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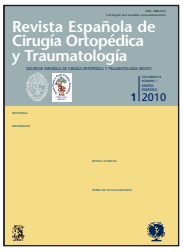

ORIGINAL PAPERS

Purpose: to review the results of one-step exchange in the infected total knee arthroplasty

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KEYWORDS
Knee;
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Abstract
Purpose: To review the results of one-step exchange in the infected total knee arthroplasy.
Materials and method: Restrospective study of 16 patients with a mean follow-up of 7 years. We studied the comorbidity of the patients, infection classification, microrganisms and clinical evaluation of the knee. We applied the Knee Score and Functional Score of the American Knee in order to carry out the corresponding clinical assessment and radiological study.
Results: In 14 patients (87,5%) the infection was eliminated with a good clinical and functional result (KS=80,78 and KSF=75,07). In the two remaining cases reinfections was caused by *staphylococcus epidermidis*.
Conclusions: One-step reimplantion is a good option for the treatment of infected total knee arthroplasty.

PALABRAS CLAVE
Rodilla;
Prótesis total de la rodilla infectada;
Recambio en un tiempo

Recambio en un tiempo para la infección periprotésica de la rodilla

Resumen
Objetivo: Valorar el resultado del recambio en un tiempo en el tratamiento de la infección protésica de la rodilla.
Material y método: Se efectuó una revisión retrospectiva de 16 pacientes con un seguimiento medio de 7 años. Se valoró la comorbilidad del paciente, el tipo de infección, el germen y la evolución clínica de la rodilla. Se aplicó el Knee Society Score (KSS) y el Knee Society Function Score (KSF) de la American Knee Society para su valoración clínica y el estudio radiográfico correspondiente.

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Resultados: Se curó a 14 pacientes (87,5%) con unos resultados clínicos y funcionales muy satisfactorios (KSS = 80,78 y KSF = 75,07). El germen causal de las 2 reinfecciones fue el *Staphylococcus epidermidis*.
Conclusiones: El recambio en un tiempo es una opción terapéutica válida para el tratamiento de la infección protésica, siempre que se indique y se efectúe de forma rigurosa.

Introduction

Prosthetic infections are the most devastating complications that can arise following a knee arthroplasty for the soft tissue and the joint itself, causing bone loss, the possibility of cutaneous necrosis, and irreversible injury to the extensor apparatus. These infections also produce systemic problems in the patient, due to the worsening of the primary disease, hypoproteinaemia due to chronic suppuration, prolonged antibiotic treatments, various surgical interventions with associated physical deterioration, and reactive depression, since the treatment that was supposed to improve the patient's quality of life through an increase in physical activity free of pain has now become a generalised worsening of all of the parameters that were supposed to provide increased autonomy. The family environment is also negatively affected by the prolonged treatments with entire months of hospitalization, which eventually cause physical and emotional fatigue. The management of the hospital is also affected by these prolonged stays through the number of germs and their increased resistance to treatments, and the exhaustion that the doctors and the economy of any health system would feel.

The ultimate goal of the treatment of this condition is the eradication of the infection with the minimal inatrogenesis possible regarding functionality and pain. Therefore, prosthetic replacement in one or two steps is the option most often taken when the local and general conditions of the patient allow it.[1]

Although a delayed replacement is the most developed option[2-6] and has even been published as being the gold standard for the treatment of prosthetic infections,[1,7] yielding infection control rates over 95%,[1,8] the one-step exchange is an attractive alternative with similar healing rates,[9-15] but in some cases it has been undervalued due to negative experiences or unfamiliarity with the procedure.

With this review we attempt to describe our experience with this type of treatment that has been little used elsewhere, and present our results obtained from 20 years of experience in knee prosthetics and their complications.

Materials and methods

We performed a retrospective descriptive study. Between 1991 and 2007, 79 infected knee arthroplasties were treated at our hospital. The therapeutic approach was chosen according to a treatment algorithm following the diagnosis of a prosthetic infection, with the following inclusion criteria for a one-step exchange: immunocompetent patient with an infection lasting over 4 weeks, with microorganisms and antibiograms assessed, whose sensitivity would permit the use of antibiotics in the cement, with healthy soft tissue that would permit skin closure without difficulty following debridement, and without the presence of active suppuration or productive fistulisation.

These conditions were met in 16 cases (20–25% of infected prostheses): 11 women and 5 men. Each of these patients received a one-step exchange. The mean follow-up time was 7 years (range: 2–13 years). The mean age of the patients was 69 years with an interquartile range of 66 to 74 years. No cases had previous local antecedents in the operated knee. Gonarthrosis was the initial diagnosis of the knee for all cases.

We performed a data collection protocol that included patient information, local injury history (initial arthropathy [cause of the arthroplasty] and previous surgical interventions on the knee) and general medical history using the Charlson index,[16] which evaluates a series of comorbidity conditions that are assigned a score (1, 2, 3, or 6) according to the risk of death from the disease.

Furthermore, we obtained the following information regarding the infection: Segawa and Tsukayama classification,[17] clinical presentation, microbiology of the causative agent and its antibiogram, clinical evolution, and treatment given.

We used the Knee Society Score (KSS) in order to evaluate the functionality of the knee using both sections: knee KSS and function KSS; each of these was based on a 100-point maximum score. The knee KSS is made up of three subdivisions: pain (0–50 points), range of motion (0–25 points) and stability (0–25 points); while the function KSS is made up of two subdivisions: walking (0–50 points) and stairs (0–50 points). Both sections have conditional deductions that can amount to 50 points. Patients are assigned one of 3 different categories according to their functional limitations in relation to their medical debilitation or afflictions in other joints: *a)* if the contralateral knee is asymptomatic; *b)* if the contralateral knee is symptomatic; and *c)* if multiple arthritic areas exist or when a medical debilitation limits function.[18]

The radiological evaluation of the knee was performed using anteroposterior (AP) and lateral views. Finally, the patient's grade of personal satisfaction was evaluated through interviews, and was rated as *bad, regular, good,* or *very good.*

Surgical technique

The joint was approached through the previous incision, attempting to avoid dissection by regions. This was followed by

an ample debridement of all granulomas and tissues suspected of being infected. The prosthetic components and cement were then removed, followed by a debridement of all periprosthetic and interface tissue, paying special attention to the radical debridement of the posterior capsule due to its technical difficulty, which then underwent an anatomopathological and microbiological analysis. Abundant irrigation was applied with 10L of saline solution through pulsatile lavage. This was followed by a complete gear change (gloves, coats, surgical cloth, instruments), then a knee stabilizing prosthetic model was put into place, as in the majority of cases, the cleaning of the devitalized bones during debridement involves some bone loss or weakening of the ligaments due to the deterioration of these tissues resulting from the infection, or when it is required to permit access for the surgical cleaning of the implant site. In most cases we used a rotational knee prosthetic model (Endo-Model, Link, Germany) cemented with antibiotics specifically aimed at the sensitivity of the causative agent, and which met the conditions of being a thermostable antibiotic, whose mode of pharmaceutical application was a powder substance that was mixed at a maximum concentration of 4g per 40g of cement.[19]

Statistical methods

The data obtained were analyzed using the SPSS statistical software package (version 16.0). The continuous variables were summarized as medians and interquartile ranges. The discrete variables were summarized as percentages. We used the Mann-Whitney U test (continuous variables) and the Chi-squared test (discrete variables) for the between-group comparisons.

Results

The evaluation of medical histories according to the Charlson comorbidity index was 0 in 7 cases, 1 in 6 cases, 2 in 2 cases, and 3 in one case. No statistically significant relationship was found between Charlson index and prosthetic reinfection (p=0.676).

The presentation of the infection, according to the Segawa and Tsukayama classification, was type 2 (first month) in 6 cases and type 4 (more than one month) in 10 cases. No statistically significant relationship was found between the type of infection and prosthetic reinfection (p=0.368).

Fifteen of the cases presented were primary prosthetic infections and one case was an infection of a prosthetic exchange due to aseptic loosening.

The isolated microorganisms were *S. epidermidis* in 8 cases (50%), *Staphylococcus aureus* in 2 cases (12.5%), one case of *Pseudomona aeruginosa* (6.25%), one case of *Staphylococcus warnerii*, one case of *Enterococcus faecalis*, one case of *Staphylococcus capitis* and one case of *Streptococcus pneumoniae*. Although both reinfections were caused by *S. epidermidis*, this correlation was not statistically significant (p=0.457).

Recurrence of infection

Following the previously described treatment, the infection was cured in 14 of the 16 cases (87.5%), based on the criteria of disappearance of clinical signs and the normalization of acute phase reactants one year following the prosthetic exchange.

No statistically significant correlation was found between infection recurrence and age (p=0.569), sex (p=0.865), Charlson index (p=0.676), and type of infection (p=0.368).

The cases of reinfection were caused by *S. epidermidis*, although this correlation also lacked statistically significant correlation (p=0.457). One of these was an infection of an aseptic exchange, and resulted in 2 arthrodeses in the knee.

Clinical results

The mean knee KSS score at the end of the follow-up period was 80.78 (range: 65–93). The resulting evaluation was excellent in 5 cases (KSS: 85–100), good in 7 cases (KSS: 70–84), acceptable in 2 cases (KSS: 60–69) and poor in no cases (KSS < 60). The mean function KSS score was 75.07 (range: 45–80). The resulting evaluation was excellent in two cases, good in 9 cases, acceptable in 2 cases, and poor in one case (it must be taken into account that this patient, who received a functional score of 45, was a category c).

Radiology

The radiological evaluations showed no radiolucencies indicative of loosening.

Satisfaction

The subjective level of satisfaction on the part of the patient was good in 10 cases, regular in 4 cases, and poor in 2 cases (the patients whose treatment failed). There was no significant relationship between level of satisfaction and age, gender, or type of infection or microorganism.

Discussion

The one-step exchange is a therapeutic option for the treatment of prosthetic infections that has been accepted by the majority of schools but with a more or less restrictive set of indications. Its use is more extensive in Europe than in the United States.[20,21] It presents an option that is equally as valid as a two-step exchange, and when correctly indicated and carried out meticulously, it can provide results even better than the two-step exchange due the decreased morbidity. Assuming that the surgical debridement is what really cures the infection by eliminating the biofilms that perpetuate the infection and that the antibiotic is adjuvant to the surgical treatment, we can conclude that a two-step exchange will be necessitated when we are unable to complete a sufficiently aggressive cleaning of the knee in order to eradicate the infection, or when an antibiotic that is sufficiently effective at fighting the causative agent is not available.

On the other hand, the supposition that the prosthetic implant in two-step exchanges is a sterile component is questionable, since a high rate of cultures (as high as 30%) taken from explanted spacers come up positive,[22] and some authors prefer external fixation to the use of spacers when

dealing with *S. aureus* or other multiresistant infections due to the rapid colonization of the material and its behaviour as a foreign body.[23]

Authors such as Zimmer and Maurer have published a treatment algorithm that can reach levels of 90% cure rates in the treatment of prosthetic infections.[20,23] We share the importance that these authors place on especially rigorous indications in order to obtain optimal results. As a result, the comparison of results between the two types of treatment in our study would not be useful, since these are samples of patients that are incomparable in terms of the causative agent, host, and type of infection.

In accordance with the treatment algorithm for correct indications, we have been able to achieve an 87.5% cure rate using one-step exchanges. Our results are comparable and even better than those published by other authors using this technique (which range from 60 to 100%). Steinbrick, from the Endo-Klinic of Hamburg, published the groundwork for the use of antibiotic-loaded cement in the procedure of a one-step prosthetic exchange.[24,25] Subsequently, Von Foester et al,[26] from the same clinic, were the first authors to publish their experiences using a one-step exchange. Between 1976 and 1985, they performed 118 exchanges with an 80.76% success rate with a follow-up period of 5 to 15 years.

Göksan and Freeman[10] published their results from 18 exchanges with a cure rate of 88.8%, and observed that the 2 failures that their study produced were in patients with rheumatoid arthritis. Cloedt et al[11] discussed their results from the treatment of prosthetic infections that, while brief (5 one-step exchanges and 5 two-step exchanges), obtained better results than direct exchanges, with a cure rate of 60%, and showed that failures were produced only in immunodepressed patients.

Lu et al[12]. presented their results from 8 exchanges with a cure rate of 87.5%, and Holzer et al[26] treated 18 tumoural megaprosthetic infections with one-step exchanges, yielding a 77.7% cure rate after an average 52 month follow-up. Siegel and Frommelt[13,14] from the Endo-Klinik compiled data on 54 hip arthroplasties and 32 knee arthroplasties that received one-step exchanges from 1984 to 1998 and found an 87.1% cure rate, although 5 cases (16.1%) required a second intervention in order to eradicate the infection.

By 2002 no North-American study was published on the subject. Silva et al[9] presented a cure rate of 89.2% following one-step exchanges of 37 infected knee arthroplasties with a 4-year follow-up time.

Zimmerli et al[20] published a treatment algorithm for prosthetic infections and their results following a 16 year period of application, and concluded that the one-step exchange (16 cases) cure rate was 94%; this is the most positive result for treatments indicated for this type of infection. For their part, Musil et al[27] maintained a 100% cure rate following 14 cases of one-step exchanges with a 43 month follow-up, and Bauer et al,[15] with prosthetic exchanges, achieved better results with the one-step technique (87%) than with the two-step technique (84%) in 107 cases treated with a mean 4 year follow-up. Gehkre communicated the latest results from the Endo-Klinik in Hamburg, and achieved a 90% cure rate with an 8 year follow-up.[28]

There is a general consensus that for this treatment to be successful requires a radical, almost "oncological" debridement of the knee.[24] Therefore, the surgical team must be experienced in this type of procedure and the hospital in question must have the adequate conditions for surgical and postoperative treatment of osteoarticular infections (specialized hospital units, microbiology and infectious disease units). Some authors use a biguanide and chlorhexidine solution for the pulsatile lavage.[28]

No concrete antibiotic regimen exists for use with prosthetic cement. However, there is a general understanding not to use more than 4g of thermostable antibiotic in powder form per 40g of cement powder in order to avoid altering the biomechanical properties of the cement. A regimen used at the Endo-Klinic is 1g gentamicin, 1g ampicillin, and 2g ofloxacin per 40g of cement.[28] We did not use a standard antibiotic regimen, but instead evaluated each case according to the microorganism and its antibiogram in order to determine the most appropriate antibiotic for the cement mixture, always maintaining a close collaboration with infectious disease specialists. Although the majority of practitioners consider the presence of fistulae or active suppuration to be a contraindication for this technique,[9,20,23] other authors[19,24,29] consider it to be a comorbidity of the infection itself and no impediment to one-step exchanges.

S. aureus and *S. epidermidis* are the 2 most frequent causative agents. Some studies implicate *S. aureus* as the most frequent[13,30] and most difficult to eradicate. In other studies,[17,31] as in ours, it is *S. epidermidis* that most frequently causes infection. Microorganisms with particularly worrying drug resistance have been detected, such as the methicillin-resistant coagulase-negative staphylococcus, which have risen as frequent hospital pathogens with relation to prosthetic infections that require complex antibiotic treatments and yield poor results.[32]

Multiple factors influence the outcome of the therapeutic strategy for infected total knee prostheses. The surgeon must personalize the medical and surgical treatment, requiring a multidisciplinary focus. The surgical technique for a one-step exchange is more demanding and an experienced surgical team is required for this type of procedure. Furthermore, the one-step exchange is a valid therapeutic option for the treatment of prosthetic infections, and requires the following indications: immunocompetent host, known causative agent and antibiogram, healthy soft tissue for closing following debridement, a radical debridement of all tissue suspected of infection, the use of cement with antibiotics tailored to the causative agent, and the use of an adequate prosthetic model for the needs of the patients' joints following the surgical cleaning.

Conflict of interest

The authors affirm that they have no conflicts of interest.

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