

METAL SENSITIVITY IN PATIENTS TREATED FOR TIBIAL FRACTURES WITH PLATES OF STAINLESS STEEL

M. CRAMERS & ULF LUCHT

Department of Dermatovenerology, Marselisborg Hospital and
Department of Orthopaedic Surgery, Aarhus Amtssygehus, Aarhus, Denmark.

In three patients a local dermatitis developed 3-3½ months after tibial osteosynthesis with plates and screws of stainless steel 316 L (AO). Two of the patients had a positive patch test for chromium (and cobalt) and one for nickel. Infection was not indicated and it is suggested that the dermatitis was caused by a metallic sensitivity. The skin affection disappeared after removal of the metal.

Key words: dermatitis; metallic sensitivity; stainless steel; tibial fracture

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Contact sensitivity to nickel, chromium and cobalt is well known although the incidence of skin sensibility to these metals in the general population is unknown. Fregert et al. (1969) have tested a group of 4,825 patients suspected of having various skin diseases and found the following frequencies of positive patch tests in the female/male patients: nickel 10.2/1.8 per cent, chromium 3.6/10.7 per cent and cobalt 6.6/7.4 per cent. A few cases of eczematous dermatitis caused by internal exposure to nickel have been reported (Fousserau & Laugier 1966, Barranco & Soloman 1972, Pegum 1974).

The aim of the present report is to draw attention to the possibility of local dermatitis caused by metal sensitivity in patients treated for tibial fractures with implants of stainless steel.

CASE REPORTS

Case 1. A 19-year-old woman sustained an uncomplicated fracture of the left tibia and fibula after an accident with a moped. The tibial fracture was fixed under compression using a plate and eight screws (AO) of stainless steel (Figure 1). She was mobilized with crutches, without weightbearing on her left leg, 8 days after the operation and the postoperative period was uncomplicated. Weightbearing was started 2 months after the operation. One month later an erythematous and infiltrated area appeared on the skin overlying the plate and at the same time local pains occurred. The roentgenograms showed no signs of reaction around the metal. An infection was suspected and 2 weeks later an incision was made. No pus was observed and no bacteria were found by culture. The erythrocyte sedimentation rate was 9 mm/1 hour. From these observations an infection seemed unlikely and some days later the metal was removed and the skin closed. Skin healing was uncomplicated without use of antibiotics and the dermatitis disappeared. The fracture healed after treatment with a plaster cast. A patch test 2 months after removal of the metal was positive for chromium and cobalt. The reaction was strongest after 96 hours without a toxic reaction.

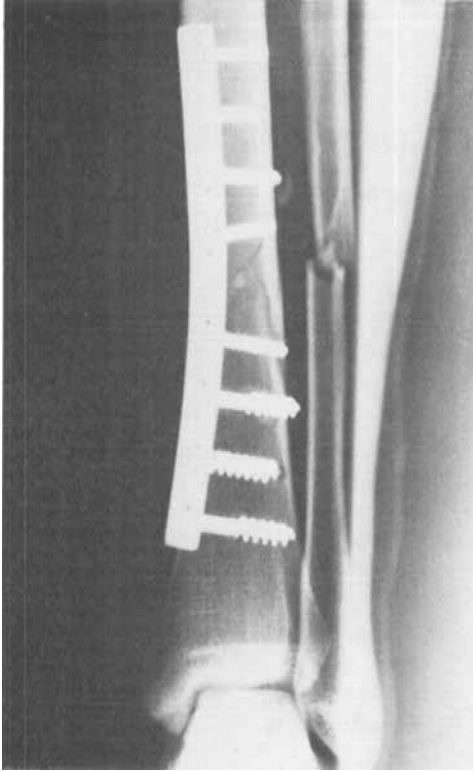


Figure 1. Case 1. Postoperative roentgenogram.

Case 2. A 19-year-old woman sustained an open fracture of her right tibia and fibula after a fall from a horse. The tibial fracture was fixed under compression with a plate and eight screws (AO) of stainless steel (Figure 2). The postoperative period was uncomplicated. She started walking, without weightbearing on her right leg, 7 days after the operation and with weightbearing after 2½ months. After 3½ months an erythematous and infiltrated area appeared on the skin overlying the plate, and local pains occurred. In the following weeks the symptoms varied in intensity. They increased after a period of walking and decreased after a period of relaxation. Five months after the operation a little bulla developed in the erythematous area. No bacteria were found by culture. The roentgenograms showed no reaction around the metal. The plate and the screws were removed and the skin closed. No pus was observed around the metal and no bacteria were found by culture. The erythrocyte sedimentation rate was 7 mm/1 hour. Skin healing was uncomplicated without the use of antibiotics and the dermatitis disappeared. The fracture was treated with a plaster cast and healed without complications.

A patch test 4 months later was positive for chromium and cobalt. The reaction was strongest after 96 hours without a toxic reaction.

Case 3. The patient was a 46-year-old woman who sustained an uncomplicated fracture of her right tibia and fibula after a fall from a table. The tibial fracture was fixed under compression with a plate and seven screws (AO) of stainless steel (Figure 3). The postoperative period was uncomplicated. Walking, without weightbearing on the right leg, was started 7 days after the operation. Three months postoperatively an erythematous and infiltrated area appeared on the skin overlying the plate and local pains occurred. In the following weeks the symptoms varied in intensity and were reduced after a period of relaxation. The roentgenograms showed no reaction around the metal. At 3½ months after the operation a bulla appeared in the erythematous area. The first cultivation for bacteria was negative, but a second which was made some days later showed staphylococcus aureus. The plate end screws were removed and the skin closed. No pus was observed around the metal and no bacteria could be cultivated from the

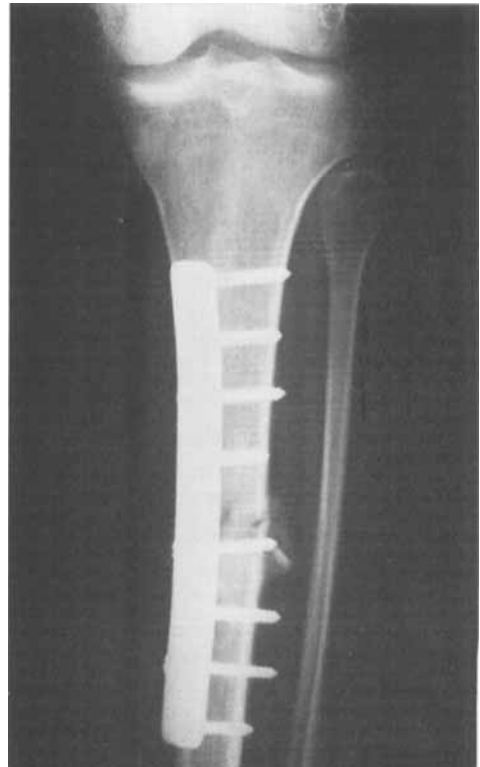


Figure 2. Case 2. Postoperative roentgenogram.



Figure 3. Case 3. Postoperative roentgenogram.

surrounding tissue. The erythrocyte sedimentation rate was 19 mm/1 hour. The skin healed without antibiotics and the dermatitis disappeared. The fracture was treated with a plaster cast and healed without complications. A patch test at the time of removal of the metal was positive for nickel. The reaction was strongest after 72 hours without a toxic reaction.

None of the three patients referred to had any recognized metal hypersensitivity or eczema prior to the accident and there was no evidence of occupational exposure to metals.

METHODS

Patch test

The following solutions of metals were used: Nickel sulphate 5 per cent, potassium dichromate 0.5 per cent, cobalt chloride 2 per cent, manganese chloride 2 per cent, ferri chloride 2 per cent, sodium molybdenum 2 and 5 per cent; all with petrolatum as vehicle. The concentrations of nickel, chromium and cobalt were the same as proposed by the Scandinavian Committee for Standardization of Routine Patch

Testing (Fregert et al. 1969). Iron, manganese and molybdenum were used in the same concentrations as used by Geiser et al. (1960).

The patch test was placed on the back just below the scapula and left for 48 hours. A reading was taken 48, 72 and 96 hours after the application. The reactions were considered positive if erythema and infiltration with or without papules or vesicles occurred.

Analysis of the implant

The stainless steel (316 L) used for the present three patients contains chromium, nickel, molybdenum, manganese, iron, carbon, silicon, sulphur and phosphorus but not cobalt.

A portion of the stainless steel was rotated for 35 days in a Ringer solution at 37.8° C. The solution was subsequently tested by atomic absorption spectrophotometry for any dissolved metal. Iron, manganese and nickel were detected but not chromium. The analysis was performed by the Division of Inorganic Chemistry, University of Aarhus, Denmark.

DISCUSSION

The three cases described are rather similar and it is strongly suggested that the skin reactions were caused by metal sensitivity and not by infection. Thus, the positive patch tests in combination with no previous known allergies and the disappearance of the skin reactions after the removal of the implant are consistent with metal sensitivity caused by the implant. The absence of bacteria after culture from the tissue around the plates, the normal sedimentation rates and the uncomplicated skin healing after the removal of the plates argue against infection.

A release of metal ions from an implant requires a corrosion of the alloy. Generally it has been believed that stainless steel implants have a high corrosion resistance. However, the following reports indicate that various metallic alloys currently in use in human beings, including stainless steel, are exposed to corrosion. Thus, Lüdinghausen et al. (1970) made histological examinations in 50 cases treated by osteosynthesis with

stainless steel (A.I.S.I. 316) and found some degree of metallosis in every case from 4–36 months after surgery. Ferguson et al. (1960) embedded different kinds of metallic implants in the spinal muscles of albino rats for 4–6 months. In the muscles surrounding the metal they found, by spectrochemical analysis, metallic elements in concentrations which were significantly higher than in controls. For stainless steel (A.I.S.I. 316) they found nickel, chromium, iron and molybdenum. Cohen (1962) tested various metals *in vitro* under cyclic stresses similar to those encountered in clinical practice. He used screws and plates and determined their weight loss after 10 million cycles. Stainless steel (A.I.S.I. 316) had a higher weight loss than vitallium. The most common site for the corrosion is the junction between components of implants (Scales et al. 1959, Emnéus 1961, Cohen 1962). Scales et al. (1959) believe that the anaerobic condition between countersinks of screws and screw holes is a cause of the corrosion which often occurs at this location.

For the three patients in the present report the concentrations of metal ions in the tissue surrounding the implants has not been measured. When the implants were rotated in a Ringer solution we found nickel, manganese and iron but not chromium. The inability to demonstrate the last metal may be due to the conditions *in vitro* being different from those *in vivo* where cyclic stresses and changes in the oxygen tension affect the implant. The present observations that the complaints of two of the patients were reduced after a period of relaxation and increased after a period of walking are consistent with a varied release of metal ions depending on variations in cyclic stresses and blood flow.

The local dermatitis in our three patients is a delayed type (Gell & Coombs type IV) hypersensitivity (Lowney 1975).

It is not possible to know with certainty if the patients were sensitive to the metal before the implantation. This, however, was not indicated by the anamnesis, and the time sequence of events rather indicates that the implants induced the sensitivity. The metal reaction in the present patients developed a relatively short time after the operation, but this may be explained by the close relationship between the implants and the skin. The two patients who had positive patch tests for cobalt were presumably sensitive to this element at the time of the operation because stainless steel does not contain cobalt. The disappearance of the dermatitis after removal of the metal is in agreement with other studies (Barranco & Soloman 1972, Fousserau & Laugier 1966).

Once acquired, specific sensitivity tends to persist but the degree of sensitivity may decline if the patient avoids contact with the specific allergen. However, after re-exposure to the primary allergen the level of the sensitivity rises rapidly, and the patient may get a new allergic reaction. It is important for the orthopaedic surgeon to be aware of this possibility, and in doubtful cases patch test the patient. Titanium may be a satisfactory substitute if a positive patch test for nickel or chromium is found.

The present report together with earlier studies (Fousserau & Laugier 1966, Barranco & Soloman 1972, Pegum 1974, Munro-Ashman & Miller 1976) stress that if a skin reaction occurs some months after osteosynthesis a metal sensitization should be suspected. In the case of metal reaction the symptoms will disappear after removal of the metal which should be performed under sterile conditions to avoid a secondary infection.

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Correspondence to: Ulf Lucht, M.D., Mirabellevej 7, DK-8240 Risskov, Denmark.