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MESTRADO INTEGRADO EM MEDICINA

Efficacy of local antibiotic-loaded calcium sulfate beads for the prophylaxis of tumoral periprosthetic joint infection

Gonçalo Vitorino de Andrade e Silva Queirós

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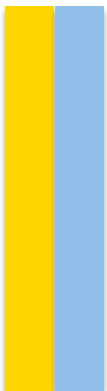
2023



Efficacy of local antibiotic-loaded calcium sulfate beads for the prophylaxis of tumoral periprosthetic joint infection

Dissertação de candidatura ao grau de Mestre em Medicina, submetida ao Instituto de

Ciências Biomédicas Abel Salazar – Universidade do Porto

Estudante: Gonçalo Vitorino de Andrade e Silva Queirós

6º ano do Mestrado Integrado em Medicina

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Agradecimentos

À Professora Doutora Vânia Oliveira, agradeço por toda ajuda, disponibilidade orientação na tese, assim como a oportunidade de poder ter mais contacto com a Ortopedia.

À minha família e amigos, agradeço por todo apoio e motivação ao longo do curso, com especial carinho ao meu avô que me incutiu o gosto pela medicina, e à minha irmã que acaba comigo estes seis anos.

Resumo

Introdução: Nos últimos anos, o tratamento de tumores músculo-esqueléticos tem evoluído bastante, devido ao *turnover* de cirurgia *Limb Salvage* com o aumento do número de reconstruções nomeadamente com endopróteses tumorais. A infeção é uma das complicações mais frequentes associadas às endopróteses tumorais e que impacta os resultados funcionais dos doentes e aumenta a sua morbilidade. Vários estudos mostram que a proporção de infeções periprotésicas nestas cirurgias é em média 15%, no entanto variam dependendo da região anatómica entre 3% a 40%. Estes doentes têm risco acrescido de infeções periprotésicas, não só pela imunossupressão, mas também por fatores relacionados com a resseção cirúrgica. Uma das estratégias para a prevenção e tratamento das infeções periprotésicas tumorais é o uso de antibioterapia local, como a colocação de "pérolas" de sulfato de cálcio com antibiótico. Estas, libertam de forma total e lenta o antibiótico contido, permitindo que este atue localmente e de forma prolongada.

Métodos: Foram analisados retrospetivamente doentes tratados no Centro Hospitalar Universitário de Santo António (CHUdSA), um Centro de Referência Nacional e Europeu na área de Tumores Músculo-esqueléticos, submetidos a ressecção tumoral alargada e reconstrução com endoprótese tumoral, com uso de antibioterapia local em sulfato de cálcio como medida adjuvante na estratégia de prevenção da infeção periprotésica. Foram analisados os dados destes doentes relativos à taxa de infeção e complicações, e foram comparados com os dados existentes de outros artigos na literatura, pesquisados em base de dados do *Pub Med®*, e *Google Scholar®*, em doentes submetidos a ressecção tumoral alargada e reconstrução com endoprótese tumoral sem o uso de antibioterapia local em sulfato de cálcio, assim como doentes do CHUdSA com estas mesmas condições.

Resultados: Nos 28 doentes analisados no nosso estudo em que se usou como estratégia profilática o uso das perolas de sulfato de cálcio com antibiótico, observamos uma taxa de infeção de 10,7%. Nos 52 doentes analisados no nosso hospital em que não se instituiu esta estratégia profilática, a taxa de infeção foi de 11,5%.

Conclusão: Uma vez que o nosso grupo de doentes tem uma dimensão reduzida, torna-se difícil inferir acerca da eficácia das pérolas de sulfato de cálcio com antibiótico, enquanto medida profilática nas infeções endoprotésicas. É deste modo importante realizar estudos maiores e multicêntricos para poder verificar a sua eficácia.

Palavras-Chave: Endoprótese tumoral; infeção periprotésica; antibioterapia local; profilaxia; pérolas de sulfato de cálcio;

Abstract

Introduction: In recent years, the treatment of musculoskeletal tumors has evolved a lot due to the turnover of Limb Salvage surgery with the increase in the number of reconstructions, namely with tumor endoprostheses. Infection is one of the most frequent complications associated with tumor endoprostheses, which impacts the functional results of patients and increases their morbidity. Several studies show that the proportion of periprosthetic infections in these surgeries is, on average, 15%. However, depending on the anatomical region, they vary between 3% to 40%. These patients are at increased risk of periprosthetic infections, not only due to immunosuppression, but also due to factors related to the surgical resection. One of the strategies for preventing and treating periprosthetic tumor infections is using local antibiotic as the antibiotic-loaded calcium sulfate beads. These release the contained antibiotic completely and slowly, allowing it to act locally and for a prolonged period.

Methods: As methods for this study, a retrospective analysis was made of the patients treated at the Centro Hospitalar Universitário de Santo António (CHUdSA), a national and European reference centre for Musculoskeletal Tumors, who underwent wide tumor resection and reconstruction with tumoral endoprosthesis, using local antibiotic therapy in calcium sulfate as an adjuvant measure in the strategy of the periprosthetic infection prophylaxis. Data from these patients regarding the rate of infection and complications were analyzed and compared to existing data from other articles in literature, searched in the Pub Med®, database and Google Scholar® of patients who underwent wide tumor resection and reconstruction with tumoral endoprostheses without the use of local antibiotic therapy in calcium sulfate, as well as CHUdSA patients in these same conditions.

Results: A total of 28 patients were retrospectively analyzed. We observed an infection rate of 10.7% in this group of patients that had calcium sulfate pearls with antibiotics as a prophylactic strategy. In 52 patients analyzed in our hospital where this prophylactic strategy was not used, the infection rate was 11.5%.

Conclusion: Since our group of patients is small, it is difficult to infer about the effectiveness of calcium sulfate beads with antibiotics as prophylaxis of endoprosthetic infection. Therefore, it is essential to carry out larger multicenter studies to verify its efficacy.

Keywords: Tumoral Endoprostheses; periprosthetic infection; local antibioteraphy; prophylaxis; calcium sulfate beads;

Abbreviations List

CHUdSA- Centro Hospitalar Universitário de Santo António

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Introduction

In recent years, the treatment of musculoskeletal tumors has significantly evolved due to the increase in Limb Salvage surgery. Presently, patients are frequently submitted to tumor resection and reconstruction using endoprostheses or biological reconstructions. Although this type of surgery brings a marked improvement in patients' quality of life and a decrease in their morbidity, on the other hand, it also increases certain complications that may jeopardize not only the patient's functionality but ultimately may threaten their life. These complications can be classified using the classification of Henderson et al.[1], which describes five types of complications associated with endoprostheses, including type IV, infection, which will be our focus. Infection is effectively one of the complications that most negatively impacts the functional outcome of patients and increases their morbidity. In fact, higher infection rates have been associated with the increment use of endoprostheses, with some studies showing that it has tripled since the beginning of the 21st century.[2] Treatment of periprosthetic joint infection often fails and results in an eventual need for amputation in nearly 50% of patients.[3] This may delay oncological adjuvant treatments, and it has a significant impact on patients' function and quality of life.[3,4]

Furthermore, this type of complication is considered one of the major risks associated with tumoral endoprosthesis, and several studies show on average 15% periprosthetic infection rate. However, it ranges from 3% to 31%,[2] depending on the anatomical site. Thus, the anatomical site of the tumor can also be considered a risk factor. The risk of infection is highest in the pelvis, followed by the proximal tibia, the femur, and the humerus.[2,4,5]

These patients are particularly at greater risk for periprosthetic infections for several different reasons. Most of these patients undergo neoadjuvant therapy before surgery, such as chemotherapy, radiotherapy, or both, which leaves these patients immunosuppressed at the time of surgery.[4,5,6] The surgical intervention increases the risk of infection since they generally need extensive surgical approaches, with large soft tissue resection, long implant exposure, significant dead space, longer surgical time and greater blood loss.[4,5,6] Furthermore, the tumor can create local vascular changes that facilitate the spread of infection, in addition to the poor local vascularization due to the surgical aggressiveness and immunosuppressed neo-adjuvant treatments that compromise the effectiveness of systemic antibiotic concentrations reaching the surgical site and penetrating the remaining exposed tissues.

Presently, there are different prophylactic measures: intravenous empirical antibiotics, antibiotic-loaded cement implants, different coatings on the surface of endoprostheses as silver-

coated implants that have shown the best results against biofilm formation, irrigation with aseptic solutions (povidone-iodine, hydrogen peroxide), and local antibiotic therapy.[7, 8, 9, 10, 11]

Intraoperative local antibiotic therapy through antibiotic-loaded calcium sulfate beads has been used to treat periprosthetic joint infections. These beads completely and slowly release the antibiotic loaded, providing a more stable and predictable release of higher local antibiotics concentration, allowing it to act more efficiently and for an extended period of time.

Furthermore, besides the antibiotic-loaded calcium sulfate beads' prophylactic use, they are previously known to be helpful when treating infection cases.[11] The antibiotics can be adjusted to the sensibility profile of the identified bacteriological agent.[12] This is especially important in revision surgeries due to an infection.[12]

This article aims to assess the effectiveness of local antibiotics (vancomycin and gentamicin) loaded in calcium sulfate as a strategic measure included in the prophylaxis of tumoral endoprosthetic infection since these patients present a higher risk for this type of complication.

Methods

A retrospective study was performed between September 2018 and December 2022 using data from patients submitted to surgical resection of a musculoskeletal tumor and reconstruction using a tumoral endoprosthesis, where local antibiotic-loaded calcium sulfate beads were used. All the endoprosthetic implants used were silver-coated MUTARS® (Implantcast®). This study was performed in CHUdSA, Oporto, a referral centre for Musculoskeletal Tumors, and was approved by the Hospital Ethical Commission, following the proper procedures.

The data was collected from the medical records in Sclinico® of CHUdSA. The demographic and clinical data were collected: gender, age, type of tumor, anatomical location, ASA score, BMI, use of local antibiotics loaded in calcium sulfate (Stimulan®), use of Trevira® Mesh, type of endoprosthesis, neo and/or adjuvant chemotherapy, neo and/or adjuvant radiotherapy, pathological fracture, date of surgery, complication type IV (endoprosthesis infection), other post-operative complications, MSTS functional score, presence of metastasis and the final status of the patient. For the infected cases, we also collected data about the date of diagnosis of the infection, the isolated pathogen, date of revision(s), DAIR surgery, revision Surgery (1-stage or 2-stage), type

of spacer used, explant and reimplant, antibiotics period, recurrence/persistence of infection and final status.

In order to assess if the local antibiotic beads are efficient in preventing infection of endoprostheses, a literature review was also performed. Papers were searched and selected from PubMed and Google Scholar databases. They were about patients with extensive tumoral resections, reconstruction with endoprosthesis but no use of antibiotic-loaded calcium sulfate beads as a prophylactic measure.

We also compared the infection rate of patients with endoprostheses, where local antibiotics were used, with the infection rate of 52 patients from our hospital that had an endoprosthesis without calcium sulfate beads used. These patients had their endoprosthesis implanted in the last ten years. We also compared their infection rate considering the anatomical location.

In order to analyze possible risk factors for endoprosthetic infection, we compared the data of our cohort of patients and analyzed: the infection rate of different tumor locations (proximal humerus, proximal femur, distal femur, proximal tibia, and pelvis); when the patient was doing either neo and/or adjuvant chemotherapy, neo and/or adjuvant radiotherapy versus none of them; when the Trevira® mesh was used versus not used; when there was a pathological fracture pre-op versus when there was not; ASA status; BMI, age.

The antibiotic-loaded calcium sulfate beads were always prepared in the same way. It was always used the Stimulan® from Biocomposites®. These beads are prepared in the operating room during surgery. The preparation kit contains the calcium sulfate powder, the mixing solution, vancomycin in powder form (1g for 10cc of Stimulan®), gentamicin in liquid form (240mg, 3 ampoules of 80mg, for 10cc of Stimulan®), a sterile mixing bowl, a spatula, a bead mat, and a paste applicator.

The first step to prepare the beads is mixing the calcium sulfate with vancomycin powder with a spatula in the sterile mixing bowl. After mixing both powders, the gentamicin is drawn up with a syringe from the vials and injected into the powder in the mixing bowl. It is then mixed for about 30 seconds until a smooth paste is obtained. The paste is then applied in a thin layer on the bead mat, ensuring that each bead cavity is properly filled with the paste applicator. After the paste is correctly applied on the bead mat, it must be left to set for around 5 minutes (3-4 minutes), until hardening. After fully hardening, the mat can be flexed to release all the beads into a sterile container and are ready to be used locally at the empty space and around the endoprosthesis in order to provide high local and sustained concentrations of antibiotics.

For all patients, the general other prophylactic measures were performed: proper oxygenation, wound care, normothermic, normovolaemic, and glycemic control, in addition to the standard recommended systemic empirical antibiotic (cefazoline or alternative clindamycin) immediately post-op. In the pelvis location, negative pressure wound therapy is frequently used.

Results

Our retrospective study included 28 patients with tumoral endoprostheses implanted (3 proximal humerus, 9 proximal femur, 11 distal femur, 4 proximal tibia, and 1 pelvis), and antibiotic-loaded calcium sulfate beads were used for infection prophylaxis (Figure 1). There were no significant differences in patients' characteristics (Table I.) The mean follow-up was 18 months (range 0-51 months)

Of the total of 28 patients, 3 (10,7%) developed a periprosthetic joint infection. Of these 3 patients, 2 had an endoprosthesis implanted in the proximal tibia and 1 in the distal femur.

The anatomical distribution of the infection rate was: distal femur (2 out of 8 patients, 25%) and proximal tibia (1 out of 3 patients, 33%). No patient had a periprosthetic infection in other locations, so the infection rates in the proximal humerus, pelvis and proximal femur were 0%. There was no statistical significance. (*p*-value=0,148; *p*-value >0,005).

Comparing the infection rate whether the patient was submitted to neo and/or adjuvant radiotherapy or chemotherapy, or none of these treatments, we got an infection rate of 9,5% when the patient was submitted to at least one of them (2 out of 21 patients), and an infection rate of 14,3% when the patient was not submitted to any of them (1 out of 7 patients). There was no statistical significance. (*p*-value =0,736; *p*-value >0,005).

When a Trevira® mesh was applied, the infection rate was 14,3% (1 out of 7 patients) compared to 9,5% (2 out of 21 patients) when it was not applied, although it was not statistically significant. (*p*-value =0,736; *p*-value >0,005).

Six patients presented pathological fractures at diagnosis, but none of them developed a periprosthetic joint infection. In the group of patients without pathological fractures, the infection rate was 14,3% (3 out of 21 patients).

Infection increased with the ASA classification. The single patient ASA I did not develop an infection. For ASA II patients, the infection rate was 6,3% (1 out of 16 patients developed infection),

and 18,9% (2 out of 11 patients) for ASA III patients. There was no statistical significance. (*p*-value =0,319; *p*-value >0,005).

The most common bacteriological agents found in the infected patients were multi-sensitive to antibiotics gram-positive from the skin flora. There was one MRSA periprosthetic infection in a patient with multiple comorbidities. The cultures of the other two patients were positive for Staphylococcus Aureus and a Coagulase Negative Staphylococcus and for a Staphylococcus Epidermidis.

The patient with the MRSA infection was treated initially with intravenous 15-day course of Piperacillin/tazobactam, and then a 2-month course of ciprofloxacin and rifampicin. Revision surgery was performed but ended up in amputation.

The patient with the *Staphylococcus Aureus* and a Coagulase Negative *Staphylococcus* was treated with a 3-month course of doxycycline and ciprofloxacin. A 2-stage revision surgery was performed, and this patient had recurrent infections with poli-microorganisms including *E.Coli* and *Candida Albicans*. He repeated the 2-stage revision and completed extended antibiotic and antifungal therapy. Presently he is on follow-up without evidence of infection.

The patient with the *Staphylococcus Epidermidis* infection was treated with a 2-month course of clindamycin and cefuroxime. No revision surgery was performed on this patient.

From the 52 patients of our hospital where no antibiotic-loaded calcium sulfate beads were used (14 proximal humerus, 1 total humerus, 7 pelvis, 13 proximal femur, 12 distal femur, 5 proximal tibia), 6 patients developed a periprosthetic infection, making up an infection rate of 11,5%. The infected endoprostheses in this group were locally distributed by the pelvis (2), distal femur (3), and proximal tibia (1). The infection rate was 28,5% at the pelvis (2 out of 7 patients), 25% at the distal femur (3 out of 12 patients), and 20% at the proximal tibia (1 out of 5 patients). No patient had a periprosthetic infection at other locations, so the infection rate for the proximal humerus and proximal femur was 0%.

There were two local tumor recurrences, one in a patient with a pelvic chondrosarcoma and the other one in a patient with a distal femur osteosarcoma. The function of the patients was calculated in their last follow-up using the MSTS score. The mean MSTS score for the upper limb was 20, and for the lower limb, it was 22. In the infected patients, the mean MSTS score was 13, with one of the three patients with periprosthetic infection having a score of 0 since they were amputated.

Of the 3 infected cases, 1 was submitted to a 1-stage revision, another 1 to a 2-stage revision. The remaining patient had no revision surgery and was treated only with antibiotic suppression when there were any signs or symptoms of inflammation and infection. The global implant failure was 17,9% (5 out of 28), with 4 cases of aseptic loosing and one case of amputation.

The implant failure in the infected group was 66,7% (2 out of 3 patients), with one case of aseptic loosening and one case of amputation.

During imaging follow-up, it was frequent the formation of heterotopic ossification (Figure 2). Nevertheless, it was asymptomatic for all patients and did not require any further attitude. It was most prevalent near the reminiscent femur.

At the final follow-up, 18 patients were alive without evidence of disease, 6 had metastatic disease, and 4 already died.

Discussion

At this point, we found no papers analyzing the efficacy of the antibiotic-loaded calcium sulfate beads in the prophylaxis of infection for tumoral endoprostheses. As explained, endoprostheses are at higher risk of infection due to the patient's immunosuppression, the extensive surgical approach, large soft tissue resection, long implant exposure, significant dead space, longer surgical time, higher blood loss, local vascular changes related to tumor ingrowth, and surgical aggressiveness.[4, 5, 6] It is also important to note that infection is the most frequent complication of tumoral endoprostheses and is related to shorter implant survival.[2, 5] Periprosthetic infection has a high psycho-socioeconomic impact, and the shorter survival of the implant is related to higher costs and patients' morbidity and functional impairment, which highly impacts their quality of life.[13] Thus, searching for and investigating new strategies to minimize infection by improving prophylaxis in patients submitted to tumoral endoprosthesis becomes increasingly relevant.

Recently, a randomized multicenter clinical study (PARITY) showed no significant differences after 1-day or 5-day post-operative prophylactic intravenous cephalosporin after tumoral endoprostheses for the lower extremity.[14] The infection rate in the 1-day regimen group was 16,7%, compared to 15% in the 5-day regimen.[14] The 5-day regimen group did not reduce the infection rate and presented significantly more antibiotic-related complications.[14]

The present study found a global infection rate of 10,7% when local antibiotic-loaded calcium sulfate beads were used for infection prophylaxis, lower than the reported rates without its application. However, the difference is not statistically significant. This prophylactic strategy was recently integrated in our practice affecting the sample size. The proximal tibia presented the highest infection rate (33%), followed by the distal femur (25%). Compared to our data on tumoral

endoprostheses without antibiotic pearls prophylaxis, the global infection rate was 11,5%, and a 28,5 % infection rate was found in the pelvis, 25% at the distal femur and 20% at the proximal tibia.

Similar studies conducted to analyze the periprosthetic infection rate and the functional outcome of patients submitted to endoprosthetic reconstruction without prophylaxis in primary implantation surgery using calcium sulfate beads have shown similar infection rates to those in our study. Khakzad et al.[5], in their study of 83 patients, showed a global infection rate of 16,8%. Comparing different anatomical locations, authors verified a 28,1% infection rate for the knee, 10,5% for the shoulder, and 6,7% for the hip.[5]

Singh et al.[6] presented an infection rate of 11,2% and 44,4% in the proximal tibia, 22,2% in the distal femur, 16,6% in the pelvis, and 11,8% in the humerus (proximal and distal). Their study shows that infection significantly affects the functional outcome, and age is related to the functional scoring independently of infection.[6] In the same way, local or distant disease progression impacted the function of the non-infected group, although patients with infected endoprosthesis had a significantly lower tumor recurrence rate. [6]

Analyzing the infection rates from the patients where the calcium sulfate beads were applied and comparing them with infection rates from patients where this prophylaxis strategy was not used (either from our hospital or other studies), we do not find statistically significant differences. Our global infection rate in patients who made the infection prophylaxis applying locally calcium sulfate beads is similar to those without it.

In the literature, there is consensus about the relationship between anatomical location and the risk of periprosthetic infection. In the present study, the knee joint presented the highest risk of infection, accordingly to the literature. The previously reported rate of periprosthetic joint infection in the knee location ranges from 22,0% to 44,4%.[6]

In general, the endoprostheses implanted in the proximal tibia are at higher risk of infection, followed by the distal femur. Proximal tibia location has the particularity of requiring extensor apparatus reconstruction and proper soft tissue recovery, frequently with gastrocnemius flap.

Analyzing our data related to patients without antibiotic-loaded calcium sulfate beads, the pelvis was the most frequently infected location. However, the cohort of patients in this group is small, which is limiting, not allowing us to take conclusions from these results.

Immunosuppressed patients have a higher risk of periprosthetic infection. Nevertheless, there was no statistically significant difference in infection rate in this study when adjuvant treatments were performed (*p*-value=0,736; *p*-value>0,005).

The use of Trevira® mesh could not be related to a higher risk of infection in the present study. Furthermore, pathological fracture was not related to infection.

Although infection increases when the ASA score is higher in this study, it is not statistically significant (*p*-value=0,319; *p*-value>0,005). The ASA classification increases in relation to higher comorbidities of the patient and subsequent risks.

In our study, we cannot infer about bacteriological agents due to the small sample size.

This study's limitations are inherent to a retrospective study, small sample size, one single centre, heterogeneity related to these oncological patients, and limited follow-up due to patients' survival or early revisions related to mechanical complications (type 3 Henderson complications). These limitations do not allow us to correctly evaluate if the locally applied antibiotic-loaded calcium sulfate beads significantly impact the prophylaxis of periprosthetic infections. This also enables us to evaluate the risk factors associated with endoprosthetic infection. We found a trend towards the risk of infection related to the knee location and higher ASA classification.

The primary endoprosthetic infection rate of patients with locally applied antibiotic-loaded calcium sulfate beads was lower than in the literature, although not statistically significant due to this study limitations. Nevertheless, its use may increase exudate and, subsequently, local seroma, heterotopic ossification, wound dehiscence, and skin necrosis. It was not reported any of these complications except the heterotopic ossification. The risk of these complications is related to higher quantities of local antibiotic pearls, and we use mainly 10cc of product and punctually 20cc for extended surgical approaches as a total femur. Lum et al. defend that the use of 100% pure calcium sulfate antibiotic-impregnated beads may help reduce post-operative wound complications and that it appears to be a safe adjunct tool in local antibiotic delivery.[15] However, they did not study tumoral endoprostheses but knee and hip arthroplasty.[15]

After surgery, a drain was used for all patients and heterotopic ossification was frequently detected during follow-up in the knee reconstructions, mainly adjacent to the residual femur and mostly presenting reduced sizes. However, it was asymptomatic and did not require any attitude. The STIMULAN® beads are 100% absorbable calcium sulfate to complement the dead space providing local antibiotic therapy. Its use has been shown to be safe and this study also confirmed it. When compared to other bone filling agents, it is expected to induce lower heterotopic ossification, particularly if 10cc are used. These beads completely and slowly release the antibiotic loaded, providing a more stable and predictable release of higher local antibiotics concentration, allowing it to act more efficiently and for an extended period of time.

Although the prophylactic use of antibiotics is important, it seems not enough by itself. It should be part of a strategy where other factors should be included to optimize patients' immunosuppression acting directly to improve the immune system of these specific patients. Furthermore, antibiotics should always be used carefully due to bacterial resistance.

Thus, we recommend using local antibiotic pearls on primary endoprostheses as one of the strategies for infection prophylaxis when using tumoral endoprostheses.

Conclusion

Infection is the most frequent complication of tumoral endoprostheses related to implant failure that seriously impacts patients' function and quality of life, with a high risk of amputation and ultimately threatening life. It also has a significant socioeconomic impact. Local antibiotic pearls have been reported as beneficial for treating periprosthetic infection, but there are no studies on their impact as a prophylactic measure for primary tumoral endoprostheses.

This study shows that the antibiotic-loaded calcium sulfate beads are a safe prophylactic measure for tumoral periprosthetic joint infection. Heterotopic ossification might be the most frequent side effect, but it has shown to be asymptomatic and without requiring any attitudes. However, this study could not take conclusions on its efficacy as a prophylactic strategy due to the small sample size. In fact, larger prospective and multicenter studies are needed to leap forward.

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Figures

Figure 1. a) Conventional radiography showing an osteosarcoma of the distal femur; b) MRI image characterizing the tumor and showing the extension to soft tissue without neurovascular involvement; c) post operative image control shows the endoprosthetic reconstruction and the antibiotic-loaded calcium sulfate beads.

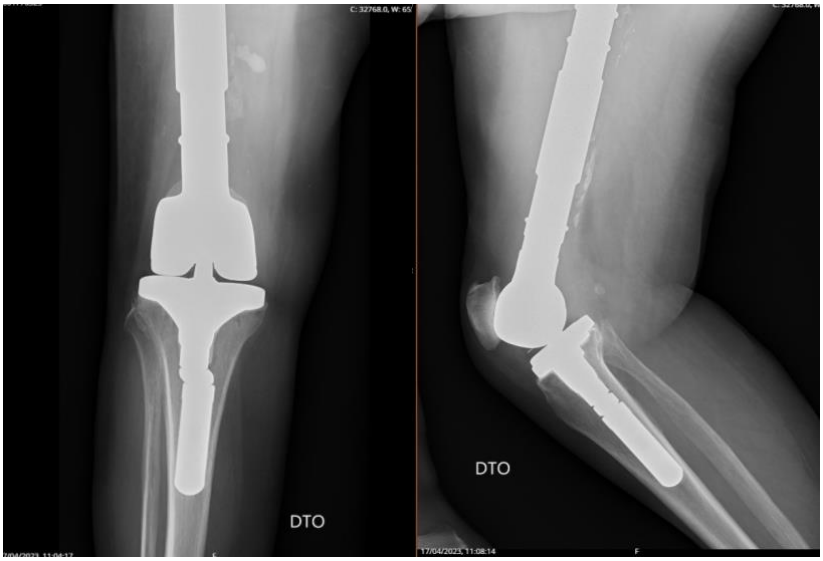

Figure 2. Conventional radiographs (frontal and lateral views) showing the formation of heterotopic ossification (asymptomatic).

Tables

Table I. Patient characteristics.

Variables	**n (%) n=28**
Gender	
Male	20 (71,4)
Female	8 (28,6)
Location	
Proximal Humerus	3 (10,7)
Pelvis	1 (3,6)
Proximal Femur	9 (32,1)
Distal Femur	11 (39,3)
Proximal Tibia	4 (14,3)
Infection	
Infected	3 (10,7)
Non-infected	25 (89,3)
Tumor	
Osteosarcoma	10 (35,7)
Chondrosarcoma	5 (17,9)
Metastasis	6 (21,4)
Ewing Sarcoma	2 (7,2)
Chondroblastic Osteosarcoma	1 (3,6)
Pleomorfic Sarcoma	1 (3,6)
Giant cells Tumor	1 (3,6)
TMBNP	1 (3,6)
Hidatid Cyst	1 (3,6)
ASA Score	
I	1 (3,6)
II	16 (57,1)
III	11 (39,3)
Trevira Mesh	
Yes	20 (71,4)
No	8 (28,2)
Pre-op Fracture	
Yes	7 (25,0)
No	21 (75,0)
Treatments	
Neo-adjuvant Chemotherapy	19 (67,9)
Adjuvant Chemotherapy	18 (64,3)
Radiotherapy Adjuvant	4 (14,3)
Age	
Mean	45,39 (15-81)
BMI	
Mean	24,86 kg/m^2 (+/- 3,94)
Complications (Henderson Classification)	
Type I	1 (3,6)
Type II	4 (14,3)
Type IV	3 (10,7)
Type V	4 (14,3)
Final Status	
No evidence of disease	18 (64,3)
Alive with disease	6 (21,4)
Dead of disease	4 (14,3)