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Pathophysiological mechanisms of joint implant loosening

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Abstract—Overthe past half-century, there have been many advances in the design, construction, and implantation of joint prostheses, resulting in a high percentage of successful long-term outcomes. One of the most common concerns of both patients and physicians is the problem of joint replacements becoming loose over time. Causes of failure include infections, aseptic loosening, dislocations, and fracture of the prosthesis or bone. Multidisciplinary research team studies are needed for an improvement in understanding in pathophysiological mechanisms of joint implant loosening and failure, which is the key point to improve implant survival and to minimize revisions.

Index Terms — diagnosis, infection, loosening, prosthetic joints

1 INTRODUCTION

As the average age of human population increases, the number of total joint arthroplasties performed is increasing dramatically. Nearly 4.500 such procedures are performed in Slovenia each year. Prosthetic joints improve the quality of life for many patients; however they may fail, necessitating a revision arthroplasty. It is believed that joint prostheses can reliably relieve pain and improve function in the majority of patients, with benefits lasting for a period of 15 to 20 years. However, approximately 14-28 % of prostheses need to be revised even before decade of service[1]. Causes of failure include infections, aseptic loosening, dislocations, and fracture of the prosthesis or bone. The incidence of revision surgeries almost doubled in the last 15 years and the revision frequency projections by 2030 are even more impressive [2].

Prosthetic joint infection (PJI), although uncommon, is the most serious complication, occurring in 0.8 to 1.9 % of knee arthroplasites and 0.3 to 1.7 % of hip arthroplasites [3]. Staphylococci account for more than half of all PJI cases. Since surgical treatment

of joint prosthesis loosening (septic or aseptic) is different, it is very important to establish the correct diagnosis of PJI, which is still a challenge in clinical practice. A misdiagnosed PJI has crucial consequences for the patients. Unfortunately, to date, there is no reliable preoperative or intraoperative test that is 100 % sensitive and specific for PJI diagnosis.

2 ACTIVITIES AND POSSIBLE ROLE IN TRANS2CARE PROJECT

The aim of our recent research project is to evaluate different intraoperative diagnostic tests, such as microbiological culturing, pathohistological analysis and molecular methods for PJI diagnosis.Ultrasonication of prostheses, followed by analysis of the dislodged material (sonicate) was suggested to improve the detection of prosthetic hip infections [4]. We therefore raised a question: how many cases diagnosed as aseptic failure are actually PJI?

Early diagnosis of PJI and a better understanding of biofilm production should lead to novel, effective treatment strategies and improved care and rehabilitation of patients with joint prostheses.

Currently, the most common cause of clinical failure of joint prostheses is aseptic loosening of the implant components [5]. Aseptic loosening of a joint prosthesis is hypothesised to be the result of a harmful combination of mechanical and biological events, which cause the destruction of the bond between implant and bone bed. In the long term,aseptic loosening is a significant clinical, as well as economic problem. The pathogenesis of prosthetic joint loosening continues to be a major focus of research in orthopaedics. The fibrous membrane that forms around the joint prosthesisis composed mostly from granulomatous tissue, namely macrophages, giant cells and also of immune cells (Figure 1). Although numerous descriptions of histological features of the fibrous membrane have been published [6, 7], the origin of this membrane and its role in progressive bone resorption, which is associated with prosthesis loosening, are still poorly understood. The gliding surfaces (counterfaces) of joint implants produce wear debris which stimulate macrophage activation[8]. Macrophages are generally recognized for their ability to phagocytise even immunologically non-opsonized wear particles and produce cytokines that stimulate osteoclast bone resorption. Our group has extensive expertise in pathohistological analyses of periprosthetic tissue obtained at revision surgery allowing as to be included in several national, as well as international multidisciplinary teams, involved in investigation of pathophysiological mechanisms of aseptic loosening.

Since wear debris produced in site of joint prosthesis and the resulting tissue reaction is the most important cause of prosthesis loosening, the idea of reducing wear debris is an important issue for improvement of long-term results of total joint replacement. It has in fact re-stimulated interest in evaluation of alternative bearing materials.

We are currently participatingin different international projects, in which our in vitro studies investigate biocompatibilities and toxicities of different bearing alloys and surface layer improvements, as well as biological response of different cell lines to biomaterials.

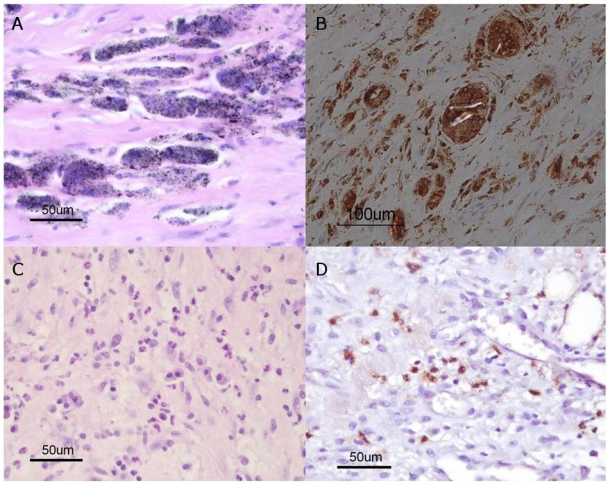

Fig.1.Histological analysis of periprosthetic tissue. A: Metal particles (black) phagocytosed by macrophages; B: Imunohistochemically stained slide under polarisation microscope with CD68 positive macrophages and giant cells (brown) with birefingent polyethylene particles (white); C: Infiltration with polymoprphonuclear leucocytes and plasma cells in periprosthetic tissue is a diagnostic for infection; D: Immunohistochemical staining with CD15 with positive granulocytes (brown) in tissue around infected joint prosthesis.

3 CONCLUSION

Total joint arthroplasty is one of the most successful orthopaedic surgery procedures; however, a number of joint replacements ultimately fail due tocomponent loosening. Because of the increasing need to implant joint prostheses in younger and more active patients, studies of interdisciplinary research teams are necessary to improve our understanding of the pathophysiology of joint implant loosening.

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