Muscular gastrocnemius spacer: a two stage reimplantation technique for infected total knee arthroplasty

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AIM: *We present a two stage reimplantation technique for infected total knee arthroplasty using a muscular gastrocnemious spacer that allows delivery of high local concentrations of antibiotics in absence of heterologous materials associated with high percentage of infection.*
MATERIAL OF STUDY: *Between January 2009 and June 2011 we selected 8 patients with diagnosis of total knee arthroplasty deep infection. All patients underwent a surgical protocol that consisted of a two stage procedure with harvesting of medial gastrocnemious rotational flap followed by delayed reimplantation of prosthesis. All of them received 6 weeks of tailored intravenous antibiotics suggested by the infectious disease consultant and none had positive cultures at the time of reimplantation.*
RESULTS: *The outcome was considered excellent for 6 of the 8 knees, good for 1, fair for 1, and poor for 0 joint. The reimplantion procedures were completely successful in all cases and all patients were able to walk again after rehabilitation program.*
DISCUSSION: *Our surgical protocol guarantees wound healing without presence of disuse osteoporosis nor joint stiffness with scar tissue obliterating joint space.*
Moreover it shows a lower percentage of reinfection. This is connected to the presence of remaining microbiological organisms at the moment of closure that can develope a biofilm that adheres to biomaterial surfaces, enabling a complete bacterial eradication. The gastrocnemious muscle plays either the role of a natural spacer, either the function of coverage and protection of the new joint articulation after the reimplantation of the new device.
CONCLUSIONS: *The surgical and medical protocol used in our study resulted in clinical absence of infection in all our patients with lower postoperative complications in relation to the complete eradication of infection.*

KEY WORDS: Arthroplasty, Autologous Spacer, Gastrocnemious Muscular Flap

Introduction

Total knee arthroplasty (TKA) has become a reliable and reproducible procedure for pain relief and restoration of function in knees with arthritis [1].

One of the most devastating and costly complications of TKA is deep infection.
Some authors have reported the overall deep infection rate to be approximately 1-2% [2-4].
Treatment of infected total joint arthroplasty has been controversial, and many options are available. The choice of treatment depends on many variables, including chronicity of the infection, host factors (age, health, immunologic compromise), and virulence of the infecting organism.
The best function has been obtained by single stage or two stage reimplantation of components [5-6].
The best results for eradication of infection and maintenance of function have been obtained with two-stage reimplantation [7-14].

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Early reimplantation, within 2 weeks of joint removal and debridement, has been 35–48% successful in eradicating infection [15-17].
Early series with the use of antibiotic-impregnated cement block spacers were encouraging with reported success rates of 80% [18-19].
The use of an antibiotic-impregnated cement spacer between stages is recommended to prevent soft tissue contraction, to increase knee mobility, and to facilitate reimplantation.
Nevertheless the choice of spacers involves the use of heterologous materials and this could result in a higher risk of early infection of the temporary devices.
This is due to the lack of a complete removal of microorganisms that is possible only with a minimum of six months targeted antibiotical therapy.
We present a two stage reimplantation technique for infected total knee arthroplasty using a muscular gastrocnemius spacer that allows delivery of high local concentrations of antibiotics in absence of heterologous materials with high percentage of infection.

Materials and Methods

We selected 8 patients (3 men and 5 women), with average age of 64.6 years old (range 38 -87 years) who presented to us between January 2009 and June 2011 with diagnosis of total knee arthroplasty deep infection, confirmed by clinical examination, radiography, serum parameters, and positive cultures obtained by preoperative aspiration of the knee or by tissue intraoperative cultures (Table I).
All of them (100%) presented cloudy or purulent joint fluid by aspiration, elevated sedimentation rate and elevated C-reactive protein.
We evaluated VES and PCR at T 0 (before explantation), T 1 (right after the first surgery), T2 (after six week of antibiotic therapy) and T3 (right before reimplantation) (Tabb. II-IV).
All patients were deemed to have a chronically infected knee.
The right knee was infected in 2 patients, and the left knee was infected in 6 patients.
At clinical examination they showed knees swelling with erithematous skin, intermittent hydro-arthrosis, pain and functional limitations.
Each patient underwent an average of 2.5 surgeries (range 1-4) before the complete replacement of the infected total knee prosthesis.
The mean time between explantation and reimplantation was 25,625 weeks (range 20-32).
The average interval between primary total knee arthroplasty and infection is 78,125 months, with a minimum of 14 and a maximum of 286 months.
All patients had positive identification of an infecting organism on preoperative aspirations or intraoperative culture specimens. The most frequently isolated infecting organism was the Staphylococcus coagulase negative species. The other three of them presented cutaneous fistula with identification of Staphylococcus Epidermidis, E. Coli and Enterococcus.
All patients received a tailored antibiotic therapy for a minimum of 6 weeks (Levofloxacin, Rifampicin or Teicoplanin) based on culture results, clinical anecdotal evidence, C-reactive protein, radiographs, and recommendation by the infectious disease service. The average follow-up for this cohort of patients was 21,6 months (range, 8-36 months) (Tabb. II-IV).
No patients were lost to follow-up. Clinical outcomes of reimplanted knee arthroplasties were assessed by the new knee society clinical rating system [16].
Post-operative treatment was performed through an anatomical brace, tailored on patients lower limb, and fixed in the upper part at the level of the homolateral hip, and in the lower part, at the foot level.
This brace guaranties a minimum degree of bending, avoids the retraction of the heads of both femur and tibia, ensuring complete balance of the entire lower limb and the possibility of postoperative mobilization.

TABLE I - *Characteristics of the sample:* ***M:*** *Male;* ***F:*** *Female;* ***R:*** *Right;* ***L:*** *Left;* ***Surg:*** *Number of surgeries before the complete replacement of the infected total knee prosthesis;* ***Time E/R:*** *Time between explantation and reimplantation in weeks;* ***Interval A/I:*** *Interval between primary total knee arthroplasty and infection in months;* ***IO:*** *Infection Organism* ***SCN:*** *Staphylococcus coagulase negative;* ***SE:*** *Staphylococcus Epidermidis;* ***EC:*** *Escherichia coli;* ***E:*** *Enterococcus;****FU:*** *Follow Up in months.*

Patient	Sex	Age	Knee	Surg	Time E/R	Interval A/I	IO	FU
1	M	47	R	3	23	35	SCN	12
2	F	52	L	2	20	38	EC	26
3	F	48	L	4	27	103	E	36
4	M	87	R	2	29	43	SCN	18
5	M	38	L	3	22	46	SCN	31
6	F	80	L	3	32	14	SE	20
7	F	81	L	2	28	60	SCN	21
8	F	84	L	1	24	286	SCN	8

TABLE II - *Modification of **ESR** values in **T0:** before explantation; in **T1:** right after the first surgery; in **T2:** after six week of antibiotic therapy; in **T3:** right before reimplantation.*

Patient	ESR			
	T0	T1	T2	T3
1	46	57	16	5
2	53	64	10	13
3	38	38	15	10
4	50	57	19	13
5	33	28	22	6
6	54	50	23	3
7	66	70	13	1
8	47	49	9	5
Average	48	51	16	7

TABLE III - ***ESR** performance in **T0:** before explantation; in **T1:** right after the first surgery; in **T2:** after six week of antibiotic therapy; in **T3:** right before reimplantation.*

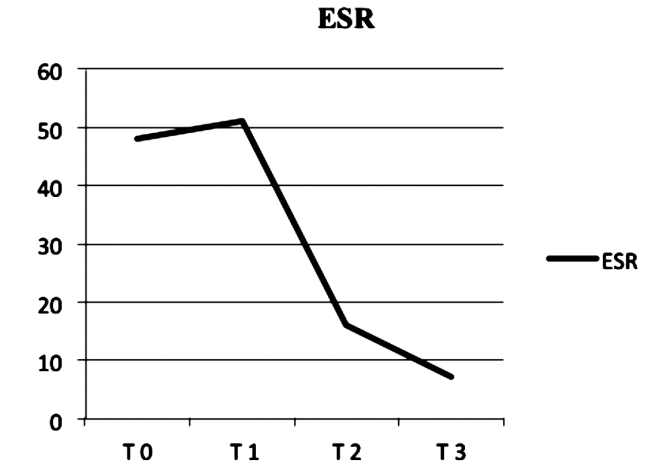
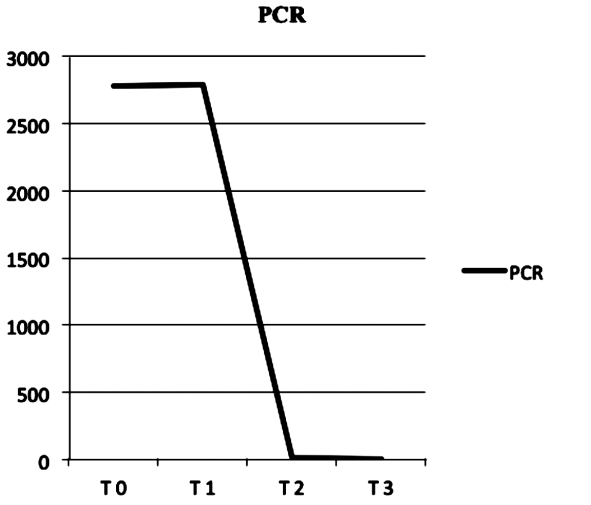


TABLE IV - *Modification of **PCR** values in **T0:** before explantation; in **T1:** right after the first surgery; in **T2:** after six week of antibiotic therapy; in **T3:** right before reimplantation.*

Patient	PCR			
	T0	T1	T2	T3
1	9360	9218	9	5
2	1922	1967	16	8
3	3340	3301	22	9
4	1021	1409	20	15
5	936	1213	15	3
6	4387	3964	13	0
7	516	682	8	3
8	789	638	6	6
Average	2784	2799	14	6

TABLE V - *PCR performance in **T0**: before explantation; in **T1**: right after the first surgery; in **T2**: after six week of antibiotic therapy; in **T3**: right before reimplantation.*



Surgical technique and Protocols

The surgical protocol consisted of a two-stage procedure with delayed reimplantation.
The first stage involved irrigation with Hydrogen peroxide, sodium hypochlorite and normal saline.
Debridement of all necrotic tissues, synovectomy, and removal of all components and cement. After that, multiple anaerobic and fungal cultures were taken from fluids, bone, soft tissues and other suspected infected materials (Figg. 1-3).
Next step was the harvesting of medial gastrocnemius rotational flap, with particular care to the preservation of muscular innervation (Fig. 4).
The flap was used as an articulating spacer sutured between the articular heads of the knee joint (Fig. 5).

Fig. 1. Preoperative view. Signs of infection with presence of fistula.

Fig. 2 Intraoperative. Infected knee prostheses.

Fig. 3. Intraoperative. Exposition of knee joint after removal of infected prostheses.

Fig. 4. Harvesting of medial gastrocnemious muscular flap.

Fig. 5. Rotation of medial gastrocnemious muscular flap.

Fig. 6. The wound is partially closed performing a direct suture in order to avoid excessive tension.

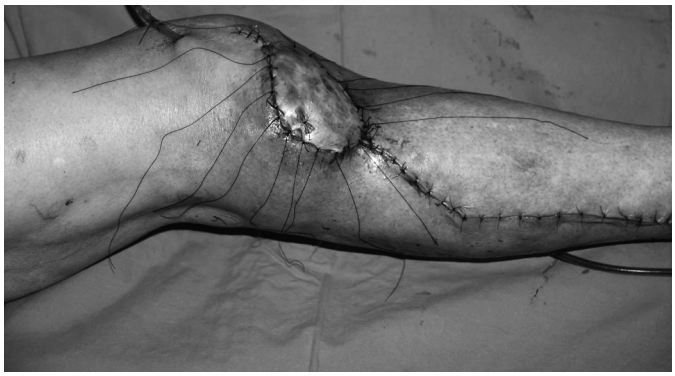


Fig. 7. Immediate postoperative view. Skin graft is used to cover the rest of the wound.

The wound was closed performing a direct suture with nonabsorbable monofilament stitches. A skin graft was used to cover the rest of the wound in order to avoid excessive tension (Figg. 6-7).

Two suction drainages were positioned at the donor site and at the level of the knee joint.

Sometimes we settle a continous drainage irrigation system in order to perform a mechanical removal of infected fluids and materials. A regimen of tailored intravenous antibiotic therapy, targeted on intraoperative coltures results, were administered to patients for a period of minimum 6 weeks and until negativization of inflamatory markers.

On average the second surgical step occurred at 6 months from the primary intervention. After the negativization of the inflammatory markers and the negative result of leucocyte scintigraphy, we proceded with the second stage of reimplantation.

All knees were operated through the previous incision with complete exposure of the joint. The soft tissues surrounding the articulating spacers seemed supple and healthy in all cases. Bone quality was good in all cases

Fig. 8. Postoperative view. Evidence of a small dehiscence. Wound healed within 10 days.

We detached and lifted the muscular gastrocnemious spacer in order to insert the new prosthesis and completed the arthroplastic procedure by covering the new device with the gastrocnemious muscle itself and by closing the wound either directly with non-adsorbable stitches, or through the use of local flaps.
Then we set the extremities in a bulky Jones dressing with a thin plaster shell for 2 to 5 days, which assisted in soft tissue recovery.
In all cases we allowed patients deambulation, with the help of a walker or crutches, and partial weight bearing after 5 or 7 day from the surgery.
We recommend to begin early "continuous passive motion" following the instructions and rehabilitation programs planned in collaboration with the physical therapy service.

Results

All our patients were deemed to have a chronically infected knee showed by clinical anecdotal evidence of infection, blood count, presence of inflammatory markers, culture results and frozen sections. The main infecting organism isolated was the Staphylococcus coagulase negative species. We also report the finding of Staphylococcus Epidermidis, E. Coli and Enterococcus. All of them received 6 weeks of tailored intravenous antibiotics suggested by the infectious disease consultant and none had positive cultures at the time of reimplantation. The reimplantion procedures were completely successful in all cases and all patients were able to walk again after rehabilitation program. No patients with diabetes mellitus or underlying chronic disease were enrolled in our study. 3 of them came back at our service presenting swollen knee, moderate knee pain and signs of late seroma. One of these shoed evidences of a small deischence that healed completely in 10 days (Fig. 8).
After aspiration and compression of the site, we collected the secretions in a sample and we sent it at the laboratory for cultural exams. Cultures resulted always negatives for any microbiological species. After 1 year by the time of surgery, 1 woman refers sporadic knee pain in absence of clinical evidences and pathological signs, probably related to the interrumption of rehabilitation program and low therapeutic compliance. There were no problems with wound healing postoperatively. No recurrent infections were registered in our cases. The outcome was considered excellent for 6 of the 8 knees, good for 1, fair for 1, and poor for 0 joint. Moderate knee pain associated to knee swelling was the cause of the worst result. The average length of follow-up was 21,6 months (range, 8-36 months). All knees were evaluated after surgery at regular intervals using clinical signs, radiographic examination, erythrocyte sedimentation rate, and serum C-reactive protein level according to the American Knee Society Scoring System [16].

Discussion

Treatment of infected total joint arthroplasty has been controversial and the choice of treatment depends on many variables, including chronicity of the infection, host factors (age, health, immunologic compromise), and virulence of the infecting organism.
A two stage reimplantation technique associated to the use of a spacer is considered the most successful method of treating chronic infected TKAs [5,13,14].
The importance of using a spacer is related to the possibility of avoiding additional problems during reimplantation stage, caused by stiffness, ligament contracture, bone atrophy and the presence of abundant scar tissue at the level of joint space.
There are three types of spacers for treatment of chronically infected total knee arthroplasties: block spacers and two types of articulating spacers, but only in 1987, Borden and Gearen first used antibiotic impregnated cement beads or block spacers for two-stage delayed reimplantation reporting a 90% success rate [18-21].

The cement used as a spacer also delivered high-dose local antibiotics to the knee in concentrations greater than that it could be achieved through intravenous administration. This regimen of antibiotic impregnated cement spacers and intravenous antibiotics and delayed exchange arthroplasty has been considered state-of-the-art in cases of infected TKAs. Several other authors reported their results with the use of this protocol assessing success rates of 88–96% in eradicating infection [5,13,14,22].

Although excellent success in eradication of infection has been achieved using block antibiotic-impregnated cement spacers with two-stage delayed reimplantation, the choice of spacers involves the use of heterologous materials and this could result in a higher risk of early infection of the temporary devices.

In literature, the reinfection rates in patients treated with heterologous articulating spacers and heterologous static spacers appear to be statistically very similar.

Emerson et al report a reinfection percentage of 7,6 % for patients with block spacers and 9% for the patients with mobile spacers [23].

Fehring et al. reported a reinfection rate of 12% with the use of a static spacer and a 7% rate with an articulating spacer [20].

Our study describes a two stage reimplantation technique for infected total knee arthroplasty using a muscular gastrocnemius spacer that allows delivery of high local concentrations of antibiotics in absence of heterologous materials with high percentage of infection.

This technique guarantees wound healing without presence of disuse osteoporosis nor joint stiffness with scar tissue obliterating joint space.

Moreover it shows a lower percentage of reinfection, representing a valuable addition to the treatment of an infected TKA.

The gastrocnemious muscle plays either the role of a natural spacer, either the function of coverage and protection of the new joint articulation after the reimplantation of the new device.

In the first case, the main point of using this technique is related to the chance of having the same functions offered by heterologous spacers, but the advantage of dealing with a homologous material, that decreases sensibly the possibility of reinfection. This is demonstrated by the high percentage of postoperative infectious problems reported in literature after the implant of heterologous devices, that show mayor susceptibility to reinfection [24-29].

It is likely connected to the presence of remaining microbiological organism at the moment of closure that can develope a biofilm that adheres to biomaterial surfaces and enable the complete bacterial eradication.

Moreover the muscular gastrocnemious spacer allows the delivering of higher doses of blood supply and local, patients-tailored antibiotics to the knee, in concentrations even greater than could be achieved with any other substitutive material or intravenous administration. It results in fundamental benefits for host defense mechanisms and improves wound healing [24-29].

At the time of second surgical step, we detach and lift the muscular gastrocnemious spacer, we insert the new prosthesis and complete the arthroplastic procedure by covering the new device with the gastrocnemious muscle itself. We settle the muscular rotational flap such as a coverage, in order to provide protection to soft tissue envelope after performing total knee arthroplasty, and allow wound and joint closure without excessive tension. In addition, it avoids direct contact with the suture or any other possible site of exposure in an attempt to prevent significant infectious complications. Operative time and surgical exposure are longer due to the need of harvesting and rotation of the flap, still, we believe this technique offers economical advantages thanks to the lower costs related to the management of postoperative complications, lower number of surgical reintervention and no need for eventual multiple substitution of the infected devices.

Conclusion

The surgical and medical protocol used in our study resulted in clinical absence of infection in all our patients. It offers the chance of performing a two stage reimplantation technique for infected total knee arthroplasty using a muscular gastrocnemius spacer in absence of heterologous materials, with lower postoperative complications in relation to the complete eradication of infection.

Riassunto

La protesizzazione totale di ginocchio rappresenta una delle procedure maggiormente utilizzate in pazienti affetti da artrite o da gonartrosi. Una delle complicanze più debilitanti che possono seguire questa procedura è rappresentata dall'infezione dei tessuti profondi il cui trattamento risulta ancora controverso. L'obiettivo del nostro articolo è di presentare una tecnica chirurgica in due tempi che preveda nella prima fase l'espianto della protesi e l'allestimento di un lembo spaziatore di gastrocnemio mediale seguito da almeno sei settimane di terapia antibiotica mirata. Solo successivamente si procede al reimpianto del nuovo dispositivo protesico, in media 6 mesi dopo il primo intervento chirurgico ed in seguito a comprovata negativizzazione dei markers di infezione.

Nel periodo compreso tra gennaio 2009 e giugno 2011 abbiamo selezionato 8 pazienti con diagnosi di infezione profonda dopo impianto di protesi articolare di ginocchio. Tutti i pazienti sono stati sottoposti al protocollo chirurgico da noi proposto ed è stato effettuato un follow-up medio di 21,6 mesi (tra 8 e 36 mesi). I nostri

risultati sono stati valutati eccellenti per 6 degli 8 pazienti, buoni e sufficienti negli altri 2. In tutti i casi la procedura di reimpianto è stata eseguita con successo e la totalità dei pazienti è stata sottoposta ad un programma di riabilitazione precoce e standardizzato, nell'ottica di un imprescindibile approccio multidisciplinare. In seguito a questo iter riabilitativo continuo tutti pazienti sono stati in grado di camminare nuovamente.
In questo studio sottolineamo l'importanza dell'utilizzo di un lembo muscolare, di derivazione autologa, che sia in grado di svolgere da una parte la funzione di spaziatore articolare, dall'altra quella di vettore di alte dosi di antibiotici. Questo risulta fondamentale per la bonifica del sito chirurgico in vista del successivo intervento di protesizzazione con aumento delle probabilità di successo e concomitante diminuzione di eventuali complicanze postoperaratorie.

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