was fixed on half-set cement not interdigitating the bone), believing that this will simplify spacers

removal during reimplantation and save the bone stock. But the practice has shown disadvantages of this approach in some patients. Due to various reasons, it was impossible to perform re-implantation the first year after successful first stage and at the time of reimplantation we've seen signs of gross instability of spacer components.

It is believed that many of the supposed benefits of articulating spacers are not confirmed with the period of follow-up above 2 years [25]. This was also demonstrated by the modest results in the CL group (1ST spacer failure - 33%, reinfection after RTKA - 11%). These spacers were not designed for long-term function. The technique showed average functional results both on spacers and after reimplantation.

Mechanical complications in the interval between the stages of 2SR in our study occurred in 3 cases (all in the CL group-3.7%). In the literature of Castelli., *et al.* [26] reported such complications in 2 out of 50 cases (4%). Van Thiel., *et al*. [27] had one mechanical complication (spacer failure) out of 60 cases (1.7%). Johnson., *et al.* [28] reported a rate of mechanical complications of about 12% in the AS group versus 0% in the SS group. Most of the authors mentioned above indicate that reimplantation was performed 8-12 weeks after the spacer implantation, which raises doubts about the large number of patients with extensive soft tissue defects requiring muscle flaps and skin grafting in the populations of these studies. The average period of reimplantation after the last CL spacer implantation was 7.23 months (2-22 months). Despite the fact that we recommended patients to come for re-implantation at 8-12 weeks after spacer implantation, for various reasons, it happened only in 14% of cases. It is obvious that long-term use of static spacers inevitably decreases the probability of achieving optimal clinical and functional results of reimplantation, and the feasibility of implanting static spacers in cases of knee PJI with preserved soft-tissue stabilizers is highly questionable.

Starting work on the creation of a new type of knee joint spacer, we set ourselves several main goals: to increase patient satisfaction with the results of treatment, both in the period after reimplantation and between stages of 2SR, to make the procedure easier and more reproducible in any orthopedic hospital, to minimize the financial costs of its reproduction, to make the spacer potentially adapted for long-term use.

Our study had a large number of limitations. One of which was the weakness of the lab part. Methods for detecting germs resistance to methicillin and vancomycin were not always available as well as methods for intraoperative detection of infection signs during reimplantation. We had a limited choice of antibiotics for the treatment of patients with polyresistant germs, and often technical reasons prevented timely reimplantation after spacers implantation.

It is known that long-term use of articulating spacers made of ALBC may lead to severe osteolysis, which can be caused by x-ray contrast agents in the products of cement wear. It was published that in fibrous tissues, at the border between spacer cement and bone chronic reaction to foreign bodies with phagocytes accumulating particles of zirconium dioxide could be found [29]. We've demonstrated that long-term use of articulating polyethylene liner spacers (beyond the recommended period of up to 6 months), with no cement participating in a wear couple, does not lead to an increase in the frequency of infection relapses or deterioration of the clinical and functional results. Reinfection after reimplantation was observed in 24% of men (4 cases) and 5.5% of women (3 cases) in the CL group. In the PL group, the rate of reinfection during the maximal recommended period of use (6 months) was only 3% (2 cases). Rolling out the spacer along the trial stems allowed to control the intramedullary dowels diameter. Together with thicker threaded reinforcing rod it minimized difficulties with the removal of dowels during re-implantation or spacer exchange in the PL group. Comparison of the PL vs. CL groups confirmed that the deviation of the tibial component of the spacer from the neutral position was significantly smaller - 1.35 ± 1.33 deg., vs. 3.28 ± 3.44 deg., correspondingly ($p < 0.01$). Since we shaped intramedullary spacers accordingly to trial stems and implanted them press-fit, it allowed us to improve tibial component stability and spacer alignment. De facto, our PL spacer had all features of revision knee implant of hybrid fixation with antibacterial properties and easily explantable intramedullary components.

Another problem that had to be solved was the choice of the optimal place for tibial dowel on the polyethylene liner. It is known that the center of the tibial canal can stand 1-15 mm in any direction from the center of the tibial plateau [30]. Due to differences in anatomy, using a straight press-fit stem can lead to poor coverage of the proximal tibia, component overhang and malalignment

in the frontal or sagittal plane [31,32]. In traditional RTKA, offset stems or offset adapters are used to solve this issue. We used tibial templates of Dr. Belokobylov A.A. and by this determined the optimal position for drilling a hole in the poly insert, for tibial IM dowel fixation, which probably also contributed to a better alignment of the components.

Probability of success was lower in patients with infection relapse after 1STSI. On the other hand, no correlation was found between prior revisions in other hospitals for the current PJI and the results of our treatment. This may be related to the fact that these procedures, performed in other hospitals, were not always radical enough or soft tissues defect was not covered with a muscle flap.

In a recent study, it was demonstrated that among patients with fistulas, the risk of 2SR failure was 7.94 times higher than the average [33]. We have not noted such a relationship. It all depended on whether there was a soft tissue deficit after debridement, making it difficult to cover the spacer/RTKA or not.

In general, the results obtained were familiar to the results of the study conducted by Preobrazhensky P. M.., *et al.* The effectiveness of the debridement and reimplantation in their study was comparable to the effectiveness of our CL group and was significantly higher with articulating spacers vs. static spacers. The average interval between stages was also quite long - 196 days. The authors noted that re-implantation after the use of static spacers more often required the use of extended approaches ($p < 0.05$), higher level of constrain in RTKA ($p < 0.05$) and was accompanied by a longer operating time ($p < 0.02$). But authors did not provide a description of spacers used. In our study, in all cases and clinics, all 1stSI were performed using the same surgical technique with principal author participating in main part of them. In addition, in order to objectify the comparative analysis, Preobrazhensky P. M., *et al*. excluded from their study patients with AORI 2B and 3 bone defects [34]. We did not do this, because after analyzing of the results, we noted that the size of bone defects did not have statistically significant effect on treatment outcomes.

Pavlov V. V., *et al*. in cases of PJI after RTKA and TKA with a median follow-up of 4.7 years made reimplantation in 89.7% of PJI cases and in 91.0% of cases achieved infection eradication. The efficiency of 2SR was 80.5% [35]. These results are also comparable with the results of the CL group, but the materials of their work are difficult to compare with ours, since combined the data of PJI after THA and TKA, did not indicate the number of patients with fistula PJI and joint capsule defects, and data on the type of spacer used.

Prokhorenko V. M., *et al.* in their work on the treatment of PJI after TKA, stated that they performed 1SR in patients with a duration of infection of less than 3 months and 2SR in patients with a longer duration of infection and in patients with reinfection risk factors [36].

Prokhorenko V. M., *et al.* performed arthrodesis in 34 cases of knee PJI, which accounted for 33% of all cases of deep infection after TKA. 7 arthrodesis (8.6%) were performed in the CL group, and 1.3% in the PL group in our study. Only 1 arthrodesis was performed in the PL group may be due to the fact that the technique is used for relatively short period of time and the average follow-up period after PL spacer implantation is only approaching 4 years.

Conclusion

Clinical success of temporary-permanent spacers with poly liner in treatment of late deep PJI after TKA made us completely abandon articulating spacers containing liner of antibiotic loaded bone cement in a wear couple. Success of temporary-permanent spacers implantation may lead us towards wider use of one stage revisions also in “high risk” knee PJI cases.

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