

Mechanical, biological, material and clinical aspects of performance of joint prostheses

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Abstract — At the Research department at the Valdoltra Orthopaedic Hospital the surgeons and researchers are joined in an interdisciplinary team which performs research work and activities directed to the understanding of prosthesis performance from several aspects including mechanical, biological, material and clinical aspects. Studies are largely based on the hospital's Arthroplasty Register which represents a valuable source of information for data-based analysis of arthroplasty treatments. Our register is special in that it includes the implant retrieval program for explanted prosthetic components and periprosthetic tissue samples. Research is versatile and interdisciplinary, and is a challenge for young researchers searching for new knowledge and scientific results.

Index Terms — orthopaedic implants, survival, register, materials for biomedical applications, biological impact, statistics

1 VALDOLTRA ORTHOPAEDIC HOSPITAL

Valdoltra Orthopaedic Hospital has celebrated its 100th anniversary in 2009. Over the years the hospital has developed from a marine sanatorium for scrofulous diseases in ancient Austro-Hungarian monarchy to a modern orthopaedic institution today. Hospital is the oldest and largest specialized hospital in Slovenia, comprising more than 50% of Slovene orthopaedic activities with 2,600 surgeries, 25,000 orthopaedic examinations and 5,500 patients in hospital care. The Hospital collaborates with domestic and foreign orthopaedic institutions aimed at developing new surgical and therapeutic methods. The Hospital is equipped with modern operating rooms, sophisticated IT and diagnostic equipment including MR and CT, endoscopic technology and highly qualified medical staff. The hospital has around 300 employees, of whom more than 30 are MDs.

2 RESEARCH DEPARTMENT

Constant education and follow-up of the latest results of clinical studies has always been very important for everyday practice at the hospital. The Research department at the Valdoltra Orthopaedic hospital was formally founded in 2002. It is devoted to the research studies in orthopaedics, primarily to long-term performance of various prostheses. Our aim was to join the surgeons and researchers in an interdisciplinary team which would perform research work and activities directed to the understanding of prostheses performance from several aspects including mechanical, biological, material and, of course, clinical aspect. The research work proceeds through the projects within the hospital targeted to solve specific problems within the hospital practice, and through projects financed by the Slovenian Research Agency, i.e. basic and applied research projects, young researcher program and bilateral projects. The hospital is involved in two international strategic projects (e-health and Trans2Care).

3 ACTIVITIES AND ROLES IN TRANS2CARE PROJECT

3.1 Arthroplasty Register

Research studies at the hospital are largely based on the hospital's Arthroplasty Register which represents a valuable source of information for data-based analysis of arthroplasty treatments. Following the example of Scandinavian arthroplasty registries we have established the Arthroplasty Register of the Valdoltra Orthopaedic Hospital in 2002 in order to assure the results of arthroplasty treatment and long-term follow-up of clinical results. The Register comprises all primary and revision hip and knee operations. For that purpose, forms and date-base have been developed. Based on the analysis of the data given in the forms, annual reports are prepared. There are numerous advantages of Arthroplasty register, among them the most important are long-term follow-up of individual types of prostheses and the possibility of early recognition of possible deviations from the expected results and subsequent fast reaction, i.e. alarm.

3.2 Long-term survival of prostheses

Our goal is to carefully follow the long-term survival results of the implanted hip and knee prostheses and relate them to other clinical scores or indicators. In the last decade we have published several papers reporting mid- and long-term results of various prostheses [1-5]. We were especially interested in the effect of type of the bearing on the long-term performance of hip prosthesis. There are namely several types of bearings, so called traditional metal-on-polyethylene and ceramic-on-polyethylene bearings, and alternative metal-on-metal and ceramic-on-ceramic bearings, aimed for younger, more active patients. Polyethylene has been used as a bearing material for more than fifty years. It represents a golden standard in orthopedics. However, wear of polyethylene and consequent formation of wear particles are the key factor

in the mechanism of aseptic loosening of total hip replacements. Pathophysiology of loosening is a complex process. Osteoclasts and their precursors have crucial role in bone resorption. The differentiation of these multinucleated cells and activation is regulated with RANK/RANKL/OPG regulatory axis.

3.3 Retrieval studies

The specialty of our Register is that it includes the implant retrieval program for explanted prosthetic components and samples of periprosthetic tissue (Fig. 1). Collected samples are the basis for various research analyses aimed to reveal the changes at the surface of the component and in the periprosthetic tissue induced during in vivo functioning of the prosthesis [6-8]. Of special interest are mechanical, chemical and structural changes at the surface of retrieved metal and polyethylene components. For that purpose we use microscopic analysis of the surface by scanning electron microscopy combined with chemical analysis, computer coordinate machine for determination of wear, roughness measurements, and other analyses of interest. Histological analysis of periprosthetic tissue samples is performed in order to determine the biological impact of wear debris products. Wear debris particles are isolated from tissue samples in order to study their morphology and size distribution. Of special interest are also studies aimed to investigate incidence of infection of joint prosthesis and its mechanism.

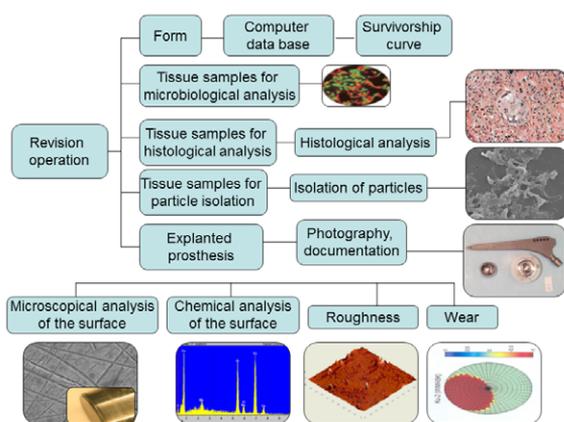


Fig. 1. Block-diagram of the Arthroplasty Register at the Valdoltra Orthopaedic Hospital.

4 CONCLUSION

Through the initiated Trans2Care project we intend at our hospital to contribute through the activities and studies aimed to a deeper understanding of prosthesis-biological environment interactions and, consequently, contribute to the improvement of approaches, materials, design and treatment selection, and eventually promote the prolongation of the life-time of prostheses in general.

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REFERENCES

- [1] I. Milošev, R. Trebše, S. Kovač, A. Cör, P. Campbell, "Dissociation of the Metal Inlay from the Polyethylene Liner in an Uncemented Threaded Cup", *Arch. Orthop. Trauma Surg.* Vol. 125, pp. 134-141, 2005.
- [2] I. Milošev, V. Pišot, P. Campbell, "Serum Levels of Cobalt and Chromium in Patients with Sikomet Metal-on-Metal Total Hip Replacements", *J. Ortop. Res.*, vol. 23 pp. 526-535, 2005.
- [3] R. Trebše, I. Milošev, S. Kovač, M. Mikek, V. Pišot, "Poor Results from the Isoelastic Total Hip Replacement: 14-17-year Follow-up Study of 149 Cementless Pprotheses", *Acta Ortop. Scan.*, vol 76, pp. 169-176, 2005.
- [4] I. Milošev, R. Trebše, S. Kovač, A. Cör, V. Pišot, "Survivorship and Retrieval Analysis of Sikomet Metal-on-Metal Total Hip Arthroplasty at a Mean of Seven Years", *J. Bone Joint Surg.*, vol. 88-A, pp. 1173-1182, 2006.
- [5] S. Kovač, R. Trebše, I. Milošev, I. Milošev, V. Pavlovčič, V. Pišot, "Long-term Survival of a Cemented Titanium-aluminium vanadium Alloy Straight Stem Femoral Component", *J. Bone Joint Surg.*, vol. 88-B, pp. 1567-1573, 2006.
- [6] S. Virtanen, I. Milošev, E. Gomez-Barrena, R. Trebše, J. Salo, Y. Konttinen, "Special Modes of Corrosion Under Physiological and Simulated Physiological Conditions", *Acta Biomaterialia*, vol. 4, pp. 468-476, 2008.
- [7] Y. Konttinen, I. Milošev, R. Trebše, P. Rantanen, R. Linden, V.-M. Tiainen, S. Virtanen, "Metal for Joint Replacement", In: „Joint Replacement Technology“, editor P.A. Revell, Woodhead Publishing, Cambridge, England, pp. 115-162, 2008.
- [8] I. Milošev, R. Trebše, S. Kovač, Materials Development and Latest Results of Various Bearings for Total Hip Arthroplasty, In: "hip Replacement: Approaches, Complications and Effectiveness", editors T. Aoi and A. Toshida, Nova Science Publishers, Inc., New York, pp. 159-232, 2009.

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