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THE INFLUENCE OF ANTIBIOTIC THERAPY ON WOUND INFLAMMATION AND SEPSIS ASSOCIATED WITH ORTHOPAEDIC IMPLANTS

A Long-term Clinical Survey

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From previous studies of patients in whom implants had been used, it was evident that there was a need for a more accurate picture of the patient-implant relationship, the more so because of improvements in the composition, design and manufacture of orthopaedic implants and the use of antibiotics in recent years. This could be achieved only by observing routine orthopaedic procedure in a sufficient number of patients and by following up those patients who retained their implants.

The survey reported here has been concerned with the use of stainless steel* and cobalt-chromium-molybdenum alloy implants* at the Royal National Orthopaedic Hospital, Stanmore and Great Portland Street, London, 1962–1969, and commercially pure titanium implants* at the Queen Elizabeth II Hospital, Welwyn Garden City, 1963–1969.

The clinical history of the patient has been followed; bacteriological and metallurgical examinations have been carried out on removed implants. All the information has been stored and retrieved, using a feature card system.**

Various aspects of the patient-implant relationships are being investigated. They can be conveniently grouped as follows:

* Specified in British Standard 3531, Amendment No. 1, May, 1964.

** J. L. Jolley and Partners Limited, High Wycombe, Bucks., designed and supplied the feature card system.

1. The clinical significance of possible inflammation and confirmed sepsis associated with metal implants and the merits of certain regimes of antibiotic therapy.

2. The choice of metals, design of implants and the methods used in their manufacture, surgical techniques and the influence of the clinical environment.

This paper deals with Part 1 of the investigation.

A statistical method of assessing results based on 95 per cent limits of confidence,* using the 20 per cent rule, was used. The advantage of using these tests is that the results can be obtained quickly and easily (when compared with more rigorous calculations) and lead to conservative judgements.

Definitions of Inflammation, Resolved Inflammation and Sepsis, as used in this Paper

Inflammation. In the presence of metal implants it is impossible to determine whether the inflammation is superficial or deep. It is not advisable to probe the wound nor will swabbing of the wound necessarily result in culture of the responsible organism. It is difficult for the clinician to differentiate between the inflammation resulting from infection, that is the survival and multiplication of microbes in the tissues, inflammation occasioned by the repair process or by the products which may emanate from implanted foreign materials. In some cases where the wound apparently healed satisfactorily, the patient later developed symptoms of clinical inflammation, with or without breakdown of the wound or formation of a sinus. Some of these cases resolved with treatment, others did not and the implant was removed. In a few cases, although the wound healed by first intention, the patient developed pain. Radiological examination suggested bone resorption in relation to the implant. In some cases the implant was removed and on culture bacteria were recovered.

Resolved inflammation. This term is used to describe those cases in which early or late inflammation resolved with treatment and those which retained their implants. If the implant was removed, it was for reasons other than sepsis and, on culture, the implant was sterile.

Sepsis. Sepsis denotes continuing inflammation, usually the result of proliferation of bacteria, which ultimately leads to the removal of

* Documenta Geigy, Scientific Tables, 6th Edition, p. 85, 1962. Geigy Pharmaceuticals Co., Ltd., Manchester.

the implant. In some cases one or more types of organism were grown on culture of the implant. In a few cases, because the patient was on antibiotic therapy, no organism was grown, but on assessing the case it was apparent, in most instances, that infection was the reason for removal of the implant.

BACKGROUND TO SURVEY

Clinical environment. The patients in the Royal National Orthopaedic Hospital, Stanmore, are accommodated in wards spread throughout extensive grounds. The theatre block, completed in 1963, has clean air ventilation under positive pressure with controlled heat and humidity. Patients at Great Portland Street, London, are looked after in the five-story hospital, built over 50 years ago and situated in a densely built-up area. The theatre, which had a positive pressure filtered air supply installed about fifteen years ago, was further improved in 1965.

The Queen Elizabeth II Hospital, Welwyn Garden City, was opened on July 10, 1963. It has absolute filtration of air with controlled humidity. A theatre is reserved for orthopaedic surgery.

Clinical care. In the RNOH, patients were under the care of eleven consultant surgeons, and in the Q. E. II Hospital, under the care of one consultant surgeon. There were the usual changes in the surgical teams. Each surgeon had his own preference for pre-operative skin preparation. Vacuum drains were used in many patients, particularly those having hip surgery. These were removed twenty-four to forty-eight hours after the operation. On closure of the wound, dry gauze dressings were invariably used; these were changed and the stitches removed after ten to fourteen days, although in some cases the dressing was removed and the wound left exposed to the air after five days. In those cases treated with plaster of Paris, the plaster was either changed after fourteen days, or retained, the stitches being removed from the wound through a window cut in the plaster. If it was suspected that there was inflammation of the wound at or before the usual time of changing the dressing and removing the stitches, the dressing was removed and the wound inspected. There was no routine swabbing of wounds in either hospital; swabs were taken for culture at the discretion of the medical staff.

Antibiotic therapy. At the RNO Hospitals the decision as to whether local antibiotic was put into the site of operation and/or intramuscular antibiotic in the twenty-four hours preceding or following operation,

depended on the preference of the surgeon. The local prophylactic antibiotics were either Crystapen* or Chloromycetin.** The administration, choice and duration of the course of intramuscular antibiotics first given at some time during the twenty-four hours preceding or following operation depended on the views of the surgeon and the advice of the anaesthetist. At the RNOH patients received either: (1) no cover; (2) pre- and post-operative systemic and local operative cover; (3) local operative cover; (4) systemic post-operative cover; (5) local and systemic post-operative cover. At the Q. E. II Hospital intramuscular or intravenous Crystamycin* was routinely administered at some time in the twenty-four hours preceding operation and continued, after operation, for five to seven days. This is called (6) pre-operative antibiotic cover.

When it was necessary, antibiotics were administered later than 24 hours after operation: this course was "*post-operative treatment*" and could be given for a variety of reasons, including pyrexia of unknown origin, suspected post-anaesthetic chest complications and wound infections.

Implants used. A variety of single and multi-piece implants, made of stainless steel, cobalt-chromium-molybdenum alloy, and titanium, were used. These included hip prostheses, intertrochanteric and supracondylar devices, bone plates, screws, staples, nails and wires.

The term implant is used to describe the complete appliance, the individual pieces of which are called components. For example, a McKee appliance is termed an implant, the components being the triflange nail, the plate, the nut, and four screws—seven components. When a patient had more than one implant and these implants were at differing sites, as with bilateral osteotomies in the treatment of congenital dislocation of the hip, this has been analysed as two cases.

Site of implant. The majority of implants were used in sites below the umbilicus, i.e. weight-bearing sites, which have been said to be particularly prone to infection—the hip, knee and foot. These are known as Group I implants. All those used above the umbilicus and in the upper limbs, i.e. non-weight-bearing sites, are known as Group II implants. See Table 1.

Removal of implants. Implants were removed for a number of reasons (Table 2). Sometimes more than one reason was given by the surgeon for the removal of the implant. It is the practice to remove

* Glaxo Laboratories Ltd., Greenford, Middlesex.

** Parke Davis and Company, Hounslow, Middlesex.

Table 1. Group site of implant RNOH – Q. E. II.

Hospital	Group I		Group II		Total
RNOH	1472	90.7 %	151	9.3 %	1623
Q. E. II	155	80.3 %	38	19.7 %	193

Table 2. Reasons for removal of implants.

Reason for removal	Total	Group I	Group II
Routine	346	311	35
Pain	164	149	15
Unsatisfactory position	69	60	9
Clinical sepsis	44	40	4
Non-union	31	28	3
Extrusion	25	19	6
Mechanical failure	21	19	2
Corrosion	0	0	0
Component penetrated joint	4	4	0

all implants in children, because of their effect on bone growth. Some surgeons remove certain devices in adults after they have fulfilled their function.

The stainless steel implants were supplied by Messrs. London Splint Company, D. Howse and Company, Down Bros. and Mayer and Phelps Limited, and a few individual items were made in the workshops of the RNO Hospitals. Vinertia and Vitallium implants, made of cobalt-chromium-molybdenum alloy, were supplied by Messrs. London Splint Company. Messrs. Down Bros. and Zimmer Orthopaedic Limited supplied those of titanium, used at the Q. E. II Hospital.

Bacteriological examination. At removel operation, the components of the implant were put directly into individual sterile jars in the theatre. In some cases a swab was taken from the implant site. In the laboratory, molten nutrient agar, which had been allowed to cool to 45°C, was poured over the components. They were then incubated for four days at 37°C. (Penicillinase was added to those cases where patients were known to be on a penicillin containing antibiotic regime.) If there were only one or two colonies growing either on or in relation to one component of a number removed from a patient, experience showed that this was the result of contamination. This may have occurred at some time during or after their removal. When there was surface growth on the agar, contamination was invariably the cause

and the organism usually an aerobic spore bearer. In a few cases, when the patient was on a course of antibiotics because of apparent clinical infection at the time of removal of the implant, no organisms were grown. Organisms which grew on the surface of the implant, or the components of the implant, were identified, and sensitivity tests for penicillin, streptomycin, tetracycline and chloramphenicol were made routinely. In certain cases their sensitivity to other antibiotics and chemotherapeutic agents was determined. Wherever possible, staphylococci were phage typed.

Further studies. After the implants had been cultured, they were autoclaved, cleaned to remove serum and agar and, using a binocular microscope, examined in detail.

Distribution of implants. Although all the relevant details were available for 2229 implants until the patients left hospital, 413 patients who could not be traced at the time of the follow-up in 1969 have had to be omitted. None of these patients had any record of continuing wound inflammation up to the time they were last seen, which in some cases was several years after operation.

The 115 patients who have died have been included in the survey, because after careful scrutiny of the clinical records none of the causes of death were, in any way, related to any complication which could be connected with the implant.

A total of 1816 implants are used in this survey.

SURVEY FINDINGS

When comparing the over-all incidence of wound inflammation at the RNO Hospitals with that at the Q. E. II Hospital, using limits of confidence, there is a significant reduction in the incidence of wound inflammation at the Q. E. II (see Table 3). However, there is no significance in the difference between the over-all incidence of sepsis in the two hospitals.

Certain factors were considered in relation to inflammation and sepsis in the RNOH and Q. E. II before dealing with the effect of antibiotics. These were: (1) sex; (2) age; (3) vacuum drainage; (4) site of implant—weight-bearing or non-weight-bearing; (5) erosion or corrosion of the metal implants; (6) chemical composition of implant.

(1) *Sex:* There was no significant difference in the incidence of either inflammation or sepsis between the sexes.

(2) *Age:* The relationship of age to inflammation and sepsis has

Table 3. Total incidence of inflammation and sepsis in RNOH and Q.E.II.

Hospital	Total number in survey	Inflammation		Sepsis	
		No.	%	No.	%
RNOH	1623	137	8.4 (6.83–9.54)	45	2.8 (2.07–3.76)
Q. E. II	193	5	2.6 (0.84–6.08)	3	1.6 (0.33–5.54)

been examined in decades (see Table 4). There was no significant difference in the incidence of inflammation and sepsis between the groups in either hospital, except in the "less than one decade" and "4-decade" groups at the RNOH.

On comparing the "less than one decade" and the "4-decade" groups at the RNOH, there was a significant difference in both the incidence of inflammation and the incidence of sepsis. Of 195 patients under 10 years of age, 96 per cent of whom were in the Group I site, there was an inflammation rate of 3.1 per cent and a sepsis rate of 0.5 per cent. Of 173 patients in the "4-decade" group—82.7 per cent of whom were in the Group I site—the inflammation rate was 12.7 per cent and the sepsis rate was 5.8 per cent. This significant difference in both wound inflammation and sepsis may be the result of local administration of antibiotic in 75.4 per cent of the "less than one decade" group. In the "4-decade" group only 38.7 per cent had local antibiotic cover.

(3) *Vacuum drainage:* It was found that vacuum drainage had no influence on either inflammation or sepsis. We are not, however, suggesting that vacuum drainage is not beneficial in preventing haematoma formation and its sequelae.

(4) *Site of implant:* There is no significance in the incidence of wound inflammation or sepsis between Group I and Group II implant sites in either hospital.

(5) *Erosion and corrosion:* In the course of the metallurgical studies of 667 removed implants, all the components were examined for evidence of dissolution of metal caused by erosion, i.e. mechanical damage of contacting surfaces, or by corrosion. No correlation has been found between the incidence of inflammation or the incidence of sepsis and erosion or corrosion of one or more parts of the metal implant.

(6) *Chemical composition of metal implants:* There was no correlation between inflammation and sepsis with stainless steel and cobalt-

Table 4. Incidence of inflammation and sepsis related to age of patient and

Age in decades	RNOH					
	No. of cases	% local cover	% Group I	% inflam.	L. C. inflam.	% sepsis
–1	195	75.4	96.0	3.1	1.09 6.46	0.5
1	213	31.0	93.0	7.9	4.64 12.69	4.7
2	87	33.5	73.6	11.5	5.65 20.12	3.4
3	93	35.5	74.2	11.8	6.05 20.18	3.2
4	173	38.7	82.7	12.7	8.3 18.96	5.8
5	381	34.4	92.0	8.9	6.38 12.25	2.4
6	310	36.0	97.0	7.4	4.65 10.91	1.9
7	130	39.0	93.0	6.9	3.2 12.79	0.77
8	37	21.0	100.0	13.5	4.54 28.77	5.4
9	4	25.0	100.0	nil	0.0 60.24	nil

chromium-molybdenum alloy implants. They can therefore be grouped together and the incidence of inflammation and of sepsis in the RNOH and Q. E. II can be compared.

WOUND INFLAMMATION RELATED TO ANTIBIOTIC COVER

There were 142 cases of wound inflammation. The incidence of this in relation to antibiotic cover at the time of operation is shown in Table 5. At the RNOH there is a significant difference, using the 20 per cent rule, between the incidence of wound inflammation in the group of patients receiving (1) no antibiotic cover at operation, and in that group of patients who received (3) local antibiotic cover.

There is a significant difference in the incidence of wound inflammation in that group of patients in the RNOH where (1) no antibiotic cover was used, when compared with that group of patients in the Q. E. II Hospital who had (6) pre-operative antibiotic regime.

site of implant RNOH and Q. E. II; also related to local antibiotic cover RNOH.

				Q. E. II		
L. C. sepsis	No. of cases	% Group I	% inflam.	L. C. inflam.	% sepsis	L. C. sepsis
0.01 2.75	7	100.0	nil	0.0 40.96	nil	0.0 40.96
2.07 8.40	21	71.4	nil	0.0 16.11	nil	0.0 16.11
0.72 9.75	31	64.5	3.2	0.08 16.7	3.2	0.08 16.7
0.67 9.14	21	71.4	9.5	1.17 30.38	4.8	0.12 23.82
2.85 10.59	21	81.0	4.8	0.12 23.8	4.8	0.12 23.82
1.20 4.57	23	78.3	nil	0.0 14.82	nil	0.0 14.82
0.73 4.33	12	66.7	nil	0.0 26.46	nil	0.0 26.46
0.02 4.21	28	100.0	nil	0.0 12.34	nil	0.0 12.34
0.66 18.19	27	92.6	3.7	0.09 18.97	nil	0.0 12.77
0.0 60.24	2	100.0	nil	0.0 84.19	nil	0.0 84.19

When comparing the group of RNOH patients who received (3) local antibiotic cover with those treated with (6) pre-operative regime at Q. E. II Hospital, there is no significant difference. The number of patients in the RNOH receiving (2) pre-operative systemic and local antibiotic cover was too small to be considered.

In the group of patients who received (4) post-operative systemic antibiotics in the first 24 hours following operation, the incidence of wound inflammation is greater than in any of the other groups. The reduced incidence of wound inflammation in the group of patients at the RNOH who received (5) local and post-operative systemic antibiotics within the first 24 hours following operation, is probably due to the addition of the local antibiotic.

The post-operative administration of antibiotic in the 24 hours following operation would seem undesirable. Tachdjian & Compere (1957) state that "the routine use of post-operative antibiotics as a prophylactic measure is unwise". Olix et al. (1959) have also claimed that the administration of post-operative antibiotics increases the

Table 5. Effect of antibiotic cover on post-operative wound inflammation.

Hospital	Type of antibiotic cover at operation	Number of patients	Number inflam-mation	% inflam-mation	Limits of confidence
RNOH 1623	1. No cover	868	76	8.8	7.11–10.94
	2. pre-op. systemic + local	11	1	9.1	0.23–41.28
	3. local	531	28	5.3	3.42– 7.54
	4. post-op. systemic	111	22	19.8	13.01–28.73
	5. local + post-op. systemic	102	10	9.8	4.9 –17.62
Q. E. II 193	6. pre-op. cover	193	5	2.6	0.84– 6.08

incidence of wound infection and the incidence of pulmonary, urinary and vascular complications was also increased. In their survey the presence or otherwise of a metal implant was not taken into account. Alexander & Altemeier (1965) have shown that when infection is introduced into experimental wounds in the rabbit, in which there is a suture acting as a foreign body, the administration of antibiotic before operation, or the introduction of antibiotic into the wound at operation, reduces the incidence of post-operative wound infection, when compared with those animals which had no operative cover or who had post-operative intramuscular penicillin G.

SEPSIS RELATED TO ANTIBIOTIC THERAPY

There was no significant difference in the incidence of sepsis in the RNOH and the Q. E. II Hospital (see Table 3).

At the RNOH it was not routine practice to administer antibiotics to those patients who had wound inflammation. Their administration

Table 6. Incidence of sepsis in treated or untreated cases of inflammation.

Hospital	Total	Inflam-mation	(a) Inflam-mation treated	Number and % sepsis	(b) Inflamma-tion not treated	Number and % sepsis
RNOH	1623	137	87	34 39.1 % (28.79–50.13)	50	11 22 % (11.53–35.96)
Q. E. II	193	5	5	3 60 % (14.66–94.73)	0	0

Table 7. The incidence of sepsis in treated cases in relation to cover at operation.

Hospital	Type of antibiotic cover at operation	Treated	Resolved with treatment	Sepsis	% sepsis	Limits of confidence
RNOH	1. No cover	54	28	26	48.1	34.4 –62.16
	2. pre-op. systemic + local	1	0	1	100.0	–
	3. local	15	13	2	13.3	1.66–40.46
	4. post-op. systemic	14	10	4	28.6	8.39–58.1
	5. local + post-op. systemic	3	2	1	33.0	0.84–90.57
Q. E. II	6. pre-op. cover	5	2	3	60.0	14.66–94.73
Total		92	55	37		

was dependent on clinical judgement of the severity of the inflammation and its possible association with infection. The choice of antibiotics was governed by the preferences of the surgeon in charge of the patient, coupled, in some cases, with bacteriological findings. At the Q. E. II Hospital all cases of clinical wound inflammation received further systemic antibiotic therapy.

Table 6 shows the incidence of sepsis in 92 patients who (a) received antibiotic treatment for either wound inflammation or symptoms which indicated wound infection, and (b) 50 patients who did not receive antibiotic treatment.

There is no significant difference between (a) and (b) in the RNOH, nor between (a) RNOH and (a) Q. E. II.

The incidence of sepsis in the group of patients where the clinician judged that the inflammation was so severe as to require further treatment was then examined in relation to antibiotic cover at operation.

Table 8. The incidence of sepsis in two main groups of patients related to antibiotic cover and therapy.

Type of antibiotic cover at operation	Total number of patients	Wound inflammation	Number of sepsis cases		Total sepsis %	Limits of confidence
			After antibiotic treatment	With no antibiotic treatment		
1 – none	868	76	26	6	3.7	2.54–5.12
3 – local	531	28	2	5	1.3	0.56–2.88

92 patients received further antibiotic therapy—of these 37 (40.29 per cent) failed to respond to treatment and their implants were removed because of sepsis. Table 7 shows that the lowest incidence of sepsis was in that group of patients who had (3) local antibiotic cover at operation—13.3 per cent. Using the 20 per cent rule of the limits of confidence, there is statistical significance in the reduced incidence of sepsis in the groups who had (3) local antibiotic cover at operation and those that had (1) no antibiotic cover at operation. This was also found to be the case when the total number of patients in these two groups was compared (see Table 8).

In this survey no case of sensitivity to antibiotics added to the wound at the time of operation has been recorded. No patient died as a result of sepsis.

Bacteriological Investigation of Removed Implants

The details of the bacteriological examination of 667 implants at the time of removal are given in Table 9.

Seven implants were not cultured because they had been dropped on the floor on removal, or the pots were broken in transit. None of these seven implants was removed from patients who had shown clinical inflammation at any time. 28 cultures were contaminated, but there was no record of the patients having clinical inflammation at any time. 41 cultures were positive. Seven cultures were sterile, although the implants were removed because of a clinical diagnosis of probable sepsis. These 7 patients were being treated with antibiotics during the 72 hours prior to removal. They had a history of either a sinus or clinical inflammation of the wound at some time. There is therefore a total of 48 cases of probable sepsis.

In 44 patients a diagnosis of clinical sepsis was made. The implants from 4 other patients were removed because of a clinical diagnosis of pain, but not sepsis.

The organisms grown from the 41 cases of positive culture are shown in Table 10. In 3 cases more than one organism was isolated.

A coagulase positive staphylococcus was grown on implants from 23 patients. In 4 patients the wound healed by first intention and there was pain but no evidence of clinical wound inflammation. Three of these patients had their implants removed because of possible sepsis and one because of pain.

A coagulase negative staphylococcus was recovered from 14 patients. In 6 patients the wound healed by first intention and at no time had

Table 9. Bacteriological examination of 667 implants.

Total in survey	Total removed	Not cultured	Total cultured	No growth on culture	Total positive culture	Contaminated but not clinically infected	Infected implant	Infected but sterile - ? due to antibiotic prior to removal
RNOH 1623	561 34.6 %	7	554	488 88.1 %	66 11.9 %	26 4.7 %	40 7.2 %	5 0.9 %
Q. E. II 193	106 54.9 %	0	106	103 97.2 %	3 2.8 %	2 1.9 %	1 0.94 %	2 1.9 %

Table 10. Details of organisms from bacteriological examination.

Hospital	Non-sterile on culture	Coag. + ve Staph.	Coag. — ve Staph.	E. Coli	Ps. Pyocyanea	Strep. Haemolyticus
RNOH	40	22	14	5	1	1
Q. E. II	1	1	–	–	–	–

the wound broken down, but there was continuous pain. Three of these patients had their implants removed because of possible sepsis and 3 because of pain. After all the metallurgical, bacteriological and clinical details had been examined, those 4 patients whose implants were removed because of pain, were assessed as sepsis.

These 10 cases where the wound healed by first intention are classed as closed sepsis. The other 38 cases of assessed sepsis are divided into two groups:

(1) 17 cases where the wound was healed when the implant was removed. All had wound inflammation, post-operative antibiotic therapy and all the implants were removed because of a clinical diagnosis of sepsis. 15 cases cleared following removal of the implant. One case developed osteomyelitis and one case could not be followed up as the patient discharged himself.

(2) 21 cases where there was a sinus and/or open wound at operation for removal of the implant. All cases except one had post-operative antibiotic therapy and all the implants were removed because of a clinical diagnosis of sepsis. 15 cases recovered completely following removal of the implant. In 5 cases sepsis persisted and one case had a disarticulation through the hip joint.

SUMMARY

In this survey the incidence of inflammation of the wound and sepsis in association with orthopaedic metal implants has been examined. The survey was carried out between 1962–1969 and involved routine procedures in 1816 patients in the Royal National Orthopaedic Hospital and the Queen Elizabeth II Hospital.

The effect of sex, age, the use of vacuum drainage, the site of implant—weight-bearing or non-weight-bearing—the presence of corrosion of the metal and the chemical composition of the metal were considered in relation to inflammation and sepsis and found not to be significant.

The effect of certain antibiotics before, during, or after operation, for prophylaxis and in the treatment of established sepsis, has been investigated.

The incidence of clinical wound inflammation appears to be reduced by either the administration of local Chloromycetin or Crystapen into the wound—RNOH, or by the pre-operative administration of Crystamycin continued post-operatively for 5–7 days—Q. E. II.

The cost of two prophylactic antibiotics (September 1970) put directly into the wound at operation has been compared with the cost of treating one case of established sepsis.

(1) Chloromycetin 5 g – 6½p

(2) Crystapen, 1 vial = 3 g – 12½p

(3) 1 patient with established sepsis, who had no local or pre-operative antibiotic, was an in-patient for a total of three months and under medical supervision for a further 3 years at a cost of £900.

On the grounds of cost effectiveness the local use of Chloromycetin or Crystapen is to be preferred to the more expensive Crystamycin regime.

There were 10 cases of closed sepsis with continuous symptoms of pain, where the wound healed by first intention, and there has been no evidence of clinical wound inflammation at any time. In 4 of these cases a coagulase positive staphylococcus was recoved. In the other 6 cases a coagulase negative staphylococcus was recovered; 3 of these implants were removed because of pain and the other 3 because of "possible sepsis". In those 3 cases, it is probable that a coagulase negative staphylococcus was the pathogen.

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