



Contents lists available at ScienceDirect

The Knee



Case Reports

Metal hypersensitivity in total knee arthroplasty: Revision surgery using a ceramic femoral component – A case report

Philipp Bergschmidt*, Rainer Bader, Wolfram Mittelmeier

Department of Orthopaedics, University of Rostock, Germany

ARTICLE INFO

Article history:

Received 12 October 2010

Received in revised form 5 January 2011

Accepted 7 January 2011

Available online xxxx

Keywords:

Knee arthroplasty
Metal hypersensitivity
Implant materials
Revision surgery

ABSTRACT

We present a case involving the revision of a total knee arthroplasty with a metal femoral component using a ceramic implant due to metal hypersensitivity. A 58-year-old female patient underwent total knee arthroplasty (TKA) with a standard metal bicondylar knee system. She suffered from persistent pain and strong limitations in her range of motion (ROM) associated with flexion during the early postoperative period. Arthroscopic arthrolysis of the knee joint and intensive active and passive physical treatment, in combination with a cortisone regime, temporarily increased the ROM and reduced pain. No signs of low grade infection or other causes of implant failure were evident. Histology of synovial tissue revealed lymphoplasmacellular fibrinous tissue, consistent with a type IV allergic reaction. Allergometry (skin reaction) revealed type IV hypersensitivity against nickel-II-sulfate and palladium chloride.

Revision surgery of the metal components was performed with a cemented ceramic femoral component (same bicondylar design) and a cemented titanium alloy tibial component. Postoperative evaluations were performed 10 days, and 3 and 12 months after the revision surgery. There was an increased ROM in flexion to 90° at the 12 month follow-up. No swelling or effusion was observed at all clinical examinations after the revision surgery. No pain at rest and moderate walking pain were evident.

The presented case demonstrates that ceramic implants are a promising solution for patients suffering from hypersensitivity to metal ions in total knee arthroplasty.

© 2011 Elsevier B.V. All rights reserved.

1. Introduction

Allergies to allergens such as chromium, cobalt and nickel can cause implant failure, which has led to a rising interest in the search for alternative solutions in total knee arthroplasty (TKA) [1–6]. The prevalence of metal sensitivity among the general population is approximately 10% to 15%, with sensitivity to nickel having an average incidence of 13.1% (female 20.4% and male 5.8%) and sensitivity to cobalt and chromium an incidence of 3% [4]. Skin reactions to metal ions have been described as being observed in up to 20% of the general population [7] but the prevalence of allergic reactions in an unselected group of orthopaedic patients was shown to be significantly lower (6.9%) in comparison to that in the dermatological studies [8]. Another study confirmed that the frequency of positive patch testing for metallic materials is higher in patients with total knee arthroplasty than in the normal population [9].

Despite these varying results, it is well known that TKA implants are particularly prone to corrosion with subsequent release of metal ions that may cause local and systemic adverse effects, aseptic

loosening and hypersensitivity reactions [10]. A relationship has been found between wear debris of all-metal articulations observed in total hip arthroplasty and the presence of pseudotumor-like periprosthetic tissue reactions, which can be histologically described as an aseptic lymphocyte-dominated vasculitis-associated lesion (ALVAL) [11–14]. In contrast, a type IV hypersensitivity reaction shows an ALVAL-like histology pattern but with a lower quantity of wear particles and macrophages and a higher number of lymphocytes [11,14].

Hypersensitivity has been proposed as a mechanism of aseptic loosening of these components [2–6,8–10]. Furthermore, local or general exanthema, urticaria and swelling can occur in cases of sensitisation against specific implant materials [3,4,6–8]. However, the significance of immune response in the outcome of arthroplasty is unclear.

We present a case involving revision of a total knee arthroplasty with a metal femoral component using a ceramic implant due to metal hypersensitivity.

2. Case report

A 58-year-old female patient had presented with prolonged left knee pain lasting 3 years. She reported an onset of the symptoms 3 years before the first surgery, without any trauma. Due to a medial meniscus lesion, she underwent an arthroscopic evaluation. During

* Corresponding author. Orthopädische Klinik und Poliklinik, Universität Rostock, Doberaner Strasse 142, 18057 Rostock, Germany. Tel.: +49 381 494 9355; fax: +49 381 494 9303.

E-mail address: philipp.bergschmidt@med.uni-rostock.de (P. Bergschmidt).

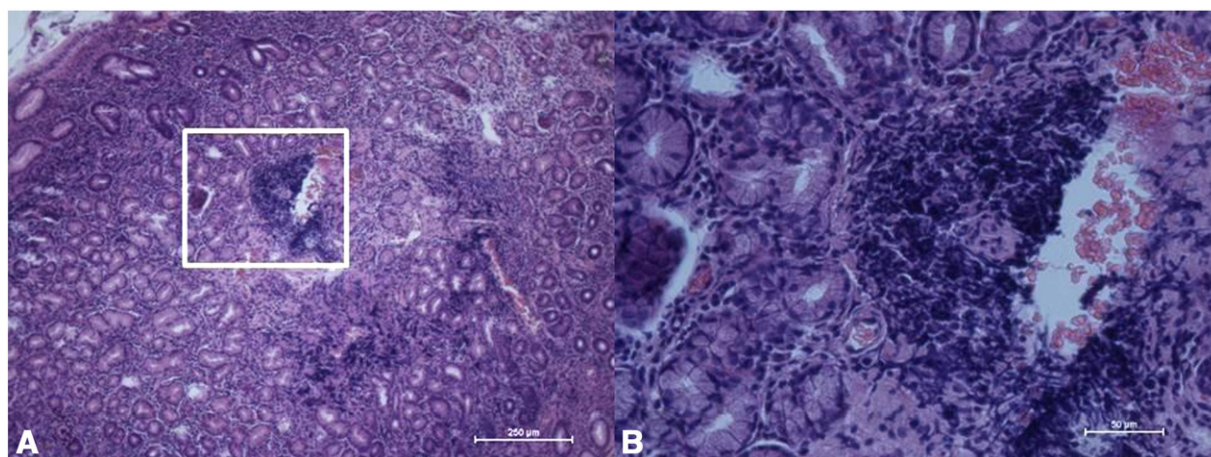


Fig. 1. Biopsy histology of the adhesion tissue at proximal recess taken during arthroscopy 4 weeks after primary TKA showing a lymphoplasmacellular fibrinous tissue consistent with a type IV allergic reaction (B magnifies the area boxed within A). Courtesy of the Department of Pathology, University of Rostock.

the procedure, a partial resection of the medial meniscus and an abrasion arthroplasty of a 2×2 cm chondral lesion of the trochlear groove were performed. Postoperatively, she developed deep venous thrombosis (DVT), which was treated with subcutaneous application of low-molecular-weight heparin at therapeutic dosages.

Since walking pain was still persistent, she underwent a re-arthroscopy 2 years later. Intraoperative evaluation revealed a grade IV chondral lesion (Outerbridge classification [15]) at the retropatellar surface and at the trochlear groove. Furthermore, a grade III chondral lesion in the medial compartment was discovered and treated with microfracture surgery.

Clinical evaluation at admission revealed no swelling or effusion, or pain on pressure at the medial joint space, and a flexion of 100° without any extension lag. Moreover, the Zohlen test and patella pressure test were positive [16]. Anteroposterior and lateral radiographs of the knee and of the whole leg revealed medial and retropatellar osteoarthritis with a joint space narrowing and moderate osteophytes, as well as a straight leg alignment. Apart from the reported knee disorder, patient history was unremarkable and so, she never received any permanent medication. Furthermore, the patient reported no signs of allergies against metal ions or other allergens.

According to the diagnosis of gonarthrosis, the patient underwent TKA with a standard bicondylar cobalt–chromium (CoCrMo) alloy femoral component and a titanium alloy tibial component (Multigen Plus Knee System, Lima Corporate, San Daniele del Friuli, Italy). A single-shot antibiotic prophylaxis (1.5 g intravenous cefuroxime) was given perioperatively. ROM intraoperatively was flexion/resting position/extension 130°/0°/5° (neutral-zero method). Antithrombotic prophylaxis was accomplished by daily subcutaneous application of low-molecular-weight heparin (MonoEmbolex® 8000 I.E. per day) and the wearing of antithrombotic stockings during the hospital stay and rehabilitation. The patient underwent full-weight-bearing mobilisation with two crutches, starting from the postoperative second day after drain removal. Postoperative radiographs showed optimal implant size and alignment. No complications were observed during the postoperative period. The patient was discharged 10 days postoperatively with a passive ROM of 90°/0°/0° and an active one of 85°/5°/0°. Slight effusion but a healed wound without any irritation was documented.

Four weeks postoperatively, the patient reported pain at rest, increasing effusion and hyperthermy without skin irritation while the ROM decreased to 60°/10°/0°. Six weeks postoperatively, a second evaluation showed a further decrease in the ROM (30°/10°/0°) and effusion, pain at rest was still evident and mobility of the patella was constricted. C-reactive protein (CRP) was 2.8 mg/dl and the white blood count (WBC) was 4200/µl.

Therefore, an arthroscopic arthrolysis was performed. Massive adhesions at the proximal recess and general synovitis were found intraoperatively. At the end of the surgery, the ROM was measured to be 100°/0°/0°, intraoperative microbiological culture was negative and histology of adhesion tissue at the proximal recess revealed lymphoplasmacellular fibrinous tissue, consistent with type IV allergic reaction (Fig. 1).

Postoperative treatment was dominated by intensive active and passive physiotherapeutic treatment to increase ROM, supported by continuous passive motion (CPM). Postoperative pain management was achieved by regional anaesthesia and a high dose of analgesics (Piritamide administered subcutaneously). The patient received intravenous cortisone at a decreasing dosage (starting with 64 mg dexamethasone) for 4 days. Evaluation at discharge showed no effusion and no swelling, with a healed wound and a ROM of 80°/0°/0°.

Five weeks after arthroscopic arthrolysis, the patient showed patella immobility, hyperthermy of the knee joint and a ROM of 30°/5°/0°. No signs of infection were evident and no specific signs of infection or implant loosening were detected during radiographical evaluation (Fig. 2). Therefore, an allergometry was performed and the skin reaction resulted positive for type IV hypersensitivity to nickel-II-sulfate and palladium chloride. Sensitisation was detected by using patch testing including haptens representative of cobalt-based alloys (CoCrMo), including bone cements (Almiral Hermal GmbH, Reinbek, Germany).



Fig. 2. Anteroposterior and lateral radiographs of the left knee preoperative to revision surgery. Signs of implant loosening were not found.

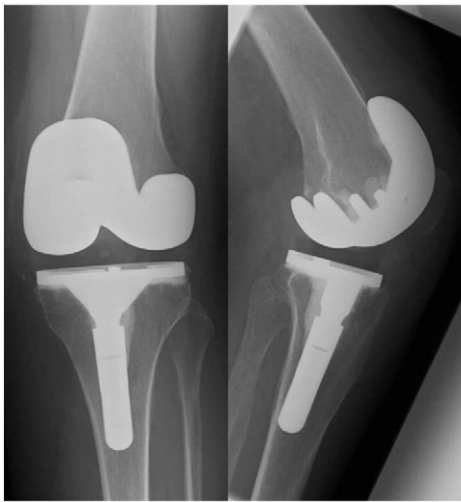


Fig. 3. Radiological evaluation (anteroposterior and lateral) at 12 months after revision surgery with a BIOLOX® delta ceramic femoral component. No signs of implant loosening or mal-alignment were found.

Revision surgery of the implant components containing nickel was performed, implanting a cemented Biolox® delta ceramic femoral and a cemented titanium alloy tibial component (Multigen Plus Knee System, Lima Corporate, San Daniele del Friuli, Italy). Microbiological samples retrieved intraoperatively were negative while histology of the massive adhesions revealed lymphoplasmacellular fibrinous tissue, consistent with a type IV allergic reaction. The patient was mobilised under full-weight bearing, supported by CPM. An antibiotic prophylaxis was accomplished using cefuroxime 3 × 1.5 g intravenously for 10 days. Before discharge, the patient showed a ROM of 80°/0°/0° with moderate pain, no effusion or swelling, stable ligaments and a mobile patella. Radiographs demonstrated an optimal implant size and alignment.

Further evaluations were performed at 3 and 12 months after revision surgery. The patient could slightly increase her ROM to 85°/0°/0° at 3 months and 90°/0°/0° at 12 months postoperatively. Both evaluations confirmed that there were no immobility of the patella and no swelling or effusion. Furthermore, pain during walking was moderate and there was no pain at rest. Remaining quadriceps atrophy and reduced proprioception caused slight problems when walking on stairs but ligaments were stable at all times. Radiological evaluation 12 months after revision surgery did not show any signs of implant migration or loosening (Fig. 3).

3. Discussion

Implantation of materials in humans, e.g., in the case of TKA, may induce an immunological response, depending on the material and sensitivity of the patient [3]. In cases of specific hypersensitivity to endoprosthetic materials, symptoms such as limited ROM and joint hyperthermy have been described [3,4,6]. Concerning the immunological classification, the hypersensitivity reactions are late type IV reactions (Coombs and Gell [3]), which show excessive lymphoplasmacellular fibrinous tissue in histological type I or IV neosynovitis, depending on the presence of foreign body particles [17–19]. Although infiltration patterns in the allergic process are not specific or clearly defined and the clinical significance of allergic reactions in arthroplasty is still rather controversial [8,9,11,14], the reported case showed clinical signs of an allergy against the implant materials. This was further demonstrated by histological type IV neosynovitis and positive skin reactions against nickel-II-sulfate and palladium chloride.

Alternative solutions in cases of hypersensitivity are implants without metal components or metallic implants treated with a non-

sensitive surface process, e.g., titanium nitride [2]. These surface treatments are shown to increase wear resistance of implants made of titanium or cobalt–chromium [2]. The layer thickness of these modified surfaces, like Oxinium™ or titanium nitride (TiN), is only a few micrometres and clinical data concerning the outcome of these knee implants are still rare [1,20–22]. However, reports of surface modifications in femoral heads after total hip arthroplasty have revealed partial surface failure due to third body wear [22].

Ceramic implants present a solution in cases of hypersensitivity to metals. Since the biologic effect of wear particles depends on the material and volume, materials with reduced wear, e.g. ceramics, are of clinical interest [1,23]. BIOLOX® delta ceramic is a composite matrix material containing alumina (Al₂O₃) and zirconia (ZrO₂), with improved mechanical characteristics in terms of strength and resistance in comparison to pure alumina [24]. An national clinical duo-center study revealed encouraging results of the early functional and radiological outcome of the Multigen Plus Knee with a BIOLOX® delta femoral component in patients without allergies [23]. We conclude that ceramic implants can be a promising solution for patients suffering from hypersensitivity reactions to metals and ALVAL. Long-term studies are recommended in order to show good clinical results and implant survival rate of the ceramic femoral components.

4. Conflict of interest

The authors certify that no actual or potential conflict of interest or grants in relation to this article exist.

References

- [1] Kircher J, Bergschmidt P, Bader R, Klues D, Besser-Mahuzir E, Leder A, et al. The importance of wear couples for younger endoprosthesis patients. *Orthopade* 2007;36:337–46.
- [2] Bader R, Bergschmidt P, Fritsche A, Ansorge S, Thomas P, Mittelmeier W. Alternative materials and solutions in total knee arthroplasty for patients with metal allergy. *Orthopade* 2008;37(2):136–42.
- [3] Thomas P. Allergic reactions to implant materials. *Orthopade* 2003;32:60–4.
- [4] Eben R, Walk R, Summer B, Maier S, Thomsen M, Thomas P. Implant allergy register – a first report. *Orthopade* 2009;38:557–62.
- [5] Hallab N, Merritt K, Jacobs JJ. Metal sensitivity in patients with orthopaedic implants. *J Bone Joint Surg Am* 2001;83-A(3):428–36.
- [6] Rau R, Thomas P, Thomsen M. Metal sensitivity in patients with joint replacement arthroplasties before and after surgery. *Orthopade* 2008;37:102–10.
- [7] Thomas P. Allergologische Aspekte der Bioverträglichkeit von Titanbasisimplantaten. *Biomaterialien* 2001;2:35–44.
- [8] Schuh A, Lill C, Höhle W, Effenberger H. Prevalence of allergic reactions to implant materials in total hip and knee arthroplasty. *Zentralbl Chir* 2008;133(3):292–6.
- [9] Granchi D, Cenni E, Tigani D, Trisolino G, Baldini N, Giunti A. Sensitivity to implant materials in patients with total knee arthroplasties. *Biomaterials* 2008;29(10):1494–500.
- [10] Lützner J, Dinnebie G, Hartmann A, Günther KP, Kirschner S. Study rationale and protocol: prospective randomized comparison of metal ion concentrations in the patient's plasma after implantation of coated and uncoated total knee prostheses. *BMC Musculoskelet Disord* 2009;10:128.
- [11] Willert HG, Buchhorn GH, Fayyazi A, Flury R, Windler M, Köster G, et al. Metal-on-metal bearings and hypersensitivity in patients with artificial hip joints. A clinical and histomorphological study. *J Bone Joint Surg Am* 2005;87(1):28–36.
- [12] Mahendra G, Pandit H, Kliskey K, Murray D, Gill HS, Athanasou N. Necrotic and inflammatory changes in metal-on-metal resurfacing hip arthroplasties. *Acta Orthop* 2009;80(6):653–9.
- [13] Counsell A, Heasley R, Arumilli B, Paul A. A groin mass caused by metal particle debris after hip resurfacing. *Acta Orthop Belg* 2008;74:870–4.
- [14] Campbell P, Ebrahmdadeh E, Nelson S, Takamura K, De Smet K, Amstutz HC. Histological features of pseudotumor-like tissues from metal-on-metal hips. *Clin Orthop Relat Res* 2010;468:2321–7.
- [15] Outerbridge RE. The etiology of chondromalacia patellae. *J Bone Joint Surg Br* 1961;43:752–7.
- [16] Michael J, Schlüter-Brust K, Eysel P. The epidemiology, etiology, diagnosis, and treatment of osteoarthritis of the knee. *Dtsch Arztebl Int* 2010;107(9):152–62.
- [17] Krenn V, Otto M, Morawietz L, Hopf T, Jakobs M, Klausner W, et al. Histopathologic diagnostics in endoprosthetics: periprosthetic neosynovitis, hypersensitivity reaction, and arthrofibrosis. *Orthopade* 2009;38:520–30.
- [18] Morawietz L, Classen RA, Schröder JH, Dynybil C, Perka C, Skwara A, et al. Proposal for a histopathological consensus classification of the periprosthetic interface membrane. *J Clin Pathol* 2006;59(6):591–7.

- [19] Witzleb WC, Hanisch U, Kolar N, Krummenauer F, Guenther KP. Neo-capsule tissue reactions in metal-on-metal hip arthroplasty. *Acta Orthop* 2007;78(2): 211–20.
- [20] Fink U. Safety aspects in the coating of titanium slide components. *Orthopade* 1997;26:160–5.
- [21] Thull R, Handke K-D, Karle EJ. Animal experiment study of titanium with surface coatings of (Ti, Nb)ON and (Ti, Zr)O. *Biomed Tech* 1995;40:289–95.
- [22] Raimondi MT, Pietrabissa R. The in-vivo wear performance of prosthetic femoral heads with titanium nitride coating. *Biomaterials* 2000;21:907–13.
- [23] Bergschmidt P, Lohmann CH, Bader R, Finze S, Lukas C, Rüther W, et al. A national prospective duo-center study on the clinical and radiological outcome of the Multigen Plus Total Knee System with a Alumina matrix composite ceramic femoral component. In: Cobb Justin P, editor. *Modern trends in THA bearings – material and clinical performance*. Springer Medizin; 2010.
- [24] Rack R, Pfaff HG. *Bioceramics in joint arthroplasty*. Stuttgart: Thieme; 2001.