Total Elbow Arthroplasty after an Infectious Process. Two-stage Surgery

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ABSTRACT

Objective: to report the results of patients with an infectious elbow process, treated in 2 surgical stages: the first with an antibiotic cement spacer (ACS) and the second with a total elbow arthroplasty. **Material and methods:** the inclusion criteria, the diagnosis of infection and the 2 surgical stages are described. **Results:** 10 patients were included (7 men and 3 women), average age: 62 years old. Initial causes: degenerative in 2 cases and traumatic in 8. 4 alloprostheses and 2 latissimus dorsi flaps were performed. Follow-up was 5 years. Flexo-extension was 117°/29° in preoperative and 130°/29° in postoperative; pain according to VAS: 6.5 and 2.5; MEPS: 40 and 80; DASH 56 and 30 respectively. The extension strength was M5 (4 cases), M4 (2), M3 (1), M1 (2) and M0 (1). One patient presented a necrosis of the flap that evolved with infection. In 9 of the 10 cases the patients were free of infection at the end of the follow-up. Two groups of patients were identified: Group A (bone defects less than 4 cm) and B (more than 4 cm). Group A patients had fewer previous surgeries and better functional outcomes. **Conclusion:** the treatment of an infectious elbow process through the placement of antibiotic cement spacer, allows a control of the infection in a high percentage of cases. Secondary prosthetic reconstruction is demanding and associated with complications. It is to be expected that the greater the bone defect and the greater the number of previous procedures, the worse the functional results.

Key words: Total elbow arthroplasty; infection; osteomyelitis; antibiotic spacer.

Level of Evidence: IV

Artroplastia total de codo después de un proceso infeccioso. Cirugía en dos tiempos

RESUMEN

Objetivo: Comunicar los resultados en pacientes con un proceso infeccioso del codo, tratados en 2 etapas quirúrgicas: la primera con un espaciador de cemento con antibiótico y la segunda con una artroplastia total de codo. **Materiales y Métodos:** Se describen los criterios de inclusión, el diagnóstico de infección y las 2 etapas quirúrgicas. **Resultados:** Se incluyeron 10 pacientes (4 hombres y 6 mujeres, edad promedio 62 años). Causas iniciales: degenerativas (2 casos) y traumáticas (8 casos). Se realizaron 4 aloprótesis y 2 colgajos de dorsal ancho. Se identificaron 2 grupos: A (defectos óseos <4 cm) y B (>4 cm). El seguimiento fue de 5 años. La flexo-extensión fue de 117°/29° en el preoperatorio y 130°/29° en el posoperatorio; los puntajes de dolor fueron 6,5 y 2,5 (EAV); 40 y 80 (MEPS); y 56 y 30 (DASH), respectivamente. La fuerza de extensión fue de M5 (4 casos), M4 (2 casos), M3 (1 caso), M1 (2 casos) y M0 (1 caso). Un paciente tuvo una necrosis del colgajo que evolucionó con infección y 9 no tenían infección al final del seguimiento. Los pacientes del grupo A tenían menos cirugías previas y mejores resultados funcionales. **Conclusiones:** El tratamiento de un proceso infeccioso de codo mediante un espaciador de cemento con antibiótico permite controlar la infección en un alto porcentaje de los casos. La reconstrucción protésica secundaria es demandante y se asocia a complicaciones. Cabe esperar que, cuanto más grande sea el defecto óseo y mayor la cantidad de procedimientos previos, los resultados funcionales sean peores.

Palabras clave: Artroplastia de codo; prótesis de codo; infección; osteomielitis; espaciador de cemento.

Nivel de Evidencia: IV

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INTRODUCTION

Total elbow arthroplasty (TEA) has been shown to treat degenerative and traumatic diseases of the elbow. However, some conditions, such as previous infections or poor soft tissue coverage, have been considered a strict contraindication for implantation.[1-4] Placement of a prosthesis in the context of a previous infection is challenging, because the initial septic process can be difficult to eradicate. Most publications describe the development of an infectious process after prosthesis failure and, in these cases, the current literature agrees that two-stage surgery is the treatment of choice.[4-7] However, to our knowledge, there are very few reports on the treatment of elbow bone infections outside the context of a prosthesis.[3,8]

The objective of this article is to report the results of a cohort of patients with an infectious process of the elbow who were treated in two surgical stages: the first with an antibiotic cement spacer (ACS) and the second with a TEA. Our secondary objective is to determine whether the magnitude of the residual defect or the number of previous procedures affect the final outcome.

MATERIALS AND METHODS

We designed a retrospective observational study of all patients undergoing TEA after an infectious process, at our institution, between 2007 and 2019. The inclusion criteria were: patients >18 years of age, with an infectious process of the elbow, treated in two surgical stages, the first with an ACS and the second with TEA; that both procedures had been performed in our institution and by the same surgical team, and a follow-up >1 year.

Suspicion of infection was established by clinical parameters (erythema, edema, pain, increase in local temperature, fistula, exposure in case of open fractures) and biochemical parameters (erythrocyte sedimentation, C-reactive protein, white blood cell count). Infectological confirmation was achieved by taking samples for cultures and pathological anatomy during surgery.

The cause of the primary surgery, the number of previous surgeries, the time from the primary surgery to the first surgical stage, the isolated germs, the duration of the ACS, the time of antibiotic therapy, the residual joint defect at the time of reconstruction, the type of reconstruction and whether the patient no longer had infection at the end of follow-up were recorded

For the objective evaluation, the range of motion was measured with a goniometer and the subjective evaluation was performed with the DASH[9] (*Disabilities of the Arm, Shoulder and Hand*) and MEPS[10] (*Mayo Elbow Performance Score*) scores, the visual analog scale (VAS) for pain and patient satisfaction; and the MRC (*Medical Research Council*) scale for elbow extension strength.[11]

Frontal and profile radiographs were taken in the immediate postoperative period, at one month, at 3, 6 and 12 months each year, and at the end of follow-up. The presence of loosening was evaluated according to the Morrey scale,[12] which classifies them as: grade 0, radiolucent line <1 mm and involving <50% of the interface; grade 1, radiolucent line of 1 mm and involving <50% of the interface; grade 2, radiolucent line >1 mm and involving >50% of the interface; grade 3, radiolucent line >2 mm and involving the entire interface; grade 4, gross loosening. The presence of heterotopic ossifications was evaluated using the Hastings classification:[13] class I: radiographically evident heterotopic ossification in the elbow or forearm, without functional limitation; class IIA: limitation in the flexion / extension plane; class IIB, limitation in the pronation / supination plane; class IIC: limitation in both planes of movement; class III: ankylosis that eliminates flexion / extension of the elbow, pronation / supination, or both.

As a secondary objective, functional results were evaluated according to the residual bone defect, and patients were grouped into those with a defect <4 cm (group A) or >4 cm (group B) in both the ulna and the humerus. This division was made taking into account that a 4 cm shortening of the humerus is usually compatible with good function.[14] Radiographic measurement was performed before the second surgical stage.

Surgical technique

First surgical stage

All patients were operated in dorsal decubitus position with regional anesthesia. The posterior approach was used in eight cases and the lateral approach in two. Whenever the posterior approach was used, the ulnar nerve was identified and repaired. A meticulous debridement of devitalized tissue was performed, including removal of

implants and residual cement, if applicable. The medullary cavities were freed of all pseudomembranes and abundantly irrigated. If there was no previous culture, a sample was taken during surgery, for staging according to the Mirra criteria, which evaluate the number of polymorphonuclear leukocytes per high-power field (500 x).15 The sample suggests infection when 5 or more polymorphonuclear leukocytes are detected per field. If there are no polymorphonuclear leukocytes, there is no clinical or microbiological sign of infection.

Several samples were sent for deferred culture. A cement spacer was made. 2 g of vancomycin were added per dose of cement in all cases and, in two patients, 1 g teicoplanin was also added. In seven cases, the ACS was placed with an intramedullary Steinmann nail in the ulna and humerus and, in three cases, it was inserted freely into the joint space.

Triceps status was assessed to design a posterior reconstruction tactic. The patients were immobilized with a posterior plaster slab and a catheter was placed to administer the parenteral antibiotic. Two weeks after the antibiotic treatment was completed, the biochemical analyses were repeated to determine erythrocyte sedimentation and C-reactive protein levels. Faced with parameters compatible with the absence of infection, reconstruction was indicated.

Second surgical stage

The second surgical stage was performed through a posterior approach in all cases. The ACS was extracted and samples were sent for intraoperative and deferred anatomic pathology analysis. Once the absence of infection was confirmed (according to the Mirra criteria), joint reconstruction was performed. Two patients required a latissimus dorsi pedicle flap to cover the posterior defect. In four cases, an alloprosthesis was placed (2 in the ulna and 2 in the humerus). Fixation of the allograft to the recipient was through a 3.5 and 4.5 mm LCP plate (Locking Compression Plate, Synthes ™, Oberdorf, Switzerland). The triceps was treated in different ways. In five patients, it was disinserted and subsequently reinserted; in two, it was repaired; in one patient, the triceps tendon was sutured to the ulna allograft; in another, the pedunculated dorsal tendon was sutured to the triceps and, in another, the pedunculated dorsal tendon was sutured to the triceps tendon of the ulnar allograft.

The prosthesis was placed in a conventional manner. A semi-constrained prosthesis was always used. Six patients received a Coonrad / Morrey prosthesis (Zimmer, Warsaw, IN, USA); two, a Discovery prosthesis (Biomet, Warsaw, IN, USA) and, two, a Discovery-SRS prosthesis (Biomet Orthopedics, Warsaw, IN, USA). The patients were immobilized with a plaster slab in extension for three weeks to allow the triceps to heal.

FINDINGS

Eleven patients were treated during this period. One was excluded due to loss to follow-up two months after the reconstruction stage and, at that time, he had no infection. The final group consisted of 10 patients (4 men and 6 women, average age 62 years [range 35-80]).

Table 1 lists the initial causes, the number of surgeries and previous treatments, the type of germs, the bone defects, and the types of reconstruction.

In eight of the 10 cases, it was possible to obtain laboratory samples for acute phase reactants (erythrocyte sedimentation and C-reactive protein) before arthroplasty and the values were pathological.

All patients underwent a previous puncture biopsy, which was positive in nine of them. In one patient, it was not possible to isolate the germ and the diagnosis was reached by the presence of more than 5 polymorphonuclear leukocytes per field in the intraoperative biopsy and the deferred pathological anatomy analysis (case 1).

In the second surgical stage, intraoperative biopsy samples were taken according to the Mirra criteria. All cases presented <5 polymorphonuclear leukocytes per field.

The average follow-up from the first surgical stage was 5 years (range 1-10).

In five patients, the previous range of motion could not be evaluated: in three of them, because the joint resections were wide and completely unstable and in two of them, because they had had fractures with great loss of bone stock. Results are shown in Table 2.

Table 1. Demographic data

Patient	Age	Sex	Cause	Previous treatment	Previous surgeries	Time until the first stage	Culture	Time 1-2 stage	Group (defect, cm)	Reconstruction time
1	80	M	PA	Infiltration	1	11 months	Negative	3	A (3 cm)	TEA (Coonrad/ Morrey)
2	65	F	RA	Synovectomy	2	14 months	Methicillin-susceptible *S. aureus*	3	A (2 cm)	TEA (Coonrad/ Morrey)
3	69	F	Supra fracture	Osteosynthesis/ debridement/ TEA	8	5 years	Polymicrobial	2	B (16 cm)	Ulnar alloprosthesis (Coonrad/ Morrey)
4	61	F	Luxation	Ligament plastic	2	9 months	Coagulase-negative staphylococcus	2.5	A (2 cm)	TEA (Coonrad/ Morrey)
5	60	M	Supra fracture	TEA/ arthrolysis	2	1 year	*S. epidermidis*	3	A (3 cm)	TEA (Coonrad/Morrey)
6	35	M	Supra fracture	Debridement	1	2 months	*S. epidermidis*	3	B (7 cm)	Humerus alloprosthesis (Coonrad/ Morrey)
7	71	F	Supra fracture	Osteosynthesis/debridement/TEA	4	4 years	*S. epidermidis*	8	B (10 cm)	TEA (Discovery-SRS)
8	60	F	Supra fracture	Osteosynthesis/debridement/TEA	19	29 years	Polymicrobial	3	B (23 cm)	Latissimus dorsi + ulnar alloprosthesis (Discovery-SRS)
9	51	F	Supra fracture	Debridement	2	1 month	Polymicrobial	4	B 15 cm)	Latissimus dorsi + humerus alloprosthesis (Discovery)
10	63	M	Terrible triad	Ligament plastic	2	4 months	Methicillin-susceptible *S. aureus*	5	A (2 cm)	TEA (C - M)
Average	61				4.3			3.6	8.3	

M = male, F = female, TEA = total elbow arthroplasty, PA = psoriatic arthritis, AR = rheumatoid arthritis.

Table 2. Findings

Patient	Follow-up (years)	Flexion-extension		Pain		MEPS		DASH		Extension strength	Cure of the infection	Loosening of the prosthesis	Heterotopic ossification	Complications
		Preoperative	Postoperative	Preoperative	Postoperative	Preoperative	Postoperative	Preoperative	Postoperative					
1	10	120/30	135/10	7	0	45	100	28	20	M5	Yes	No	No	No
2	9,5	130/30	140/35	6	0	60	75	72	33	M4	Yes	1	No	No
3	5,3	Not evaluated	125/30	8	3	20	75	68	26	M3	Yes	No	No	No
4	5	110/30	140/25	7	4	40	90	39	50	M5	Yes	No	No	Bolt loosening
5	4,5	110/30	130/15	5	1	45	100	46	20	M5	Sí	No	No	No
6	9	Not evaluated	135-40	---	1	---	70		24	M4	Sí	2	No	No
7	1,7	Not evaluated	110/40	5	2	50	75	65	23	M0	Sí	2	No	No
8	1	Not evaluated	120/30	6	7	20	40	72	58	M1	No	3	No	Flap necrosis
9	2,3	Not evaluated	140/30	---	2	---	85	-	23	M1	Sí	No	I	No
10	1	115/25	120/30	8	5	35	80	58	27	M5	Sí	1	IIC	No
Average	**5**	**117/29**	**130/29**	**6,5**	**2,5**	**40**	**80**	**56**	**30**					

DASH (*Disabilities of the Arm, Shoulder and Hand*), MEPS (*Mayo Elbow Performance Score*).

One patient (case 4) presented a bolt loosening due to a technical failure in the insertion two months after surgery, and required a new operation for its correct placement (Figure 1). On the other hand, a flap necrosis with recurrence of the infection was detected in one patient (case 8). Except for this last patient, all had normal biochemical parameters in the postoperative period and no relapse of the infection was detected in the last follow-up.

When evaluating the patients according to their bone stock, five were included in group A and five in group B (Figures 2 and 3). Group A had fewer previous surgeries and obtained better functional results, mainly in the recovery of extension force, than group B (Table 3).

Figure 1. A. Radiograph of a 63-year-old woman (case 4) 9 months after surgery for elbow instability with joint wear and infection. **B.** Cement spacer with antibiotic. **C.** Radiograph at 2 months showing loosening of the prosthesis bolt. **D and E.** Radiographs 3 years after surgery. **F and G.** Final mobility.

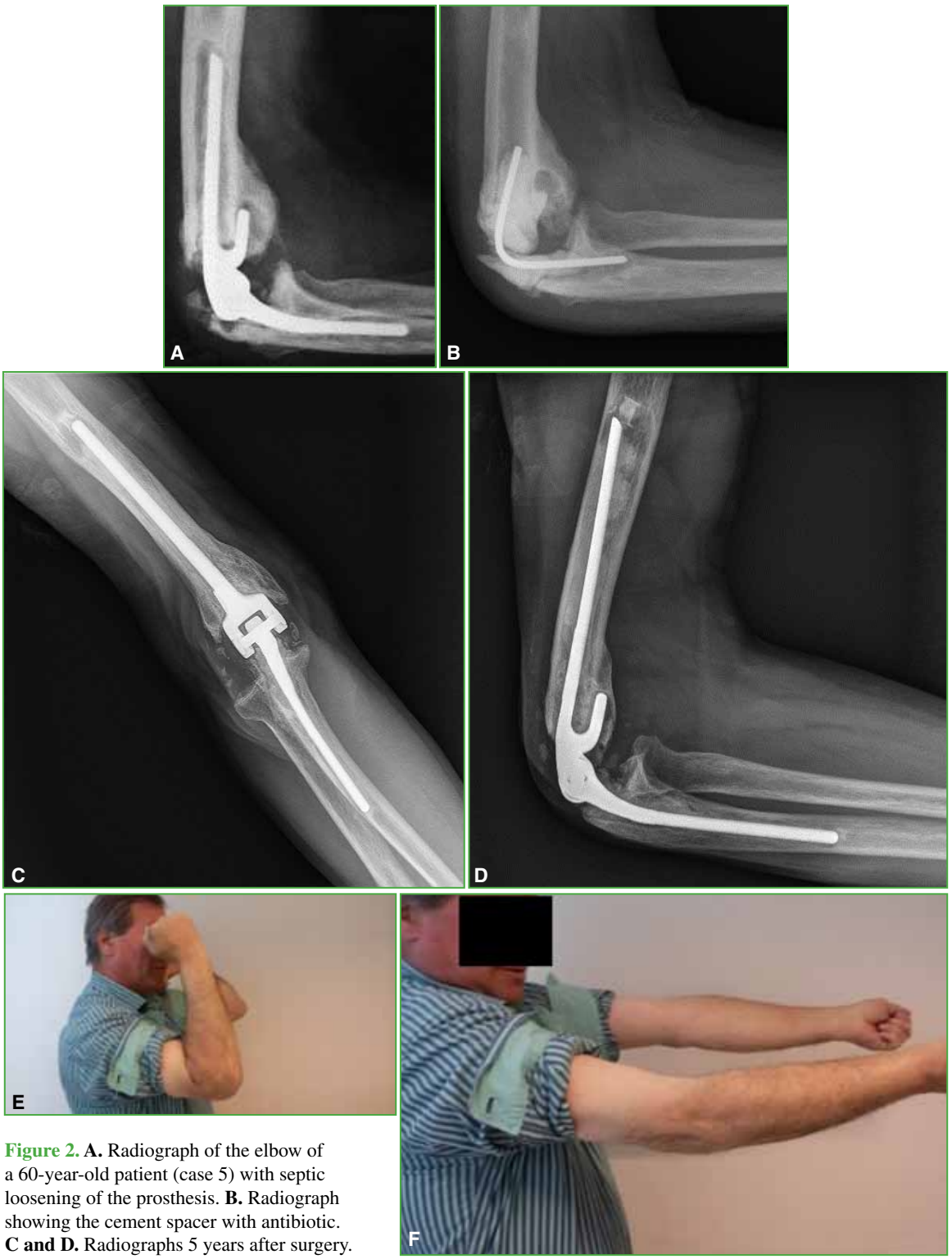

Figure 2. A. Radiograph of the elbow of a 60-year-old patient (case 5) with septic loosening of the prosthesis. **B.** Radiograph showing the cement spacer with antibiotic. **C and D.** Radiographs 5 years after surgery. **E and F.** Final mobility.

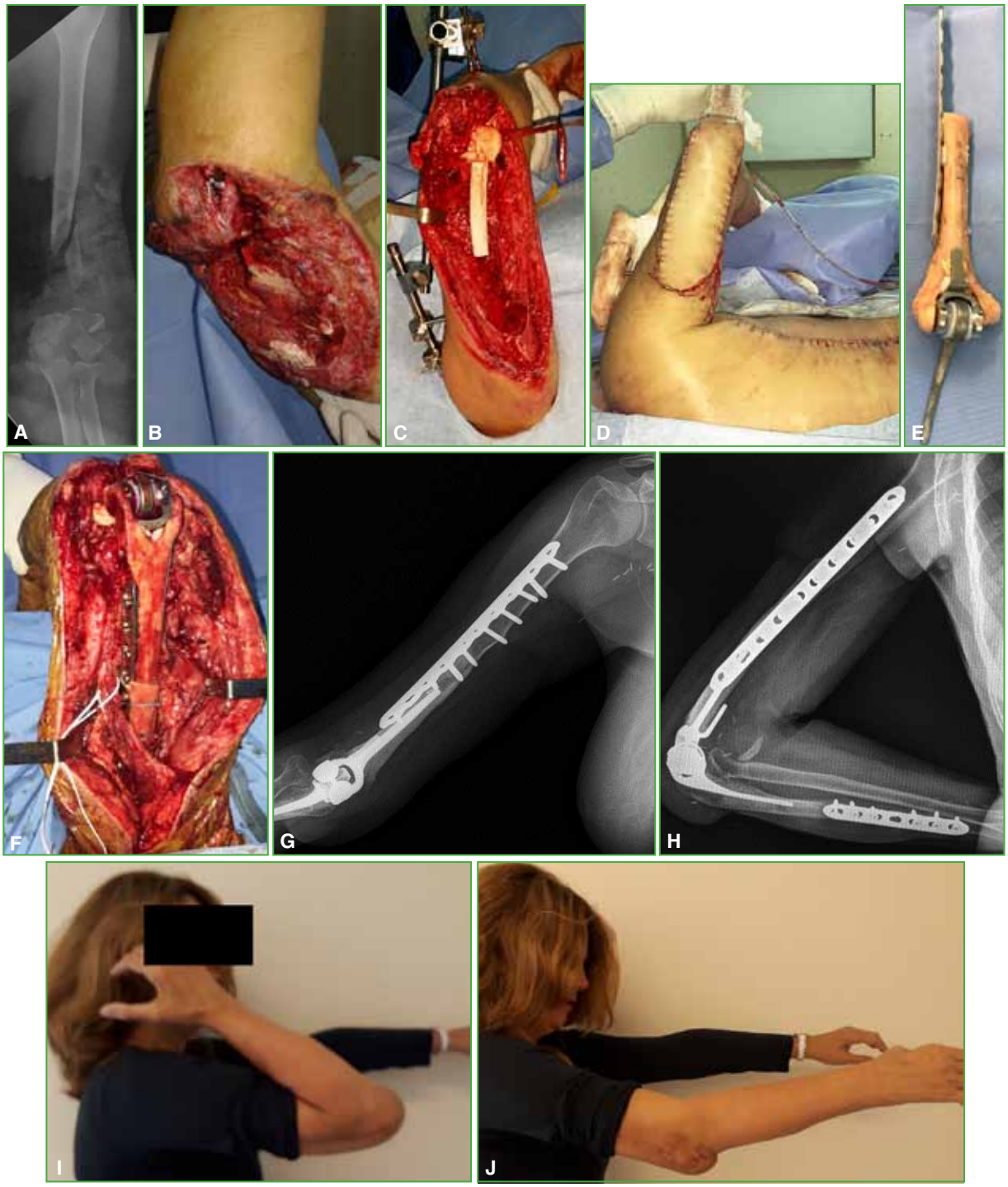

Figure 3. **A.** Humerus radiograph of a 51-year-old woman (case 9) with sequela of an exposed infected fracture of one month of evolution. The great loss of bone stock is observed. **B.** Posterior soft tissue loss (including the extensor apparatus). **C.** Cement spacer with antibiotic and external tutor. **D.** Latissimus dorsi flap. **E.** Preparation of the distal humerus alloprosthesis. **E.** Alloprosthesis placed with good compression in the osteotomy.
G and H. Radiograph 2 years after surgery.
I and J. Final mobility.

Table 3. Comparison between groups A and B

	Group A		Group B	
Number of patients	5		5	
Age	67 (range 60-80)		56 (range 35-69)	
Previous surgeries	2,2 (range 1-4)		6,4 (range 1-19)	
Pain	Preoperative	6,4 (range 5-8)	Preoperative	6,6 (range 6-8)
	Postoperative	2,4 (range 0-5)	Postoperative	2,6 (range 0-7)
DASH	Preoperative	47 (range 28-65)	Preoperative	57 (range 33-72)
	Postoperative	28 (range 20-50)	Postoperative	41 (range 23-72)
MEPS	Preoperative	43 (range 35-60)	Preoperative	33 (range 20-60)
	Postoperative	92 (range 80-100)	Postoperative	69 (range 40-85)
Triceps strength	Postoperative	4 x M5 1 x M4	Postoperative	1 x M4 1 x M3 2 x M1 1 x M0
Satisfaction	8 (range 5-10)		6 (range 2-8)	

DASH (*Disabilities of the Arm, Shoulder and Hand),* MEPS (*Mayo Elbow Performance Score).*

DISCUSSION

The elbow is a joint with limited soft tissue coverage and therefore more prone to infectious processes compared to other joints.[16-19] For years, osteomyelitis has been considered a contraindication for the placement of a prosthesis. However, the great advance in the treatment of infections, mainly in the revision of hip and knee prostheses, determined that this contraindication is, nowadays, less frequent.

When the literature on the causes of infectious processes in the elbow is analyzed, arthroplasty emerges as the most common triggering cause. So much so that there are few reports of TEA after a non-prosthetic degenerative or traumatic episode.

Our cohort included six patients with osteomyelitis who had not been treated with prostheses and, in the remaining four, TEA had been part of one of their previous treatments.

Two-stage surgery is the treatment of choice for patients with infectious joint processes. Peach et al.[20] reported good results with the two-stage treatment of 33 patients with infected prostheses and a low rate of reinfection. In a systematic review of 309 TEAs, Gutman et al.[21] identified an infection cure rate of 81.2% with two-stage surgery. Zmistowski et al.[19] reported 26 patients with prosthetic infections. Ten of them underwent debridement with implant retention and 16 underwent two-stage ACS surgery. Five of the first 10 patients developed an infection, while, in the second group, three of the 16 patients evolved unfavorably.

Resection arthroplasty without ACS is a therapeutic option in cases of infection.[22-24] Yamaguchi et al.[3] published the results of 10 patients undergoing TEA after an infectious process that had initially been treated with a resection arthroplasty. Seven patients had a previous prosthesis and three cases corresponded to septic arthritis and an infected distal humerus fracture. The average time from resection arthroplasty to implantation was 3.8 years. Eight of the patients had no infection at the end of follow-up and two suffered a relapse of the infectious process.

The implantation of an ACS after debridement in a patient with osteomyelitis not only helps to obtain a lower concentration of germs at the site, but also allows the formation of a synovial pseudomembrane around it.[25] The benefits of this pseudomembrane were reported by Pelissier et al.[26] who demonstrated the production of growth factors and osteoinductive factors capable of differentiating into cells of the osteoblastic line. In addition, the spacer provides a certain stability that, together with the specific antibiotic, is essential to cure the infection.

Infection in the elbow joint frequently affects soft tissue and the functional results of a prosthesis are not comparable with those prostheses that have not suffered an infection.

Kwak et al.[6] evaluated the radiological and clinical results in patients who had undergone a revision TEA due to infectious and non-infectious causes. In this study, they found that the clinical outcome was inferior in the infected group, and that patients with longer waiting periods for implant placement had poorer clinical outcomes.

Our research yielded similar results. Patients with long-course evolution, resection arthroplasties due to recurrent infection, larger bone defects and multiple surgeries obtained poorer functional results, despite the remission of the infectious process.

Eradication of all infected tissue is paramount in treating an infection. This can lead to the need for a wide resection of bone and soft tissue. Previous implants or loose prostheses often produce marked osteolysis that increases the loss of bone stock; in general, the greater the residual bone defect, the greater the accompanying soft tissue injury. The triceps is particularly susceptible in this type of scenario and, therefore, its insufficiency is so frequent despite attempts at reconstruction. Dukin et al.[27] analyzed 93 patients after an infected TEA and observed a final weakness of the triceps in 55% of the cases. This demonstrates the importance of conserving the extensor apparatus in these types of situations.

Our study has several limitations, such as the retrospective design, the limited number of patients, the heterogeneity of the initial causes, the variety of residual defects, the 4-cm bone defect criterion for the classification of the groups (without a true scientific basis) and the short follow-up for a prosthesis replacement. However, and unlike other studies, our casuistry includes many patients with previous non-prosthetic causes, which is not widely reported in the literature.

The cure rate of the infection was high (9 out of 10 patients), but without satisfactory function in all cases. The greater the bone resection—and, therefore, the greater the soft tissue injury—the poorer the functional results, especially in terms of recovery of extension force.

CONCLUSIONS

The treatment of an infectious process of the elbow through meticulous debridement associated with the placement of an ACS allows the infection to be controlled in a high percentage of cases. Secondary reconstruction is demanding and is associated with complications mainly in the difficult recovery of the extension. It is expected that the larger the bone defect and the greater the number of previous procedures, the worse the functional result.

Conflict of interests: The authors declare they do not have any conflict of interests.

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