

Tumor Prostheses for Bone and Joint Reconstruction

The Design and Application

TUMOR PROSTHESES FOR BONE AND JOINT RECONSTRUCTION —The Design and Application—

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Acknowledgments

The First International Workshop on "Design and Application of Tumor Prostheses for Bone and Joint Reconstruction" was a unique meeting, preceded only by a similar symposium on "Operative Treatment of Bone Tumors" held in Basel, Switzerland about fourteen years ago. The aim of this Workshop was to foster the current knowledge on the indications, designs, and applications of custom implants to reconstruct the skeletal and joint defects caused by tumor resection. It was also hoped that a common forum could be established among the scientists from various disciplines to serve this important and well-recognized field in orthopedic surgery. These goals have been successfully achieved, mainly due to the overwhelming support and participation by many renowned investigators from more than eighteen countries throughout the world. It was truly a heart warming and exciting experience that each participant could offer something new to his colleagues, making their journey to Rochester, thousands of miles from their homelands, extremely worthwhile. We wish to express our sincere gratitude to, not only those who contributed to the presentations and discussions, but also to every attendee for this well intentioned endeavor. We also wish to recognize all the authors for their generosity in offering their best work for this volume and their determination in finishing their manuscripts to meet the deadline for submission. A few papers did not match the format of this book, and we chose to exclude them merely for editorial purposes. We appreciate the contributors' efforts just the same.

We would like to pay tribute to Dr. Franklin H. Sim, one of the co-chairmen of the Workshop, for his enthusiastic help in the planning and organizing of the event. The Workshop would not have been possible without the endorsement of the staff of the Department of Orthopedics at the Mayo Clinic, particularly those in the Oncology Section and our colleagues from Pathology, Radiology, Physical Medicine and Rehabilitation, and other related subspecialties. During the Workshop sessions and evening activities, all the personnel of the Orthopedic Biomechanics laboratory devoted their own time to make the meeting run smoothly, and our distinguished guests and participants felt quite at home. Among them, we would like to single out Mrs. Sharon Wellik and Mrs. Joanne Murray for working long hours preparing the Workshop material, overseeing its progression and, most importantly, putting this book together in a publishable form. Mrs. D.J. Pritchard contributed much to this Workshop by her extra efforts and attention paid to many details which made the event a very pleasant and memorable experience for everyone. We could not let her hard work go unnoticed. Many others were also helpful in putting this Workshop together, and we are also deeply in debt to them.

The Workshop would have been impossible without the support and encouragement from the National Cancer Institute of NIH through research grant No. CA 23751. We particularly wish to acknowledge the participation of our industrial colleagues, since without their help no custom prostheses could ever be made to the designers' specifications. It is a well known fact that custom prostheses are generally a money losing proposition for most orthopedic appliance manufacturers. Their willingness to see the perfection of this field is truly an act of humanity.

Finally, we would like to thank Thieme-Stratton for publishing this volume, since editing papers from an international collection of authors can be a painstaking

task. We appreciate the editorial staff's hard work in turning many difficult chapters into valuable documents to convey the original ideas of the contributing authors. We hope that this book will serve as a valuable communication to those who are interested in this rather specialized endeavor to help in alleviating the suffering of many unfortunate patients.

Edmund Y. S. Chao, Ph.D.

John C. Ivins, M.D.

The First International Workshop on "Prostheses for Bone and Joint Reconstruction" was a unique and highly successful event, held in Basel, Switzerland about twenty years ago. The aim of this Workshop was to foster the exchange of knowledge on the indications, design, and application of prosthetic devices to reconstruct the skeletal and joint defects caused by minor trauma. It was also hoped that a common forum could be established among the various disciplines to develop the important and well-recognized field of orthopedic surgery. These goals have been successfully achieved, mainly due to the overwhelming support and participation by many renowned investigators from more than eighteen countries throughout the world. It was truly a heart warming and exciting experience that each participant could offer something new to his colleagues, making their journey to Rochester thousands of miles from their homelands. We wish to express our sincere gratitude to not only those who contributed to the presentations and discussions, but also to every attendee for this well-attended endeavor. We also wish to recognize all the authors for their generosity in offering their best work for this volume and their dedication in finishing their manuscripts to meet the deadline for submission. A few papers did not match the format of this book, and we chose to exclude them merely for editorial purposes. We appreciate the contributors' efforts just the same.

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The Workshop would have been impossible without the support and encouragement from the National Cancer Institute of NIH through research grant No. CA-23751. We particularly wish to acknowledge the contribution of our industrial colleagues, since without their help in custom prostheses or prosthetic made to the designers' specifications, it is well known that their custom prostheses are generally a costly proposition for most orthopedic prosthetic manufacturers. Their willingness to see the perfection of this field is truly an act of generosity. Finally, we would like to thank Thomas Strain for publishing this volume since editing papers from an international collection of authors can be a painstaking

Preface

Aggressive benign or low-grade malignant lesions in bone can often be successfully treated by local resection and reconstruction of the limb. Even in high-grade primary malignant bone and soft tissue tumors, the current clinical trials of multimodality regimens appear to show that limbs can be saved without undue prejudice to life. Careful patient selection and accurate clinical staging are important requisites for the success of such treatment. Also required is close teamwork between pathologists, radiologists, oncologists, and surgeons. In addition, engineers and material scientists must assume responsibility for solving the problems involved in reconstructing these defects for restoration of function. Extensive utilization of bioengineering knowledge, ranging from cartilage and bone mechanics to implant design and patient functional evaluation, is essential in this multidisciplinary effort.

Special segmental bone and joint prostheses, utilizing modern design techniques and bone ingrowth materials to minimize component failure, are now being used. The problem of custom fitting for a wide range of resection dimensions has been solved by introducing a "modular" system of implants with interchangeable components of varying sizes and lengths. Titanium fiber-metal coating has been used to allow bone ingrowth for permanent fixation. Animal studies have been carried out to examine the bone ingrowth characteristics and the possible adverse effects of stress-shielding resorption.

In the 1981 Workshop, anatomic regions of replacement included the proximal humerus, the proximal and distal femur, the proximal tibia, portions of the pelvis, spinal segments, and the diaphyses of the major long bones. In addition to prosthetic replacement, the experiences of applying autografts and allografts to bridge skeletal defects were reported. The use of free vascularized bone and joint transplants was also introduced as a potential alternative to achieve effective biologic union with the host tissues. The majority of these patients had localized aggressive tumors. Among the high-grade malignant tumor patients, the local recurrence rate was surprisingly low in the carefully selected cases. In patients with metastatic disease, these treatment modalities were able to provide pain relief and increase in functional ability, and they facilitated other adjuvant therapies. Custom implants now in use can be expected to survive a minimum of 5 years without mechanical failure. With the current improvement in prosthetic design and surgical techniques, the success rate is expected to be even higher.

Since these procedures are still regarded as experimental, careful clinical and biomechanical follow-up is mandatory. Joint motion and strength measurements, as well as gait evaluations, should be routinely performed on these patients. Based on the evaluation results, effective postoperative management and rehabilitation regimens can be established to improve the patient's performance, as well as to protect the implants. The development and experience gained in these efforts have helped to pace the progress in many other orthopedic fields, including regular total joint replacement.

Although these new procedures appear to have unlimited potential in treating a large class of patients with significant bone and joint defects, their future is still plagued with many unsolved problems that will require continuing research and development from all related disciplines. Effective adjuvant therapies are required to reduce the size of the lesion, to facilitate en bloc resection, and to prevent local

recurrence. A standard surgical staging system for musculoskeletal neoplasms is mandatory for proper patient selection. Surgical techniques must be improved to safely eradicate the tumor and proceed with effective reconstruction for restoration of function.

Better implant materials and design configurations are needed to improve the longevity of the artificial devices under severe in vivo loading conditions. Special internal fixation systems, tailored to provide improved cortical graft fixation strength, and surgical techniques should be developed and standardized to facilitate bone and joint transplant procedures. The incorporation of bone ingrowth into porous implants must be investigated under the effect of extensive chemotherapy and radiotherapy. Electrical stimulation may improve osteogenic responses in older patients with less efficient osseous repair and remodeling potential. Postoperative patient care must be rationalized for effective function restoration and implant protection. These research efforts are too broad and specialized to be undertaken by any individual group. Collaborative effort must, therefore, be solicited. This Workshop was intended to stimulate such spirit.

The enthusiastic response to this conference has reflected a positive commitment by all experts in the field to answer our specific pleas for an all-out cooperative effort. These proceedings contain the contemporary knowledge and experience on the subject of limb saving and reconstruction, generously contributed by many renowned scientists and physicians from all corners of the world. Such a document is invaluable to help pave the way for future development.

We wish to extend our hearty appreciation to all the participants for making this a truly meaningful and worthwhile endeavor. This gathering only marked the beginning of a long and continuing course of interaction. It is our sincere hope that such effort will be spotlighted in the ensuing meetings, so that the ultimate goal of developing a safe and effective method for limb salvage can be realized in the foreseeable future.

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